

COMPENDIUM EDEXCEL

Pearson Edexcel International A Level

GEN 2026



Gerard Romo Garrido

Toomates Coolección vol. 79.5



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Todas las soluciones desarrolladas se presentan después de su bloque de enunciados correspondiente.

Pearson Edexcel International Advanced Level

Tuesday 20 January 2026

Afternoon (Time: 1 hour 30 minutes)

**Paper
reference**

WDM11/01A

Mathematics

**International Advanced Subsidiary/Advanced Level
Decision Mathematics D1
Question Paper**

You must have:

Answer book (sent separately).

Do not return this question paper with the answer book.

Turn over ►

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Pearson

1.

5.0 1.8 6.2 2.8 3.0 4.0 3.8 2.4 0.6 0.8 7.8

The numbers in the list are the lengths, in feet, of eleven pieces of wood. They are to be cut from planks of wood of length 10 feet. You should ignore wastage due to cutting.

- (a) Calculate a lower bound for the number of planks needed. You must make your method clear. (2)
- (b) Use the first-fit bin packing algorithm to determine how these pieces could be cut from 10 feet planks. (3)
- (c) Carry out a quick sort to produce a list of the lengths in descending order. You should show the result of each pass and identify your pivots clearly. (4)
- (d) Use the first-fit decreasing bin packing algorithm to determine how these pieces could be cut from 10 feet planks. (2)

(Total for Question 1 is 11 marks)

2.

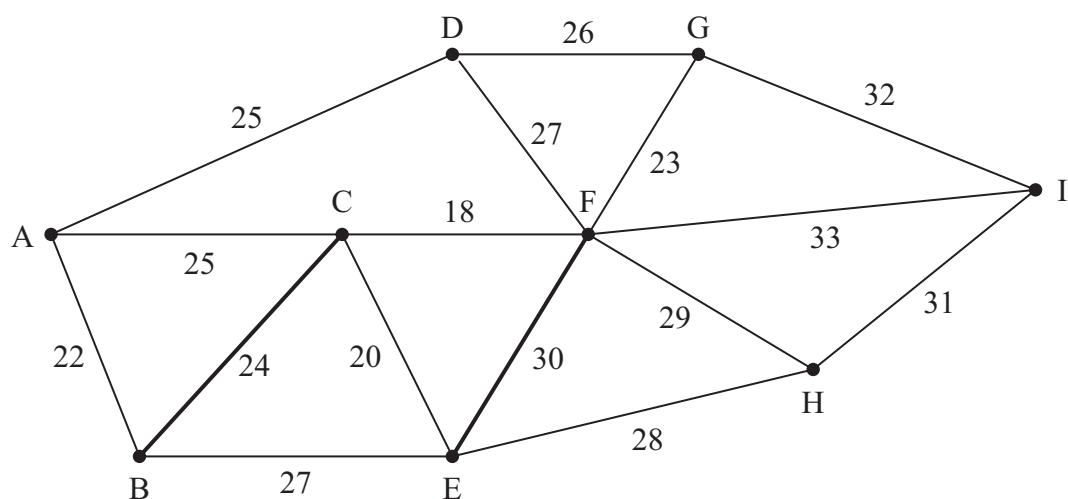


Figure 1

Figure 1 represents nine buildings, A, B, C, D, E, F, G, H and I, recently bought by Newberry Enterprises. The company wishes to connect the alarm systems between the buildings to form a single network. The number on each arc represents the cost, in pounds, of connecting the alarm systems between the buildings.

- (a) Use **Prim's** algorithm, starting at A, to find the minimum spanning tree for this network. You must list the **arcs** that form your tree in the order that you select them. (3)
- (b) State the minimum cost of connecting the alarm systems in the nine buildings. (1)

It is discovered that some alarm systems are already connected.
There are connections along **BC** and **EF**.
Since these already exist, it is decided to use these arcs as part of the spanning tree.

- (c) Use **Kruskal's** algorithm to find the minimum spanning tree that includes arcs **BC** and **EF**. You must list the arcs in the order that you consider them. In each case, state whether you are adding the arc to your spanning tree. (3)
- (d) State the new minimum cost of connecting the nine buildings. (1)

(Total for Question 2 is 8 marks)

3.

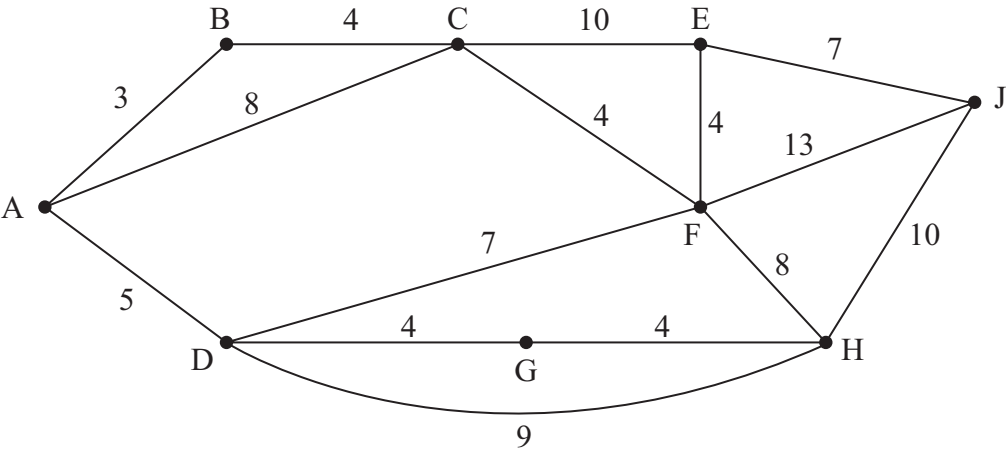


Figure 2

[The total weight of the network is 100]

Figure 2 represents a network of pipes in a building. The number on each arc represents the length, in metres, of the corresponding pipe.

- (a) Use Dijkstra’s algorithm to find the shortest path from A to J. State your path and its length. (6)

On a particular day Kim needs to check each pipe. A route of minimum length, which traverses each pipe at least once and starts and finishes at A, needs to be found.

- (b) Use an appropriate algorithm to find the arcs that will need to be traversed twice. You must make your method and working clear. (4)

- (c) Write down a possible route, giving its length. (2)

All the pipes directly attached to B are removed. Kim needs to check all the remaining pipes and may now start at any vertex and finish at any vertex. A route is required that excludes all those pipes directly attached to B.

- (d) State all possible combinations of starting and finishing points so that the length of Kim’s route is minimised. State the length of Kim’s route. (3)

(Total for Question 3 is 15 marks)

4. Draw the activity network described in this precedence table, using activity on arc and dummies only where necessary. (5)

Activity	Immediately preceding activities
<i>A</i>	–
<i>B</i>	–
<i>C</i>	–
<i>D</i>	<i>B, C</i>
<i>E</i>	<i>A</i>
<i>F</i>	<i>C</i>
<i>G</i>	<i>D, E</i>
<i>H</i>	<i>D, E</i>
<i>I</i>	<i>F, G</i>
<i>J</i>	<i>C</i>
<i>K</i>	<i>G, H</i>

(Total for Question 4 is 5 marks)

5. Michael and his team are making toys to give to children at a summer fair. They make two types of toy, a soft toy and a craft set.

Let x be the number of soft toys they make and y be the number of craft sets they make.

Each soft toy costs £3 to make and each craft set costs £5 to make.

Michael and his team have a budget of £1000 to spend on making the toys for the summer fair.

(a) Write down an inequality, in terms of x and y , to model this constraint. (1)

Two further constraints are:

$$y \leq 2x$$

$$4y - x \geq 210$$

(b) Add lines and shading to Diagram 1 in the answer book to represent all of these constraints.
Hence determine the feasible region and label it R. (4)

Michael’s objective is to make as many toys as possible.

(c) State the objective. (1)

(d) Determine the exact coordinates of each of the vertices of the feasible region, and hence use the vertex method to find the optimal number of soft toys and craft sets Michael and his team should make. You should make your method clear. (7)

(Total for Question 5 is 13 marks)

6.

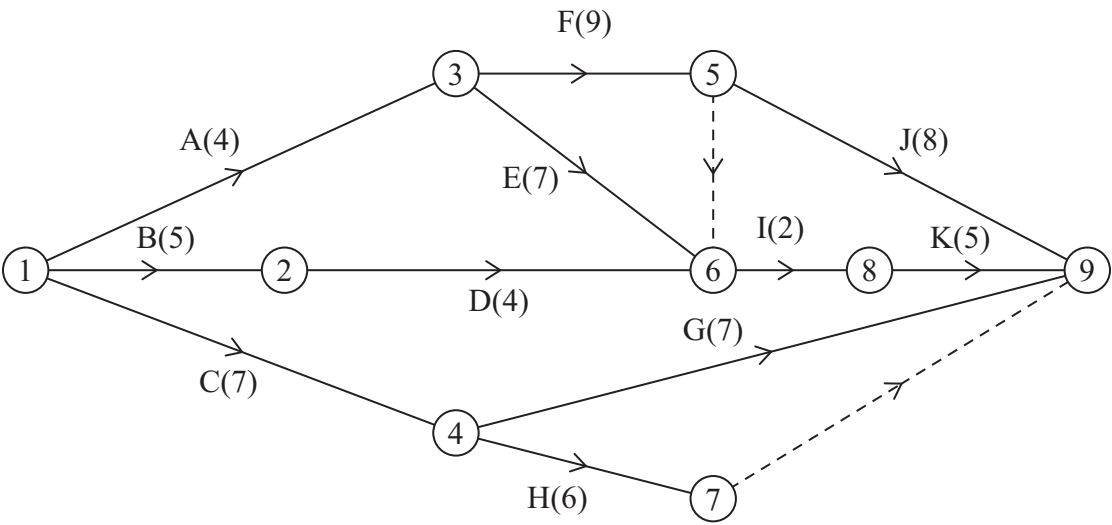


Figure 3

A project is modelled by the activity network shown in Figure 3. The activities are represented by the arcs. The number in brackets on each arc gives the time required, in hours, to complete the activity. The numbers in circles are the event numbers. Each activity requires one worker.

- (a) Complete Diagram 1 in the answer book to show the early event times and the late event times. (4)
- (b) State the minimum project completion time. (1)
- (c) Calculate a lower bound for the minimum number of workers required to complete the project in the minimum time. You must show your working. (2)
- (d) On Grid 1 in your answer book, draw a cascade (Gantt) chart for this project. (4)
- (e) On Grid 2 in your answer book, construct a scheduling diagram to show that this project can be completed with three workers in just one more hour than the minimum project completion time. (3)

(Total for Question 6 is 14 marks)

7. Emily is planning to sell three types of milkshake, strawberry, vanilla and chocolate.

Emily has completed some market research and has used this to form the following constraints on the number of milkshakes that she will sell each week.

- She will sell fewer than 200 non-vanilla milkshakes in total.
- She will sell at most 2.5 times as many strawberry milkshakes as vanilla milkshakes.
- At most, 75% of the milkshakes that she will sell will be vanilla.

The profit on each strawberry milkshake sold is £0.75, the profit on each vanilla milkshake sold is £1.20 and the profit on each chocolate milkshake sold is £1.45

Emily wants to maximise her profit.

Let x represent the number of strawberry milkshakes sold, let y represent the number of vanilla milkshakes sold and let z represent the number of chocolate milkshakes sold.

(a) Formulate this as a linear programming problem, stating the objective and listing the constraints as fully simplified inequalities with integer coefficients.

(6)

In week 1, Emily sells 100 strawberry milkshakes and 25 chocolate milkshakes.

(b) Calculate the maximum possible profit and minimum possible profit, in pounds, for the sale of all milkshakes in week 1. You must show your working.

(3)

(Total for Question 7 is 9 marks)

TOTAL FOR PAPER IS 75 MARKS

Please check the examination details below before entering your candidate information

Candidate surname		Other names	
Centre Number		Candidate Number	

Pearson Edexcel International Advanced Level

Tuesday 20 January 2026

Afternoon (Time: 1 hour 30 minutes)

Paper reference **WDM11/01A**

Mathematics

International Advanced Subsidiary/Advanced Level

Decision Mathematics D1

Answer Book

You must have:

Question paper (sent separately)

Calculator

Total Marks

Candidates may use any calculator allowed by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B). Coloured pencils and highlighter pens must not be used.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- There are 7 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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Question 1

Write the answer to Question 1 on these 2 pages

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5.0 1.8 6.2 2.8 3.0 4.0 3.8 2.4 0.6 0.8 7.8



Question 2

Write the answer to Question 2 on these 2 pages

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DO NOT WRITE IN THIS AREA

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Question 2 continued

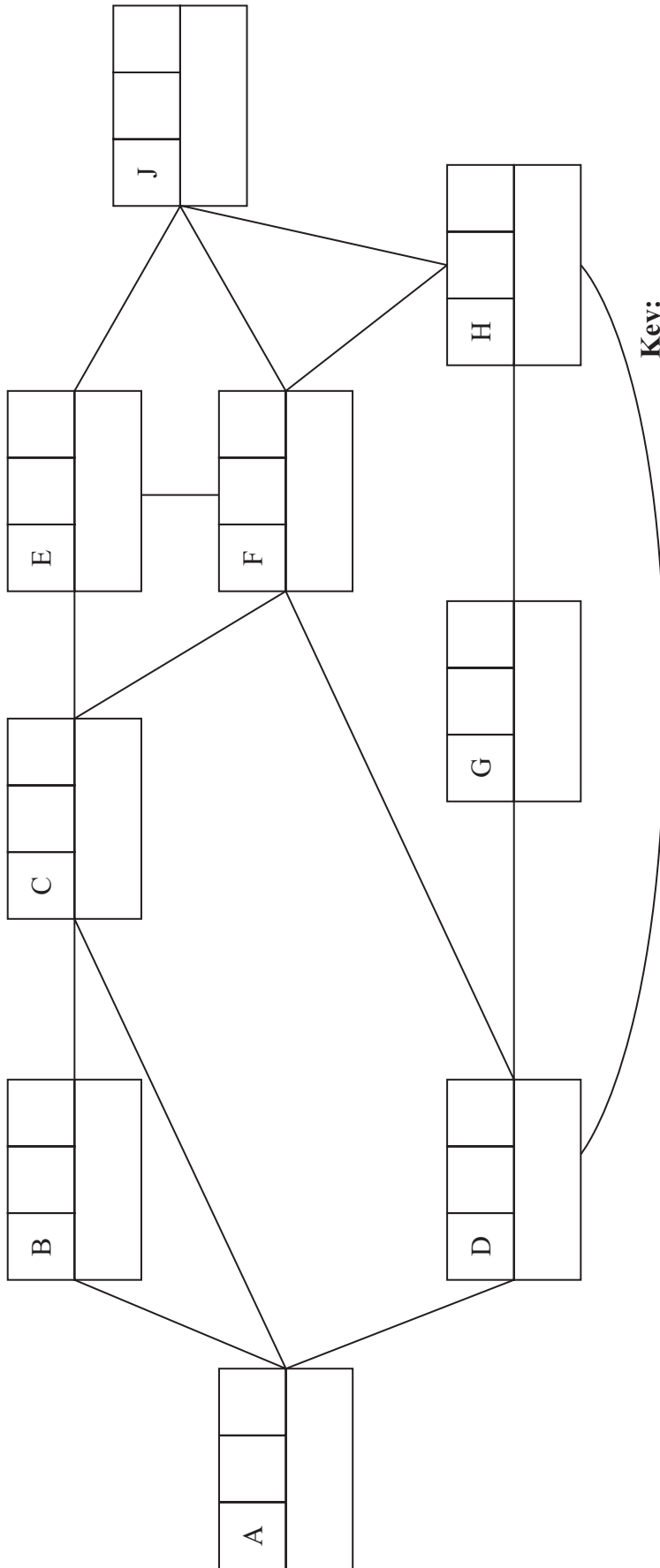
This is the end of Question 2 answer space. Please turn the page for Question 3 answer space.

(Total for Question 2 is 8 marks)



Question 3

Write the answer to Question 3 on these 4 pages



Key:

Vertex	Order of labelling	Final value
Working values		

Shortest path

Length of shortest path



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Question 3 continued

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Question 3 continued

Lined area for writing the answer to Question 3.

This is the end of Question 3 answer space. Please turn the page for Question 4 answer space.

(Total for Question 3 is 15 marks)



Question 4

Write the answer to Question 4 on these 2 pages

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Question 4 continued

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(Total for Question 4 is 5 marks)



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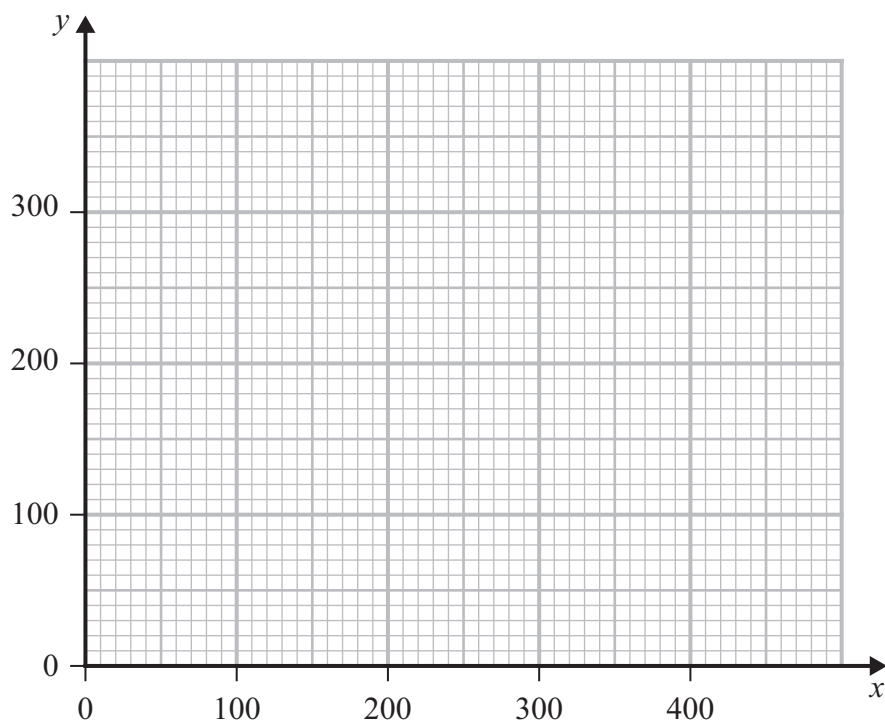


Diagram 1

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DO NOT WRITE IN THIS AREA



Question 5 continued

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Question 5 continued

This is the end of Question 5 answer space. Please turn the page for Question 6 answer space.

(Total for Question 5 is 13 marks)



Question 6

Write the answer to Question 6 on these 2 pages

(a)

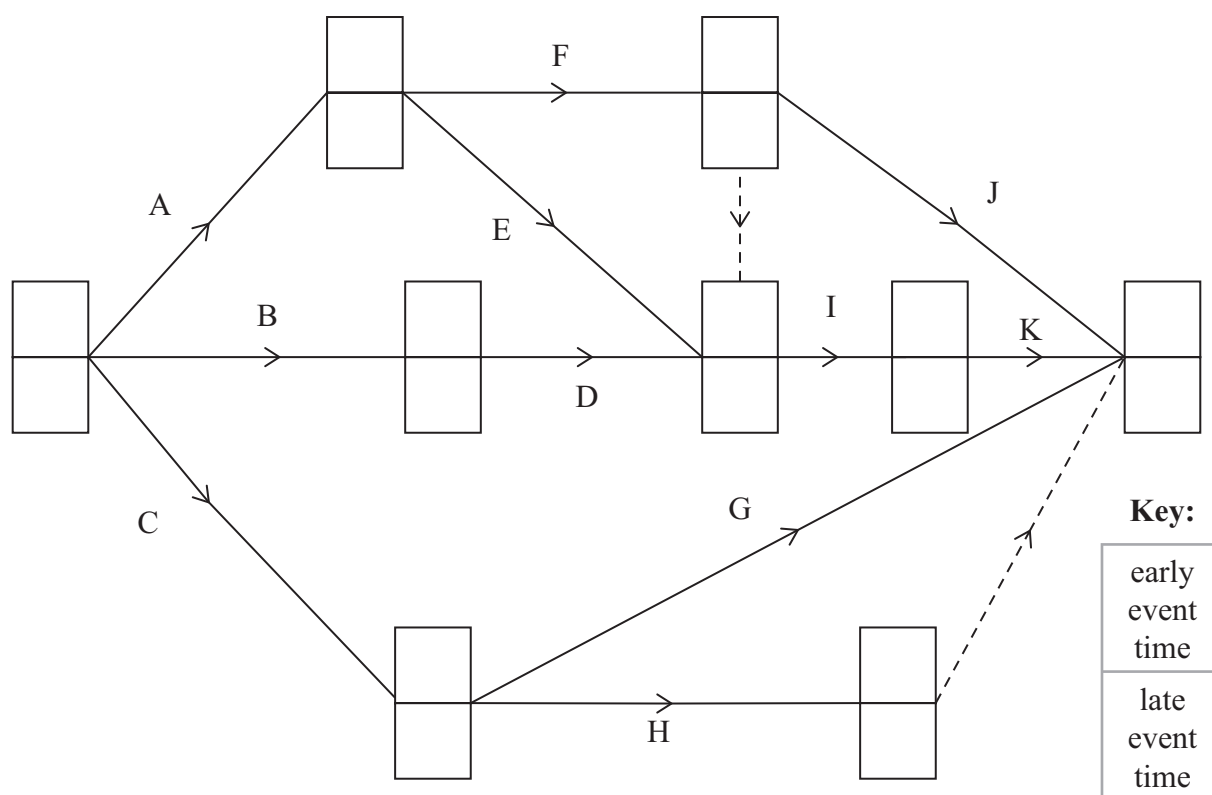


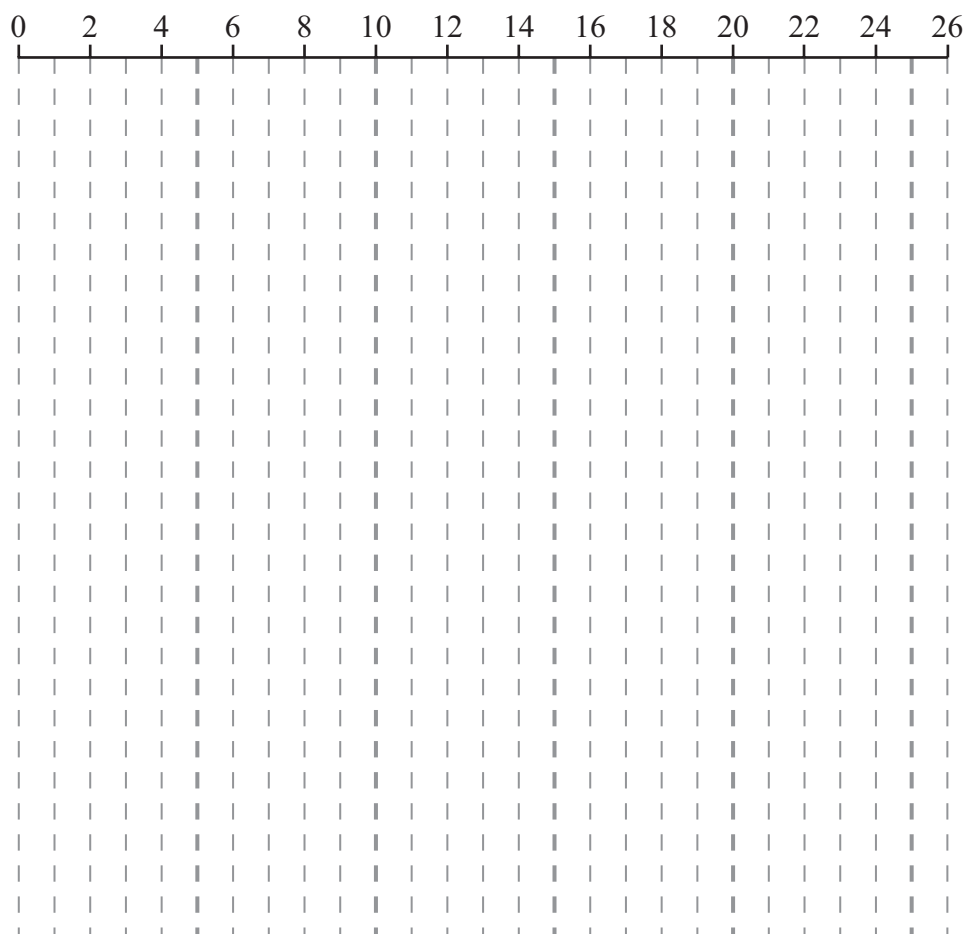
Diagram 1

(b)

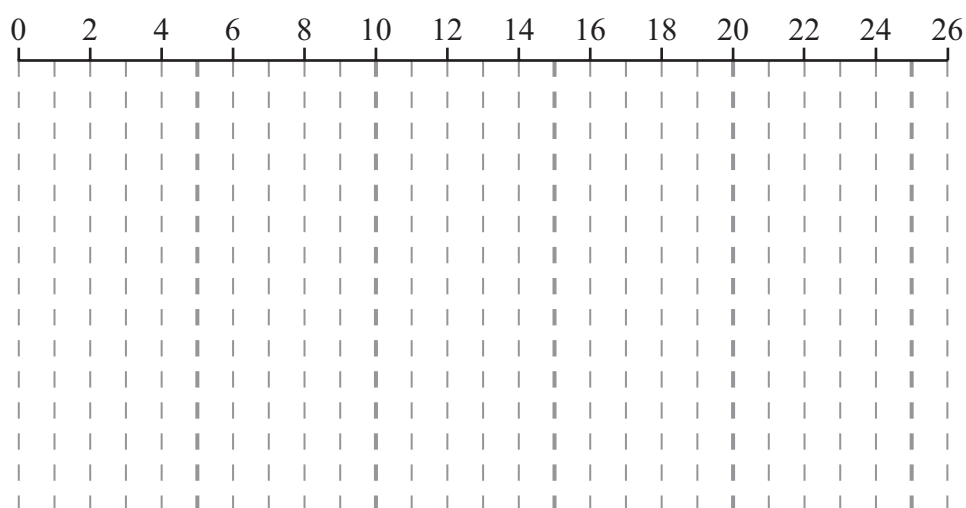
(c)

Question 6 continued

(d)

**Grid 1**

(e)

**Grid 2**

This is the end of Question 6 answer space. Please turn the page for Question 7 answer space.

(Total for Question 6 is 14 marks)



Question 7

Write the answer to Question 7 on these 3 pages

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA



Question 7 continued

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(Total for Question 7 is 9 marks)

TOTAL FOR PAPER IS 75 MARKS



Mark Scheme (Final)

January 2026

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Mathematics D1

WDM11/01A

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January 2026

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Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.

Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.

There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.

All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.

Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.

When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.

Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:

'M' marks

These are marks given for a correct method or an attempt at a correct method.

M marks are sometimes dependent (DM) on previous M marks having been earned.

'A' marks

These are dependent accuracy (or sometimes answer) marks and can only be awarded if the previous M mark has been earned. E.g. M0 A1 is impossible.

'B' marks

These are independent accuracy marks where there is no method (e.g. often given for a comment or for a graph)

A few of the A and B marks may be f.t. – follow through – marks.

3. General Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
 - ft – follow through
 - the symbol $\checkmark$ will be used for correct ft
 - cao – correct answer only
 - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
 - isw – ignore subsequent working
 - awrt – answers which round to
 - SC: special case
 - oe – or equivalent (and appropriate)
 - dep – dependent
 - indep – independent
 - dp decimal places
 - sf significant figures
 - * The answer is printed on the paper
 - $\square$ The second mark is dependent on gaining the first mark
4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.
5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.
6. If a candidate makes more than one attempt at any question:
- If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
7. Ignore wrong working or incorrect statements following a correct answer.

Question Number	Scheme	Marks
1.		
(a)	$\frac{38.2}{10} = 3.82$ so lower bound is 4 (planks/bins)	M1 A1 (2)
(b)	Bin 1: 5.0 1.8 2.8 Bin 2: 6.2 3.0 0.6 Bin 3: <u>4.0</u> <u>3.8</u> 0.8 Bin 4: <u>2.4</u> Bin 5: 7.8	M1 <u>A1</u> A1 (3)
(c)	e.g. Middle Right Pivots 5.0 1.8 6.2 2.8 3.0 4.0 3.8 2.4 0.6 0.8 7.8 4.0 5.0 6.2 7.8 <u>4.0</u> 1.8 2.8 3.0 3.8 2.4 0.6 0.8 6.2, 3.8 7.8 <u>6.2</u> 5.0 <u>4.0</u> <u>3.8</u> 1.8 2.8 3.0 2.4 0.6 0.8 (7.8, 5.0), 2.4 <u>7.8</u> <u>6.2</u> <u>5.0</u> <u>4.0</u> <u>3.8</u> 2.8 3.0 <u>2.4</u> 1.8 0.6 0.8 3.0, 0.6 <u>7.8</u> <u>6.2</u> <u>5.0</u> <u>4.0</u> <u>3.8</u> <u>3.0</u> 2.8 <u>2.4</u> 1.8 0.8 <u>0.6</u> (2.8), 0.8 <u>7.8</u> <u>6.2</u> <u>5.0</u> <u>4.0</u> <u>3.8</u> <u>3.0</u> <u>2.8</u> <u>2.4</u> 1.8 <u>0.8</u> <u>0.6</u> (1.8)	M1 A1 A1ft A1 (4)
	e.g. Middle Left Pivots 5.0 1.8 6.2 2.8 3.0 4.0 3.8 2.4 0.6 0.8 7.8 4.0 5.0 6.2 7.8 <u>4.0</u> 1.8 2.8 3.0 3.8 2.4 0.6 0.8 6.2, 3.8 7.8 <u>6.2</u> 5.0 <u>4.0</u> <u>3.8</u> 1.8 2.8 3.0 2.4 0.6 0.8 (7.8, 5.0), 3.0 <u>7.8</u> <u>6.2</u> <u>5.0</u> <u>4.0</u> <u>3.8</u> <u>3.0</u> 1.8 2.8 2.4 0.6 0.8 2.4 <u>7.8</u> <u>6.2</u> <u>5.0</u> <u>4.0</u> <u>3.8</u> <u>3.0</u> 2.8 <u>2.4</u> 1.8 0.6 0.8 (2.8), 0.6 <u>7.8</u> <u>6.2</u> <u>5.0</u> <u>4.0</u> <u>3.8</u> <u>3.0</u> <u>2.8</u> <u>2.4</u> 1.8 0.8 <u>0.6</u> 1.8 <u>7.8</u> <u>6.2</u> <u>5.0</u> <u>4.0</u> <u>3.8</u> <u>3.0</u> <u>2.8</u> <u>2.4</u> <u>1.8</u> 0.8 <u>0.6</u> (0.8)	
(d)	Bin 1: 7.8 1.8 Bin 2: 6.2 3.8 Bin 3: 5.0 4.0 0.8 Bin 4: 3.0 2.8 2.4 0.6	M1 A1 (2)
		11 marks

	Notes for Question 1	
	If 5.0 4.0 3.0 written as 5, 4, 3 penalise once only with the first CSO mark earned in a part of the question where they have used 5, 4 or 3	
a1M1	38.2 (30.4 – 46) / 10 total in the range 38.2 +/- 7.8	
a1A1	CAO correct calculation seen or 3.82 and 4 (planks/bins) An answer of 4 with no working is M0. Do not award if any incorrect working seen.	
b1M1	First five numbers placed correctly (the bold numbers) and at least seven numbers put in bins. Condone cumulative totals here only.	
b1A1	First nine numbers placed correctly (bold and underlined) with no repeated or additional values.	
b2A1	CSO – all correct.	
c1M1	Quick sort – pivots, p, selected and first pass gives >p, p, <p. If only choosing 1 pivot per iteration M1 only. Must choose middle item as pivot – any other choice is M0. Bubble sort is M0. If sort ascending this can score a maximum of M1 A1 A0 A0 for fully correct even if then reversed. Condone one additional number/error/omission.	
c1A1	First pass correct and next pivots chosen correctly/consistently for second pass.	
c2A1ft	Second and third passes correct (ft from their first pass and choice of pivots) – next pivots chosen correctly/consistently for fourth pass.	
c3A1	CSO all correct including choice of pivots for the fifth pass (MR) or sixth pass (ML)	
d1M1	Must be using their ‘sorted’ list in decreasing order. Their first six numbers placed correctly (bold numbers) and at least seven numbers put in bins. First-fit increasing is M0.	
d1A1	CSO – all correct.	

Sort ascending
Middle right

											Pivots
5.0	1.8	6.2	2.8	3.0	4.0	3.8	2.4	0.6	0.8	7.8	4.0
1.8	2.8	3.0	3.8	2.4	0.6	0.8	<u>4.0</u>	5.0	6.2	7.8	3.8, 6.2
1.8	2.8	3.0	2.4	0.6	0.8	<u>3.8</u>	<u>4.0</u>	5.0	<u>6.2</u>	7.8	2.4, (5.0, 7.8)
1.8	0.6	0.8	<u>2.4</u>	2.8	3.0	<u>3.8</u>	<u>4.0</u>	<u>5.0</u>	<u>6.2</u>	<u>7.8</u>	0.6, 3.0
<u>0.6</u>	1.8	0.8	<u>2.4</u>	2.8	<u>3.0</u>	<u>3.8</u>	<u>4.0</u>	<u>5.0</u>	<u>6.2</u>	<u>7.8</u>	0.8, (2.8)
0.6	0.8	1.8	2.4	2.8	3.0	3.8	4.0	5.0	6.2	7.8	

Middle left

											Pivots
5.0	1.8	6.2	2.8	3.0	4.0	3.8	2.4	0.6	0.8	7.8	4.0
1.8	2.8	3.0	3.8	2.4	0.6	0.8	<u>4.0</u>	5.0	6.2	7.8	3.8, 6.2
1.8	2.8	3.0	2.4	0.6	0.8	<u>3.8</u>	<u>4.0</u>	5.0	<u>6.2</u>	7.8	3.0, (5.0, 7.8)
1.8	2.8	2.4	0.6	0.8	<u>3.0</u>	<u>3.8</u>	<u>4.0</u>	<u>5.0</u>	<u>6.2</u>	<u>7.8</u>	2.4
1.8	0.6	0.8	<u>2.4</u>	2.8	<u>3.0</u>	<u>3.8</u>	<u>4.0</u>	<u>5.0</u>	<u>6.2</u>	<u>7.8</u>	0.6, (2.8)
<u>0.6</u>	1.8	0.8	<u>2.4</u>	<u>2.8</u>	<u>3.0</u>	<u>3.8</u>	<u>4.0</u>	<u>5.0</u>	<u>6.2</u>	<u>7.8</u>	1.8
0.6	0.8	1.8	2.4	2.8	3.0	3.8	4.0	5.0	6.2	7.8	

Question Number	Scheme	Marks
2.(a)	AB, BC, CF, CE; FG, AD; EH, HI	M1 A1 A1 (3)
(b)	(£)191	B1 (1)
(c)	(BC EF) CF, reject CE, AB, FG; {AD, reject AC}, reject DG, {reject BE and DF}, EH, reject FH, HI, (reject GI FI) (Note BC and EF are already in the tree and may be listed before CF)	M1 A1 A1 (3)
(d)	(£)147	B1 (1)
		8 marks
	Notes for Question 2	
a1M1	First four arcs (AB, BC, CF, CE) correctly chosen, or first five nodes ABCFE chosen in order. If any rejections seen M1 only. If Prim starting at any other node M1 only for the correct first four arcs (not nodes).	
a1A1	First six arcs (AB, BC, CF, CE; FG, AD) correctly chosen, or all nodes in order ABCFEGDHI.	
a2A1	CSO (must be arcs)	
b1B1	CAO	
c1M1	First three arcs (CF, AB, FG) correctly chosen and at least one rejection seen at some point. (Kruskal not Prim.) We do not need to see BC and EF added to the tree.	
c1A1	All arcs in tree selected correctly at correct time. Ignore any reference to BC and EF.	
c2A1	CSO including all rejections correct (GI and FI do not need to be explicitly rejected) and at the right time. Penalise any reference to BC and EF unless correctly added before CF.	
d1B1	CAO	

Question Number	Scheme	Marks
3.		
(a)		
		M1 A1 (ABDC) A1(GFH) A1ft (EJ)
	Shortest route: A – B – C – F – E – J	A1
	Length: 22 (metres)	A1ft
		(6)
(b)		
	$A(BCF)E + F(E)J = 15 + 11 = 26$ $A(BC)F + EJ = 11 + 7 = 18^*$ $A(BCFE)J + EF = 22 + 4 = 26$	M1 A1ft A1
	Arcs AB, BC, CF, EJ will be traversed twice	A1
		(4)
(c)		
	Route: e.g. ABADGHDFHJEJFECFCBCA	B1
	Length: $100 + 18 = 118$	B1ft
		(2)
(d)		
	(Start/finish at) E/J, or (start/finish at) C/J (one pair stated)	M1
	(Start/finish at) E/J, and (start/finish at) C/J (both pairs stated)	A1
	Length: $100 - 3 - 4 + 4 = 97$ (metres)	A1
		(3)
		[15]

Notes for Question 3

In (a) it is important that all values at each node are checked very carefully – the order of the working values must be correct for the corresponding A mark to be awarded e.g. at J the working values must be 24 23 22 in that order (so 24 22 23 is incorrect)

It is also important that the order of labelling is checked carefully – some candidates start with a label of 0 at A (rather than 1) – which is fine. Also the order of labelling must be a strictly increasing sequence – so 1, 2, 3, 3, 4,... will be penalised once (see notes below) but 1, 2, 3, 5, 6,... is fine. Errors in the final values and working values are penalised before errors in the order of labelling

a1M1: A larger value replaced by a smaller value in at least two of the working value boxes at either C or E or F or H or J

a1A1: All values at A, B, D and C correct and working values in the correct order. Condone lack of 0 in As working value

a2A1: All values at G, F and H correct and the working values in the correct order. Penalise order of labelling only once per question (G, F and H must be labelled in that order and G must be labelled after A, B, D and C)

a3A1ft: All values at E and J correct on the follow through and the working values in the correct order. Penalise order of labelling only once per question. To follow through E check that the working values at E follow from the candidate's final values from the feeds into E (which will come from nodes C and F (in the order in which the candidate has labelled them)) and that the final value, and order of labelling, follows through correctly. Repeat this process for J (which will possibly have working values from F, H and E with the order of labelling determined by the candidate's order of labelled at F, H and E)

a4A1: CAO (accept in terms of arcs) (do accept route from J to A)

a5A1ft: ft their final value at J (if 22 stated and 22 is not the final value at J then A0)

If route and length are written on the wrong lines this can still score both marks

b1M1: The correct three pairings of the correct four nodes (A, E, F and J)

b1A1ft: Two rows correct including pairings and totals follow through their final values at E, F and J

b2A1: All three rows correct including pairings and totals

b3A1: Correct repeats (AB, BC, CF, EJ) must be arcs so do not accept ABCF and EJ

c1B1: CAO – must be 20 vertices starting and finishing at A with correct repeats (shown in bold) and visiting every vertex (may be in terms of arcs)

c2B1ft: Length of route correct on the follow through (100 + smallest repeat) but must be from a choice of 3 totals from the correct 3 pairs of vertices

d1M1: One correct pair (E and J or C and J)

d1A1: Both pairs correct – accept as a minimum EJ and CJ without any comment on start/finish

d2A1: CAO (97)

Question Number	Scheme	Marks
4.		M1 A1 A1 A1 A1 (5)
		[5]
	Notes for Question 4	
	Condone lack of, or incorrect, numbered events throughout. ‘Dealt with correctly’ means that the activity starts from the correct event but need not necessarily finish at the correct event, e.g. ‘H dealt with correctly’ requires the correct precedences for this activity, i.e. D and E labelled correctly and leading into the same node and H starting from that node but do not consider the end event. Activity on node is M0	
	If an arc is not labelled, for example, if the arc for activity E is not labelled (but the arc is present) then this will lose the first A mark and the final (CSO) A mark – they can still earn the second A mark on the bod. If two or more arcs are not labelled then mark according to the scheme. Assume that a solid line is an activity which has not been labelled rather than a dummy (even if in the correct place for where a dummy should be). Ignore incorrect or lack of arrows on the activities for the first four marks only	
	If two activities are labelled with the same letter and one is in the correct position for this activity please award the A mark on BOD, but penalise the second incorrectly labelled activity.	
a1M1	Eight activities (labelled on arc), one start and at least two dummies placed	
a1A1	Activities A, B, C, 1 st dummy (including correct arrow), D, and E dealt with correctly	
a2A1	Activities F, G, H and J dealt with correctly	
a3A1	Activities I and K dealt with correctly and both dummies from the end of G to end of F and end of H (including correct arrows)	
a4A1	CSO – all arrows correctly placed for each activity with one finish and exactly three dummies	
	Please check all arcs carefully for arrows – if there are no arrows on any dummies then M1 only. Note that additional (but unnecessary) ‘correct’ dummies that still maintain precedence for the network should only be penalised with the final A mark if earned.	

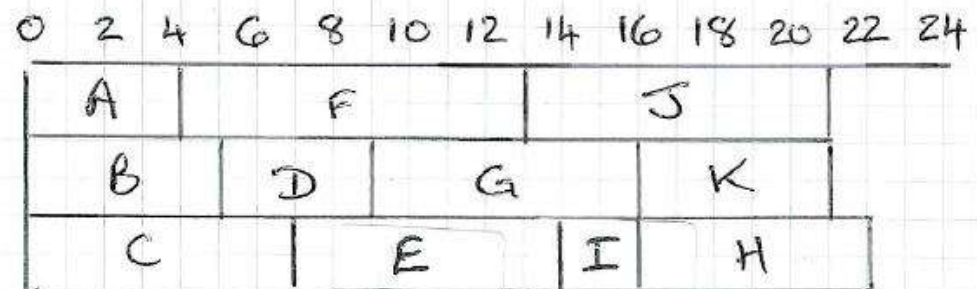
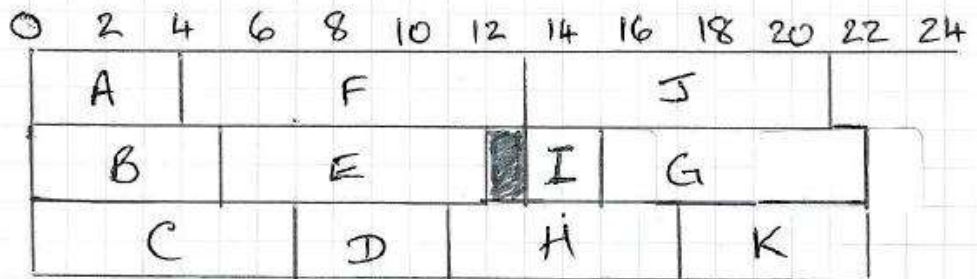
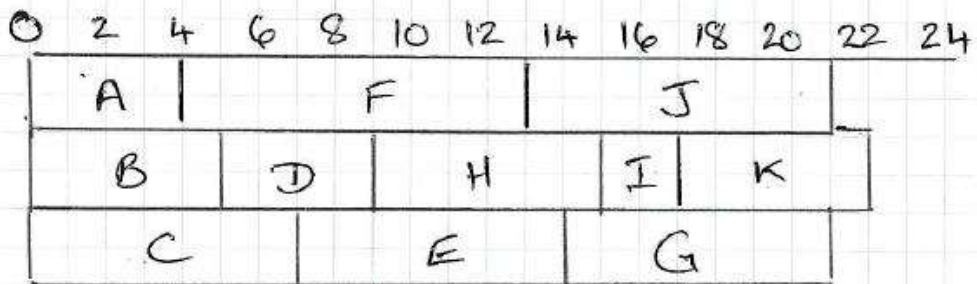
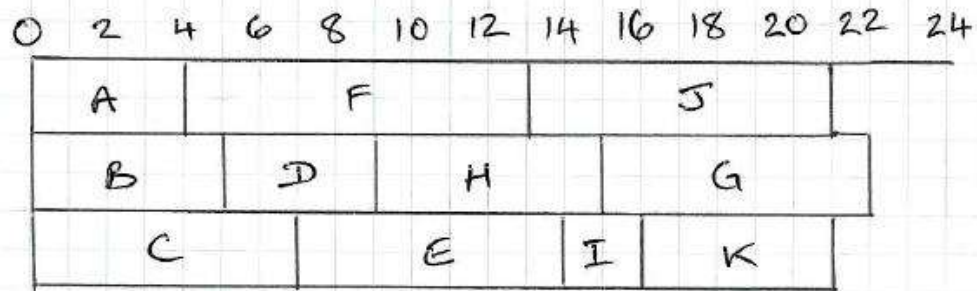
Question Number	Scheme	Marks																				
5. (a)	$3x + 5y \leq 1000$	B1 (1)																				
(b)		B1 B1 B1 dB1 (4)																				
(c)	Objective is to maximise (P =) $x + y$	B1 (1)																				
(d)	$(A =) (30, 60), (B =) \left(76\frac{12}{13}, 153\frac{11}{13}\right) \left(\frac{1000}{13}, \frac{2000}{13}\right),$ $(C =) \left(173\frac{9}{17}, 95\frac{15}{17}\right) \left(\frac{2950}{17}, \frac{1630}{17}\right)$ At A, $P = 90$ At B, $P = 230\frac{10}{13} \left(\frac{3000}{13}\right)$ At C, $P = 269\frac{7}{17} \left(\frac{4580}{17}\right)$ So C is optimal point Testing integer solutions around C, <table><tr><th></th><th>$4y - x \geq 210$</th><th>$3x + 5y \leq 1000$</th><th>(P =) $x + y$</th></tr><tr><td>(173, 95)</td><td>207 (N)</td><td>(994 (Y))</td><td>(268)</td></tr><tr><td>(173, 96)</td><td>211 (Y)</td><td>999 (Y)</td><td>269</td></tr><tr><td>(174, 95)</td><td>206 (N)</td><td>(997 (Y))</td><td>(269)</td></tr><tr><td>(174, 96)</td><td>(210 (Y))</td><td>1002 (N)</td><td>(270)</td></tr></table> $x = 173$ and $y = 96$ is optimal integer solution, so they should make 173 soft toys and 96 craft sets		$4y - x \geq 210$	$3x + 5y \leq 1000$	(P =) $x + y$	(173, 95)	207 (N)	(994 (Y))	(268)	(173, 96)	211 (Y)	999 (Y)	269	(174, 95)	206 (N)	(997 (Y))	(269)	(174, 96)	(210 (Y))	1002 (N)	(270)	dM1 A1 A1 ddM1 A1 M1 A1 (7)
	$4y - x \geq 210$	$3x + 5y \leq 1000$	(P =) $x + y$																			
(173, 95)	207 (N)	(994 (Y))	(268)																			
(173, 96)	211 (Y)	999 (Y)	269																			
(174, 95)	206 (N)	(997 (Y))	(269)																			
(174, 96)	(210 (Y))	1002 (N)	(270)																			

		(13)
	Notes for Question 5 B1: CAO	
(a)		
(b)	All lines should be within half a small square of the stated points and must be long enough to fully define the feasible region (if necessary the line should be extended to the stated points) 1B1: $3x + 5y = 1000$ drawn CAO (if correct passes through (0, 200) and (300, 20)) 2B1: $y = 2x$ drawn CAO (if correct passes through (0, 0) and (100, 200)) 3B1: $4y - x = 210$ drawn CAO (if correct passes through (30, 60) and (150, 90))	
(c)	4dB1: R labelled with correct shading, either consistently outside the region or inside the region (dependent on all three lines correct)	
(d)	B1: maximise (accept max but not maximum) and (P=) $x + y$ 1dM1: Attempt to solve two pairs of the above equations simultaneously (may be using calculator, so no working may be seen, but do not accept 3 pairs of coordinates with integer values which have been read off the graph. The correct three pairs of coordinates implies M1A1A1) (dependent on scoring at least 2/4 in (b)) 1A1: At least 1 correct R vertex found awrt 1dp (76.9, 153.8) (173.5, 95.9) 2A1: All correct R vertices but must be exact values ($A =$) (30, 60) $(B =) \left(76\frac{12}{13}, 153\frac{11}{13} \right) \left(\frac{1000}{13}, \frac{2000}{13} \right) (C =) \left(173\frac{9}{17}, 95\frac{15}{17} \right) \left(\frac{2950}{17}, \frac{1630}{17} \right)$ 2ddM1: Attempt to evaluate at least 2 points in $x + y$ (may be using calculator, so no working may be seen – the correct three values implies M1A1) (dependent on previous M mark)(condone use of integer coordinates here) 3A1: The 2 correct P values for B and C either exact or awrt 1 dp (230.8, 269.4) $(230\frac{10}{13}, 269\frac{7}{17})$ 3M1: Attempt to test at least two integer points around their “C” in both inequalities or one failed inequality. (Accept a clear indication that the point has been tested against the inequalities such as a tick or cross without explicitly stating the numerical values) 4A1: CAO – must be in context, so do not accept $x = 173$ and $y = 96$ or (173, 96)	

Question Number	Scheme	Marks
6(a)		M1 A1 M1 A1 (4)
(b)	21 (hours)	B1 (1)
(c)	$\frac{4+5+7+4+7+9+7+6+2+5+8}{21} = \frac{64}{21} \approx 3.048$ so at least 4 workers required	M1 A1 (2)
(d)		M1 A1 A1 A1 (4)
(e)	e.g. see alternatives below	M1 A1ft A1 (3)
		14 marks

	Notes for Question 6																																																	
a1M1	All top boxes complete, values generally increasing in the direction of the arrows ('left to right'), condone one rogue value which is a number in a top box greater than the subsequent value																																																	
a1A1	CAO (top boxes)																																																	
a2M1	All bottom boxes complete, values generally decreasing in the opposite direction of the arrows ('right to left'), condone one rogue value which is a number in a bottom box greater than the previous value. Condone missing 0 and/or their 21 (at the end event) for the M mark only																																																	
a2A1	CAO (bottom boxes)																																																	
b1B1	CAO																																																	
c1M1	64 (+/-9)/"21" a calculation using the sum of the activities (accept a total in the range 55 – 73) divided by their finish time or sight of awrt 3.05 (accept 3.04 truncated)																																																	
c1A1	CAO – 4 note an answer of 4 with no working is M0																																																	
d1M1	Cascade Chart not a schedule. At least 7 activities including at least 4 floats																																																	
d1A1	Critical activities (AFJ) correct and at least 3 non-critical activities correct																																																	
d2A1	At least 6 non-critical activities correct																																																	
d3A1	CAO All 11 activities present (just once). No errors.																																																	
e1M1	Schedule not a cascade (Gantt) chart. 3 'workers' used at most and at least 8 activities placed.																																																	
e1A1ft	All 11 activities present (just once) with a finish time of 22 (ft their end time + 1). Condone at most two errors. An activity can give rise to at most three errors; one on duration, one on time interval and only one on IPA																																																	
e2A1	3 workers. All 11 activities present (just once). No errors. The table shows the possible time intervals to allow the project to be completed by 3 workers in 22 hours <table><tr><th>Activity</th><th>Time Interval</th><th>IPA</th><th>Duration</th></tr><tr><td>A</td><td>0 to 5</td><td>-</td><td>4</td></tr><tr><td>B</td><td>0 to 6</td><td>-</td><td>5</td></tr><tr><td>C</td><td>0 to 8</td><td>-</td><td>7</td></tr><tr><td>D</td><td>5 to 15</td><td>B</td><td>4</td></tr><tr><td>E</td><td>4 to 15</td><td>A</td><td>7</td></tr><tr><td>F</td><td>4 to 14</td><td>A</td><td>9</td></tr><tr><td>G</td><td>7 to 22</td><td>C</td><td>7</td></tr><tr><td>H</td><td>7 to 22</td><td>C</td><td>6</td></tr><tr><td>I</td><td>13 to 17</td><td>D, E, F</td><td>2</td></tr><tr><td>J</td><td>13 to 22</td><td>F</td><td>8</td></tr><tr><td>K</td><td>15 to 22</td><td>I</td><td>5</td></tr></table>	Activity	Time Interval	IPA	Duration	A	0 to 5	-	4	B	0 to 6	-	5	C	0 to 8	-	7	D	5 to 15	B	4	E	4 to 15	A	7	F	4 to 14	A	9	G	7 to 22	C	7	H	7 to 22	C	6	I	13 to 17	D, E, F	2	J	13 to 22	F	8	K	15 to 22	I	5	
Activity	Time Interval	IPA	Duration																																															
A	0 to 5	-	4																																															
B	0 to 6	-	5																																															
C	0 to 8	-	7																																															
D	5 to 15	B	4																																															
E	4 to 15	A	7																																															
F	4 to 14	A	9																																															
G	7 to 22	C	7																																															
H	7 to 22	C	6																																															
I	13 to 17	D, E, F	2																																															
J	13 to 22	F	8																																															
K	15 to 22	I	5																																															

Possible alternative schedules for (e). This is not exhaustive.



Note: it is possible to swap J with I and K (I starts at 14) in the top diagram (and in the main scheme), J with G in the second diagram, J with I and G (J starts at 13) in the third diagram and J with I and H (I starts at 14) in the bottom diagram.

7.		
(a)	Maximise ($P = $) $0.75x + 1.2y + 1.45z$	B1
	Subject to $x + z < 200$	B1
	$5y \geq 2x$	M1 A1
	$\frac{3}{4}(x + y + z) \geq y \quad \Rightarrow \quad 3x + 3z \geq y$ $(x, y, z \geq 0)$	M1 A1 (6)
(b)	Use $x = 100, z = 25$ to obtain two values of y , leading to $40 \leq y \leq 375$ Minimum profit (£)159.25, Maximum profit (£)561.25	M1 A1ft A1 (3)
		9 marks
	Notes for Question 7	
a1B1	CAO objective function (oe) + maximise (accept max but not maximum) Do not ISW if converted to integer coefficients without a correct multiple of P.	
a2B1	CAO ($x + z < 200$)	
a1M1	$5y \square 2x$ where $\square$ is any inequality (accept $2.5y \square x$ o.e. for M1 only) or special case $2y \geq 5x$ (must be integers)	
a1A1	CAO ($5y \geq 2x$)	
a2M1	$\frac{3}{4}(x + y + z) \square y$ where $\square$ is any inequality If they use 75% only award this mark when this is converted to a fraction or decimal (which may be implied by the correct fully simplified inequality)	
a2A1	CAO ($3x + 3z \geq y$) (or equivalent rearrangement, but must be fully simplified)	
b1M1	Obtaining two values of y (by substituting $x = 100$ and $z = 25$ into their inequalities but not $y \geq 0$)	
b1A1ft	Correct maximum and minimum values for y (ft y for the special case $2y \geq 5x$ only; accept if $y \geq 2.5x$ seen in (a)) either as inequalities or stated values (If they have $2y \geq 5x$ their minimum value is 250)	
b2A1	CAO on minimum and maximum profit (The correct minimum and maximum values with no incorrect working seen implies M1 A1 A1)	

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Pearson Edexcel International Advanced Level

Tuesday 20 January 2026

Afternoon (Time: 1 hour 30 minutes)

Paper

reference

WDM11/01

Mathematics

**International Advanced Subsidiary/Advanced Level
Decision Mathematics D1**

You must have:

Decision Mathematics Answer Book (enclosed), calculator

**Candidates may use any calculator allowed by Pearson regulations.
Calculators must not have the facility for symbolic algebra manipulation,
differentiation and integration, or have retrievable mathematical formulae
stored in them.**

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B). Coloured pencils and highlighter pens must not be used.
- **Fill in the boxes** at the top of the answer book with your name, centre number and candidate number.
- Do not return the question paper with the answer book.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the D1 answer book provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- There are 8 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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P 7 8 9 8 7 A


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Write your answers in the D1 answer book for this paper.

1. In the following list, eleven sports are identified by their initial letter

(V) Volleyball

(H) Handball

(W) Wheelchair basketball

(B) Baseball

(R) Rugby

(G) Golf

(C) Cricket

(P) Paratriathlon

(T) Tennis

(D) Diving

(S) Squash

(a) Explain why a binary search cannot be performed on this list in its current form.

(1)

(b) Write the list in an appropriate form and show how a binary search is used to try to locate (F) Football. You must make your choice of pivots clear.

(4)

(Total for Question 1 is 5 marks)



2.

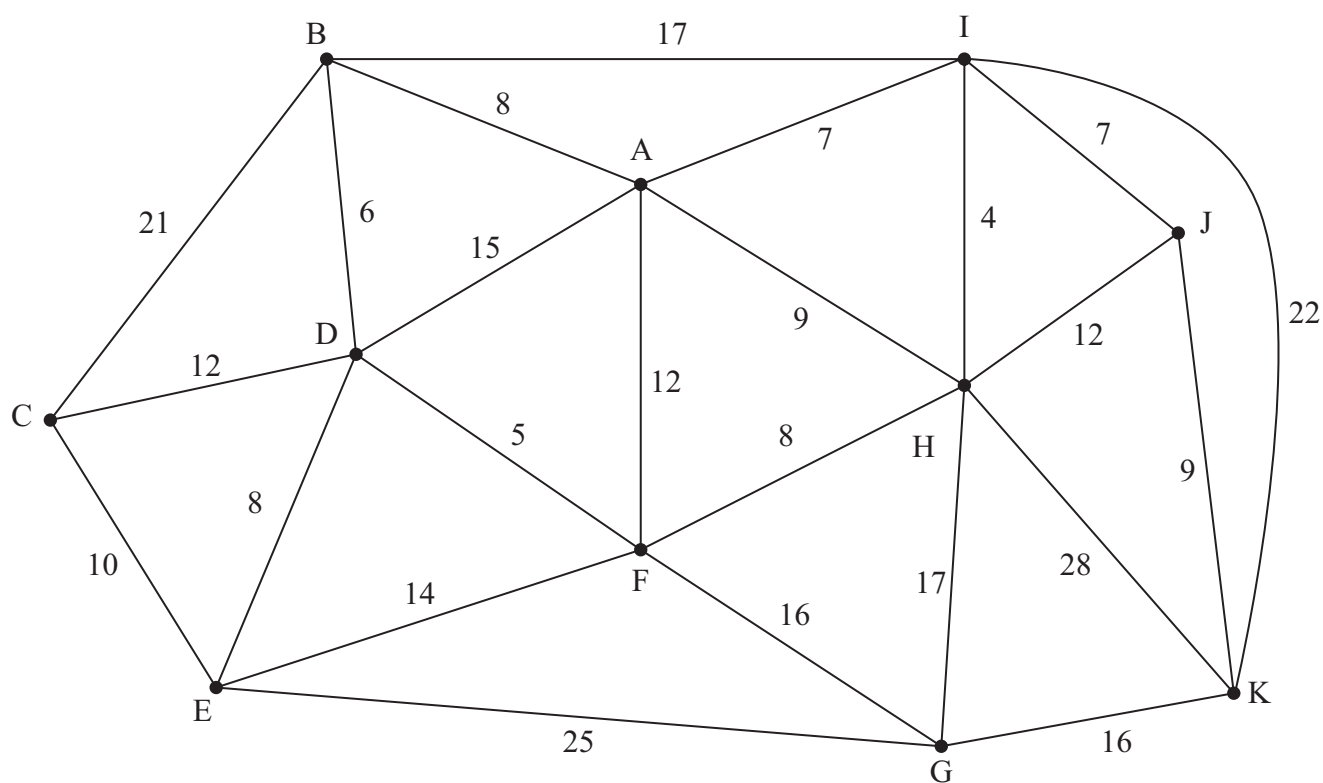


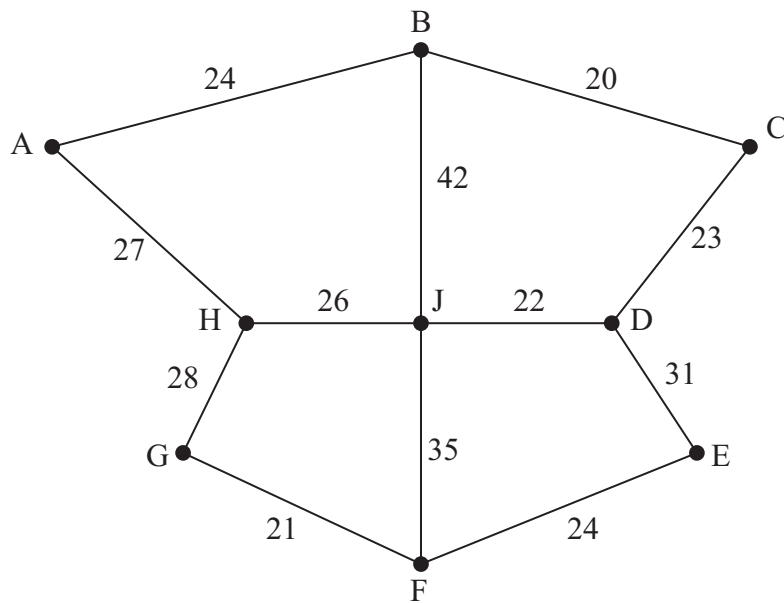
Figure 1

Figure 1 shows a network of paths between eleven viewing points in a bird sanctuary. The number on each arc represents the time taken, in minutes, to walk between the viewing points.

Use Dijkstra's algorithm to determine the quickest route from C to K. You should state the route and the quickest time.

(Total for Question 2 is 6 marks)

3.



(Total weight 323 metres)

Figure 2

Figure 2 represents a network connecting nine locations. The number on each arc is the distance in metres between the corresponding locations.

- (i) (a) Explain how Kruskal's algorithm can be adapted to obtain a spanning tree of least weight that contains a specific arc. (1)

Using the adaptation of Kruskal's algorithm from part (i)(a) on the network in Figure 2,

- (b) find the spanning tree of least weight **that includes arc BJ**.
You must show your working and clearly state the order in which arcs are added. (3)
- (c) State the weight of the spanning tree found in part (i)(b). (1)

- (ii) An engineer needs to inspect the network in Figure 2. Her route must start and finish at A. She must travel along each arc at least once, minimising the length of her route.
- (a) Determine the length of the engineer's route. You must make your method clear and state the arcs which need to be repeated. (5)

On another day the engineer decides to start her route at F and end at J. She must travel along each arc at least once, minimising the length of her route.

- (b) Determine how much shorter this route is than the route obtained in part (ii)(a).
You must make your working clear. (3)

(Total for Question 3 is 13 marks)

4. The following list of eleven **distinct integers** is to be sorted into ascending order.

44 35 73 x 24 58 32 21 61 54 31

The first two passes of bubble sort are

35 44 x 24 58 32 21 61 54 31 73

35 44 24 x 32 21 58 54 31 61 73

(a) Explain why x must satisfy the inequality $45 \leq x \leq 57$

(2)

(b) Carry out one more pass of bubble sort, showing the result at the end of the pass.

(2)

Given that

- when the numbers are placed in bins of size 120, the lower bound for the number of bins required is five
- when the first-fit decreasing algorithm is used to place the numbers in bins of size 160, x is placed in the second bin, which also contains 54

(c) determine the value of x . You must make your reasoning clear.

(3)

(Total for Question 4 is 7 marks)

5. A carpenter produces three sizes of table, small, medium and large.

The information below shows the quantity of wood required for each size of table, the production time, the profit on each table and the totals available.

	Quantity of wood required	Production time	Profit
Small	1.2 m ²	4 hours 20 minutes	£275
Medium	2.5 m ²	7 hours 30 minutes	£425
Large	4.0 m ²	9 hours	£650
Total available	60 m ²	200 hours	

The tables produced should meet the following conditions

- at least 40% of the tables must be small
- there must be at least twice as many small tables as medium tables
- no more than 30% of the tables must be large

The carpenter wishes to maximise the profit from the sale of the tables.

Let x be the number of small tables, y be the number of medium tables and z be the number of large tables produced.

Formulate this as a linear programming problem. You should clearly state the objective function and give the constraints as simplified inequalities with integer coefficients.

(Total for Question 5 is 8 marks)



6.

	A	B	C	D	E	F	G	H
A	-	24	19	28	25	32	29	31
B	24	-	22	31	25	23	37	41
C	19	22	-	18	21	41	31	35
D	28	31	18	-	24	21	27	26
E	25	25	21	24	-	17	31	25
F	32	23	41	21	17	-	26	31
G	29	37	31	27	31	26	-	24
H	31	41	35	26	25	31	24	-

The table shows the least distances, in km, between eight towns. Imani wants to visit all eight towns. She needs to find a route which minimises the distance travelled, starting and finishing at A.

- (a) Show that there are two nearest neighbour routes starting at A. You must make your method clear and state the routes and their lengths. (4)
- (b) State, giving a reason, which route from part (a) gives the better upper bound for the length of Imani's route. (1)
- (c) By deleting A and all of its arcs, use Prim's algorithm, starting at B, to obtain a lower bound for the length of Imani's route. You must show your working. (4)
- A second lower bound of 172 km is obtained by deleting H.
- (d) Write down the smallest interval that must contain the optimal length for Imani's route. (1)

(Total for Question 6 is 10 marks)

7.

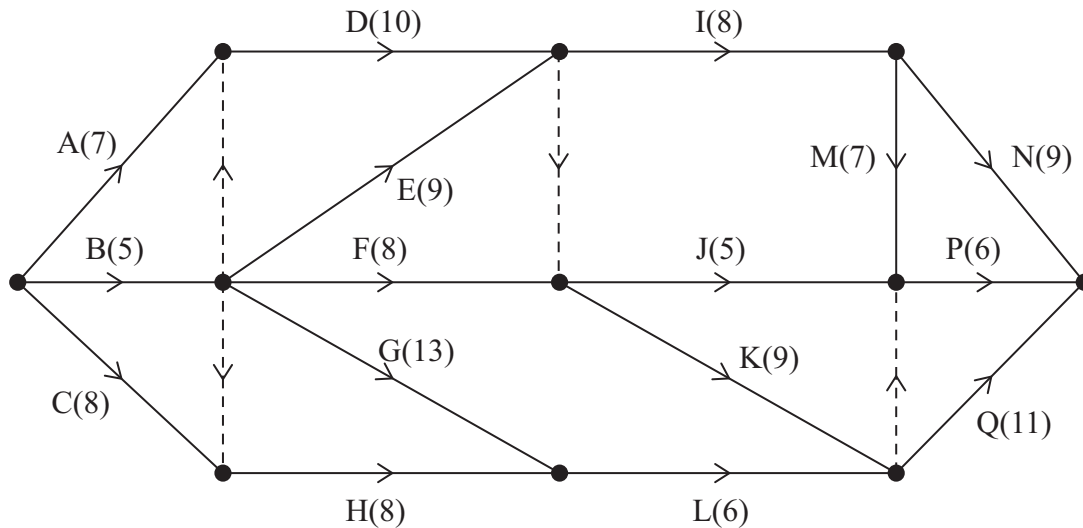


Figure 3

A project is modelled by the activity network shown in Figure 3. The activities are represented by the arcs. The number in brackets on each arc gives the time, in days, to complete the activity. Each activity requires exactly one worker. The project is to be completed in the shortest possible time.

- (a) Complete the table in the answer book to show the immediately preceding activities for the network. (3)
- (b) Complete the diagram in the answer book to show the early event times and the late event times. (4)
- (c) State the critical activities. (1)
- (d) Calculate a lower bound for the minimum number of workers required to complete the project in the minimum time. (2)
- (e) On the grid in the answer book, draw a schedule to show how the activities can be completed in the minimum time, using the minimum number of workers. (4)

(Total for Question 7 is 14 marks)

8. A linear programming problem is formulated as follows

$$\begin{array}{ll}\text{Maximise} & P = 6x + 5y \\ \text{Subject to} & y \leq 3x + 10 \\ & x + 4y \leq 162 \\ & 5x + 2y \leq 200 \\ & y \geq 15 \\ & x \geq 0\end{array}$$

- (a) Complete the graph in the answer book to show these inequalities, shading those regions which are **not** included in the feasible region. Label the feasible region R (3)
- (b) Use the vertex method to determine the exact coordinates of the optimal vertex. (4)
- (c) The practical solution to this problem requires integer solutions. Determine the optimal solution and state the value of the objective function. (3)

The objective function is now changed to

$$P = kx + y$$

where k is a constant.

- (d) Determine the range of values for k for which the optimal vertex is unchanged. (2)

(Total for Question 8 is 12 marks)

TOTAL FOR PAPER IS 75 MARKS

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Please check the examination details below before entering your candidate information

Candidate surname

Other names

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Candidate Number

Pearson Edexcel International Advanced Level

Tuesday 20 January 2026

Afternoon (Time: 1 hour 30 minutes)

Paper
reference

WDM11/01

Mathematics

**International Advanced Subsidiary/Advanced Level
Decision Mathematics D1**

Answer Book

Do not return the question paper with the answer book.

Total Marks

Turn over ►

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Question 1 continued

(Total for Question 1 is 5 marks)

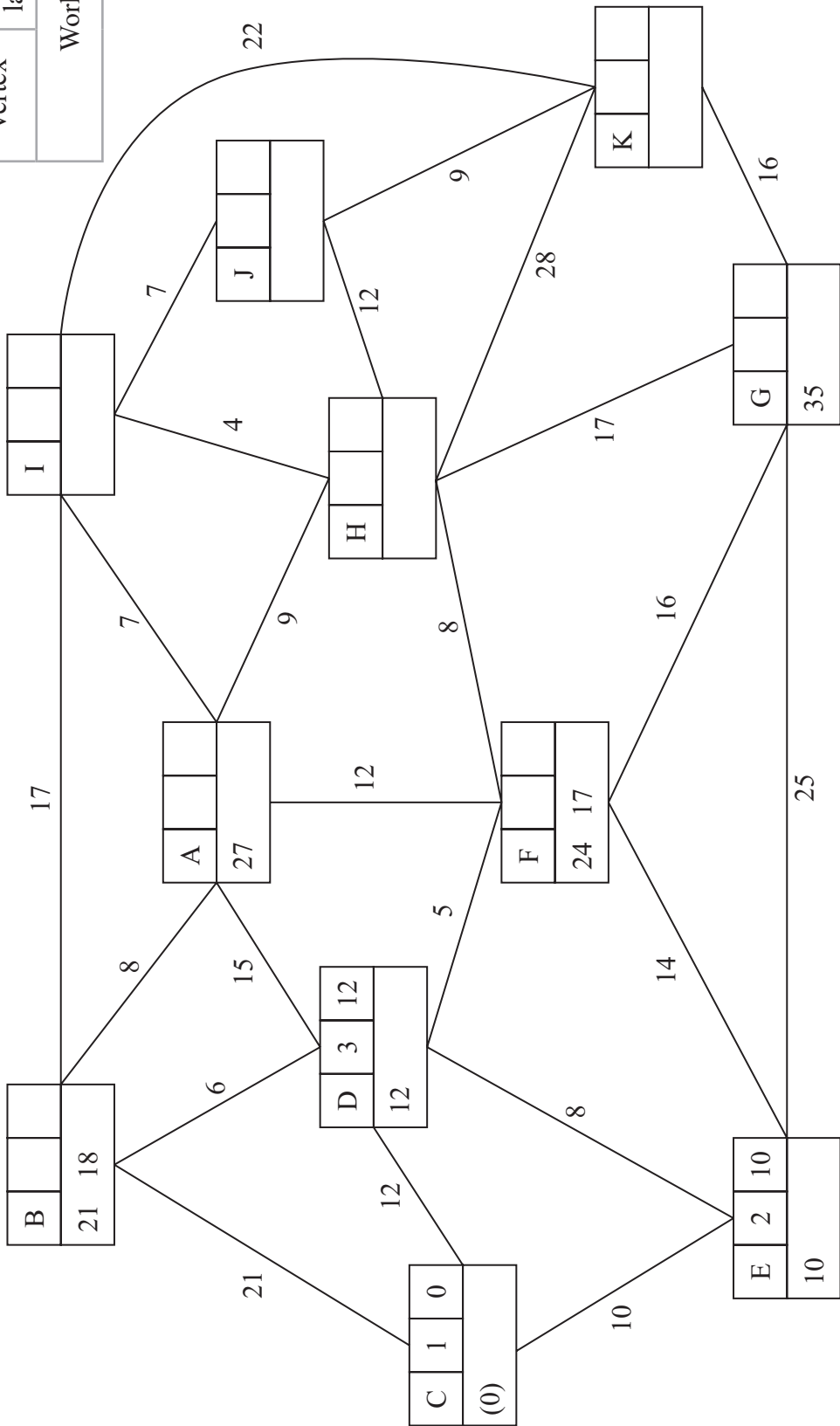




2.

Key:

Vertex	Order of labelling	Final value
Working values		



Quickest route from C to K:

Quickest time from C to K:

(Total for Question 2 is 6 marks)

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Question 3 continued

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Question 3 continued

(Total for Question 3 is 13 marks)



4.

44	35	73	x	24	58	32	21	61	54	31
35	44	x	24	58	32	21	61	54	31	73
35	44	24	x	32	21	58	54	31	61	73



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5.

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Question 5 continued

(Total for Question 5 is 8 marks)



6.

	A	B	C	D	E	F	G	H
A	-	24	19	28	25	32	29	31
B	24	-	22	31	25	23	37	41
C	19	22	-	18	21	41	31	35
D	28	31	18	-	24	21	27	26
E	25	25	21	24	-	17	31	25
F	32	23	41	21	17	-	26	31
G	29	37	31	27	31	26	-	24
H	31	41	35	26	25	31	24	-

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Question 6 continued

	A	B	C	D	E	F	G	H
A	-	24	19	28	25	32	29	31
B	24	-	22	31	25	23	37	41
C	19	22	-	18	21	41	31	35
D	28	31	18	-	24	21	27	26
E	25	25	21	24	-	17	31	25
F	32	23	41	21	17	-	26	31
G	29	37	31	27	31	26	-	24
H	31	41	35	26	25	31	24	-

(Total for Question 6 is 10 marks)



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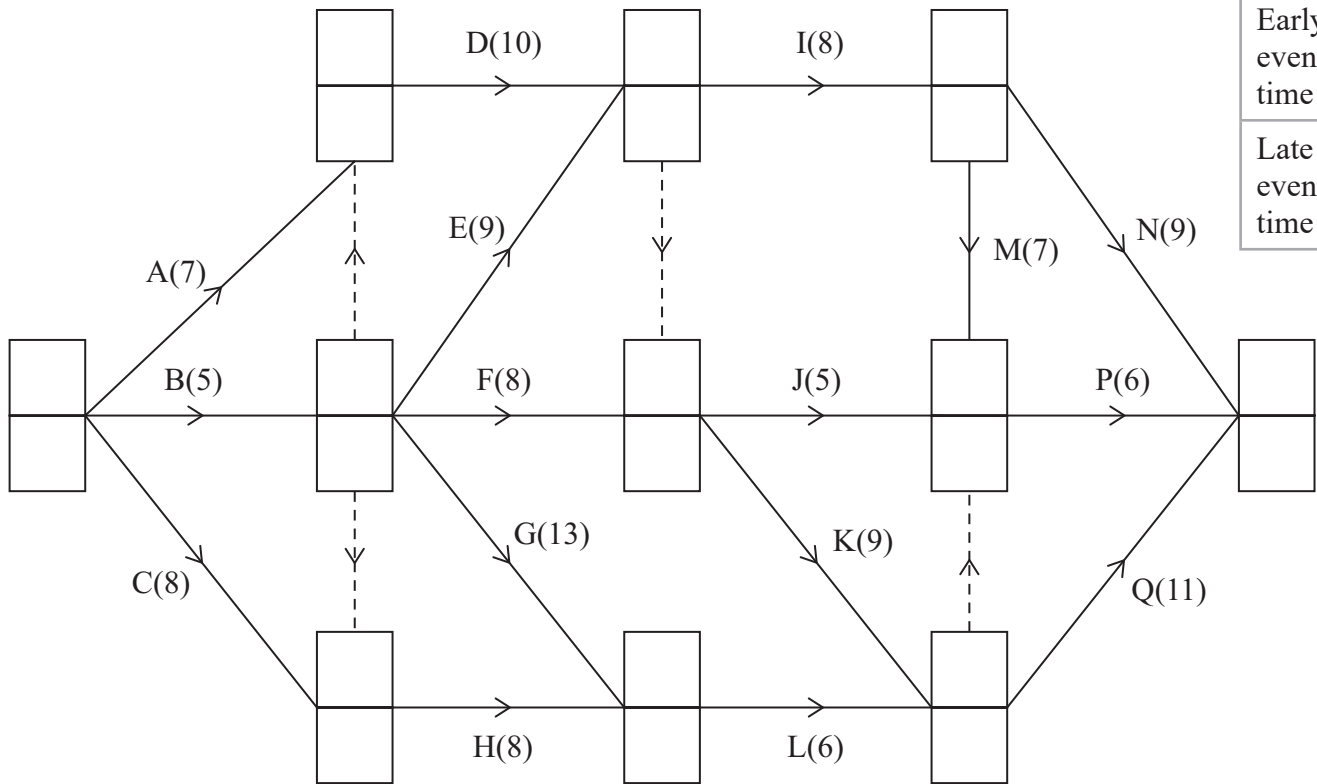
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Early
event
time

Late
event
time



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Question 8 continued

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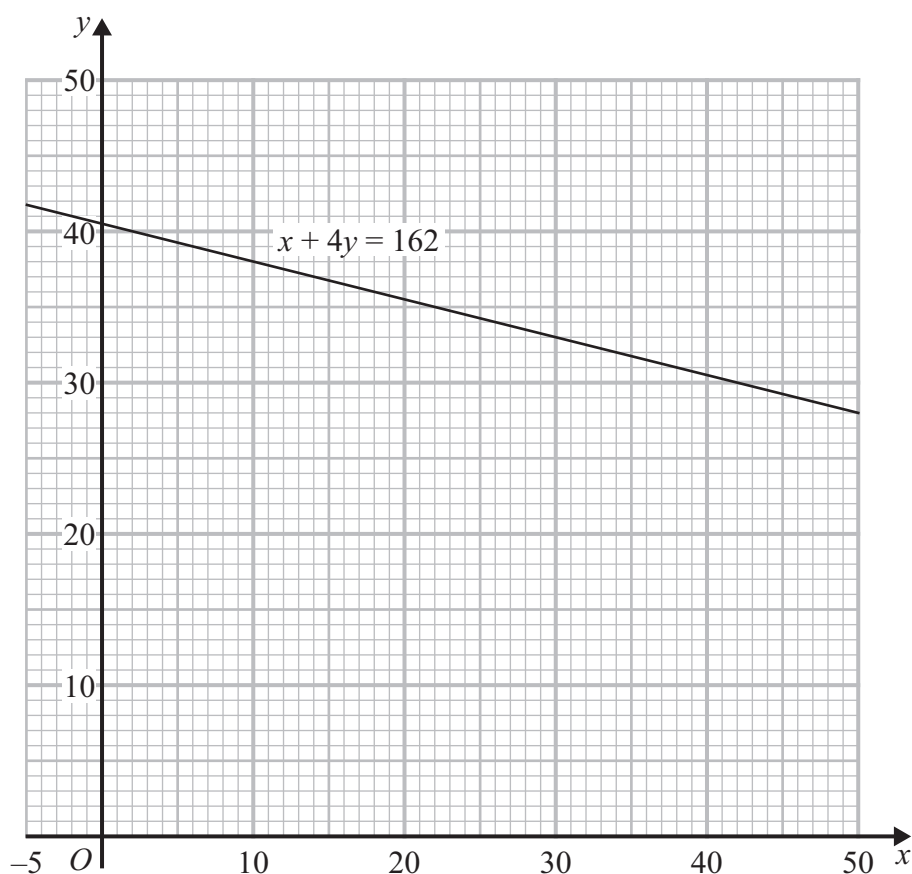
Question 8 continued

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Only use this copy of the axes if you need to redraw your diagram.



Spare copy

(Total for Question 8 is 12 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (Final)

January 2026

Pearson Edexcel International Advanced Level In Decision
Mathematics D1

WDM11/01

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January 2026

Question Paper Log Number P78987A

Publication Code WDM11_01_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:

'M' marks

These are marks given for a correct method or an attempt at a correct method. In Mechanics they are usually awarded for the application of some mechanical principle to produce an equation.

e.g. resolving in a particular direction, taking moments about a point, applying a suvat equation, applying the conservation of momentum principle etc.

The following criteria are usually applied to the equation.

To earn the M mark, the equation

- (i) should have the correct number of terms
- (ii) be dimensionally correct i.e. all the terms need to be dimensionally correct

e.g. in a moments equation, every term must be a 'force x distance' term or 'mass x distance', if we allow them to cancel 'g' s.

For a resolution, all terms that need to be resolved (multiplied by sin or cos) must be resolved to earn the M mark.

M marks are sometimes dependent (DM) on previous M marks having been earned.

e.g. when two simultaneous equations have been set up by, for example, resolving in two directions and there is then an M mark for solving the equations to find a particular quantity – this M mark is often dependent on the two previous M marks having been earned.

'A' marks

These are dependent accuracy (or sometimes answer) marks and can only be awarded if the previous M mark has been earned. E.g. M0 A1 is impossible.

'B' marks

These are independent accuracy marks where there is no method (e.g. often given for a comment or for a graph)

A few of the A and B marks may be f.t. – follow through – marks.

3. General Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
 - ft – follow through
 - the symbol $\frac{\square}{\square}$ will be used for correct ft
 - cao – correct answer only
 - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
 - isw – ignore subsequent working
 - awrt – answers which round to
 - SC: special case
 - oe – or equivalent (and appropriate)
 - dep – dependent
 - indep – independent
 - dp decimal places
 - sf significant figures
 - * The answer is printed on the paper
 - The second mark is dependent on gaining the first mark
4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.
 5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.
 6. If a candidate makes more than one attempt at any question:
 - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
 7. Ignore wrong working or incorrect statements following a correct answer.

Question Number	Scheme				Marks
1.(a)	The list is not in (alphabetical) order				B1 (1)
(b)	B	B			M1 A1 A1ft
	C	C			
	D	D			
	G	G	G	G	
	H	H	H		
	P				
	R				
	S				
	T				
	V				
	W				
	Football is not in the list				A1 (4)
					5 marks
	Notes for Question 1				
a1B1	CAO - Accept alternatives such as “the list is not in ascending/descending order” or “The list is not ordered”, give BOD here.				
b1M1	Orders list alphabetically (condone one slip) and correct choice of pivot May be implied by selecting ‘6’ or ‘P’ or sight of $\frac{11+1}{2}$				
b1A1	Discards P and above (or equivalent e.g. 6-11 discarded) and correctly chooses second pivot – if pivot not discarded then A0				
b2A1ft	Discards their second pivot and below, if pivot chosen correctly for their list following their first discard, and correctly chooses third pivot – if pivot not discarded then A0. Must be discarding the correct ‘half’ of the list to locate F.				
b3A1	CSO discards H and compares G with F concluding not in list				
Note: If they omit one item or add one item (e.g. F) they can score M1A0A0A0.					
Note: If they refer to the position number throughout for a correctly ordered list this is acceptable and all marks are available.					

Question Number	Scheme	Marks
2.(a)		M1 A1 (EDFB) A1 (HAIG) A1ft (JK)
	Quickest route from C to K is CDFHIJK	A1
	Quickest time is 45 (minutes)	A1ft
		6 Marks
	Notes for Question 2	
	In (a) it is important that all values at each node are checked very carefully – the order of the working values must be correct for the corresponding A mark to be awarded e.g. at F the working values must be 24 17 in that order (so 17 24 is incorrect) It is also important that the order of labelling is checked carefully. The order of labelling must be a strictly increasing sequence – so 1, 2, 3, 3, 4, ... will be penalised once (see notes below) but 1, 2, 3, 5, 6, ... is fine. Errors in the final values and working values are penalised before errors in the order of labelling	
a1M1	A larger value replaced by a smaller value at least twice in the working values at either A, G, I, J, K	
a1A1	All values at E, D, F and B correct and the working values in the correct order	
a2A1	All values at H, A, I and G correct and the working values in the correct order	
a3A1ft	All values in J and K correct on the follow through and the working values in the correct order. To follow through J check that the working values at J follow from the candidate's final values for the nodes that are directly attached to J (which are H and I (and K)). For example, if correct then the order of labelling of nodes H and I are 6 and 8 respectively so the working values at J should come from H and I in that order. The first working value at J should be their 37 (the Final value at H) + 12 (the weight of the arc HJ), the second working value at J should be their 29 (the Final value at I) + 7 (the weight of the arc IJ). Repeat the process for K (which will have working values from H, I, G and J with the order of these nodes determined by the candidate's order of labelling at H, I, G and J)	
a4A1	CAO	
a5A1ft	Follow through their final value at K only – if answer is 45 but the final value at K is not 45 then A0 (condone lack of minutes)	

Question Number	Scheme	Marks
3(i) (a)	Start by adding the required arc and then continue (with Kruskal's algorithm until tree is completed)	B1 (1)
(b)	BJ add BC add FG add DJ add CD reject {AB add} either order {EF add} HJ add AH reject GH add (DE FJ reject)	M1 A1 A1 (3)
(c)	207 (metres)	B1 (1)
(ii)(a)	Consider all pairings of B, D, F and H	M1
	BD + FH $43 + 49 = 92$ BF + DH $77 + 48 = 125$ BH + DF $51 + 55 = 106$	A1 A1
	Length of route = $323 + 92 = 415$ (metres)	A1
	Repeat BC CD FG GH	A1 (5)
(b)	Must now consider B, D, H and J BJ + DH $42 + 48 = 90$ BD + HJ $26 + 43 = 69$ BH + DJ $51 + 22 = 73$	M1 A1
	Difference in length = $92 - 69 = 23$ (metres)	A1 (3)
		13 Marks
	Notes for Question 3	
(i)aB1	CAO. We need both elements to be mentioned i.e. selecting the (specific) arc first AND continuing to select arcs (by Kruskal's)	
bM1	First 4 arcs (BJ to DJ) added in the correct order and at least one rejection seen	
b1A1	Next 4 arcs (CD to HJ) dealt with correctly in the correct order	
b2A1	CSO all arcs added/rejected in the correct order (DE and FJ do not need to be seen)	
cB1	CAO	
(ii)aM1	The correct three pairings of the correct four nodes (B, D, F and H)	
a1A1	Two rows correct including pairings and totals	
a2A1	All three rows correct including pairings and totals	
a3A1	CAO but must have three pairings of the correct nodes	
a4A1	CAO must be arcs so BCD and FGH is A0	
(ii)bM1	The correct three pairings of the correct four nodes (B, D, H and J)	
b1A1	All three rows correct including pairings and totals	
b2A1	CAO	

Question Number	Scheme	Marks
4 (a)	(In second pass) 44 compared with x and does not swap x compared with 58 and does not swap	B1 B1 (2)
(b)	35 24 44 32 21 x 54 31 58 61 73	M1 A1 (2)
(c)	$21 + 24 + 31 + 32 + 35 + 44 + 54 + 58 + 61 + 73 + x > 480$ $x > 47$ Bin 1: 73 61 24 Bin 2: 58 54 x $x + 58 + 54 \leq 160$ $x \leq 48$ $x = 48$	M1 M1 A1 (3)
		7 marks
	Notes for Question 4	
a1B1	Compares 44 with x and states does not change or equivalent. Whilst a reference to the second pass needn't be stated, incorrect statements should be penalised, e.g. " x is compared to 44 in the first pass... " is B0.	
a2B1	Compares x with 58 and states does not change or equivalent.	
bM1	Eleven terms including the x present, works L to R with 44 swapped with 24, and 58 in correct position.	
bA1	CAO	
c1M1	Considers sum of all values >480 and obtains inequality for x or equivalent work , such as setting up lower bound calculation of total weights e.g. $\frac{433 + x}{120} > 4 \text{ leading to } x > 47 \text{ or } x \geq 48 \text{ or } 48 \leq x \leq 57.$	
c2M1	Considers bin 2 and obtains inequality for x or equivalent .	
cA1	CSO	

Question Number	Scheme	
5.	$1.2x + 2.5y + 4z \leq 60 \Rightarrow 12x + 25y + 40z \leq 600$ $4\frac{1}{3}x + 7\frac{1}{2}y + 9z \leq 200 \Rightarrow 26x + 45y + 54z \leq 1200$ $x \geq \frac{40}{100}(x + y + z) \Rightarrow 3x \geq 2y + 2z$ $x \geq 2y$ $z \leq \frac{30}{100}(x + y + z) \Rightarrow 7z \leq 3x + 3y$ $x, y, z \geq 0$ Maximise ($P =$) $275x + 425y + 650z$	M1 A1 A1 M1 A1 A1 B1B1
		7 marks
Notes for Question 5		
a1M1	Attempts constraints for quantity of wood and production time (do not need to be simplified) Look for $1.2x + 2.5y + 4z \bullet 60$ and $4\frac{1}{3}x + 7\frac{1}{2}y + 9z \bullet 200$ where $\bullet$ is any inequality or equals. Condone e.g. 4.33 or 4.2 instead of $4\frac{1}{3}$ for the M mark	
a1A1	CAO One of these constraints fully simplified	
a2A1	CAO Both constraints fully simplified	
a2M1	Attempts at least two other non-trivial constraints (any inequality or equals)	
a3A1	Two other non-trivial constraints correct – fully simplified with integer coefficients	
a4A1	All other non-trivial constraints correct – fully simplified with integer coefficients – and trivial constraints stated	
a1B1	Objective function correct	
a2B1	Maximise stated and objective function correct Accept e.g. ' $P_{\max} = \dots$ ' or 'Max' but not 'Maximum P='.	

Question Number	Scheme	Marks
6.(a)	ACDFEBGHA length 192 ACDFEHGBA length 185	M1 A1 A1 A1
		(4)
(b)	ACDFEHGBA 185 as this is the shorter length.	B1ft
		(1)
(c)	BC CD DF FE EH HG or BC CD CE FE EH HG Length 127 (accept $22 + 18 + 21 + 17 + 25 + 24$) Adds AB AC $127 + 19 + 24 = 170$	M1 A1 dM1 A1
		(4)
(d)	$172 \leq d \leq 185$	B1ft
		(1)
		10 marks
Notes for Question 6		
a1M1	Nearest Neighbour – first four arcs correctly chosen in order (AC, CD, DF, FE ...) or first five nodes {A, C, D, F, E, ... } correctly chosen in order. Order of nodes may be seen at the top of a matrix/table {1, -, 2, 3, 5, 4, -, - }.	
a1A1	One NN route correct, either listed as arcs or ACDFEBGHA or ACDFEHGBA	
a2A1	Both NN routes correct, either listed as arcs or ACDFEBGHA and ACDFEHGBA	
a3A1	Both lengths correct – must be clearly linked to the correct route	
b1B1ft	CAO Route and reason. Must have found two routes with distinct lengths.	
c1M1	Prim starting at B to find RMST – first four arcs correct either (BC, CD, DF, FE ...) or (BC CD CE FE ...) or first five nodes {B, C, D, F, E, ... } or {B, C, D, E, F ...} Order of nodes may be seen at the top of a matrix/table, where A may or may not have been crossed out, either { -, 1, 2, 3, 5, 4, -, - } or { -, 1, 2, 3, 4, 5, -, - }.	
c1A1	CAO RMST and 127 (or $22 + 18 + 21 + 17 + 25 + 24$) seen (if 127 with no working then M0) – arcs for RMST must be stated, not just seen e.g. circled in table.	
c2dM1	Dependent on previous M – adds two shortest arcs from A (AB and AC). Sight of '127'+19+24 or '127+43' or ' $22 + 18 + 21 + 17 + 25 + 24 + 19 + 24$ ' is sufficient here.	
c2A1	CAO Note: M1A0M1A1 is possible in (c).	
d1B1ft	CAO – allow strict inequalities Follow through their smaller value from (a) as the upper bound and the larger of 172 and their answer to (c) for their lower bound. Their lower bound must be less than their upper bound.	

Question Number	Scheme	Marks																																				
7.(a)	<table><tr><th>Activity</th><th>IPA</th><th>Activity</th><th>IPA</th></tr><tr><td>A</td><td>-</td><td>I</td><td>D E</td></tr><tr><td>B</td><td>-</td><td>J</td><td>D E F</td></tr><tr><td>C</td><td>-</td><td>K</td><td>D E F</td></tr><tr><td>D</td><td>A B</td><td>L</td><td>G H</td></tr><tr><td>E</td><td>B</td><td>M</td><td>I</td></tr><tr><td>F</td><td>B</td><td>N</td><td>I</td></tr><tr><td>G</td><td>B</td><td>P</td><td>J K L M</td></tr><tr><td>H</td><td>B C</td><td>Q</td><td>K L</td></tr></table>	Activity	IPA	Activity	IPA	A	-	I	D E	B	-	J	D E F	C	-	K	D E F	D	A B	L	G H	E	B	M	I	F	B	N	I	G	B	P	J K L M	H	B C	Q	K L	B1 (HIJ) B1 (KLM) B1 (NPQ) (3)
Activity	IPA	Activity	IPA																																			
A	-	I	D E																																			
B	-	J	D E F																																			
C	-	K	D E F																																			
D	A B	L	G H																																			
E	B	M	I																																			
F	B	N	I																																			
G	B	P	J K L M																																			
H	B C	Q	K L																																			
(b)		M1 A1 M1 A1 (4)																																				
(c)	ADIMP	B1 (1)																																				
(d)	$\frac{7+5+\dots+6+11}{38} \Rightarrow \frac{129}{38} = 3.3947\dots$ Therefore 4 workers	M1 A1 (2)																																				
(e)	e.g.	M1 A1 A1 A1 (4)																																				
		14 marks																																				

	Notes for Question 7			
a1B1	Activities H to J correct			
a2B1	Activities K to M correct			
a3B1	Activities N to Q correct			
b1M1	All top boxes complete, values generally increasing in the direction of the arrows ('left to right'), condone one rogue			
b1A1	CAO (top boxes)			
b2M1	All bottom boxes complete, values generally decreasing in the opposite direction of the arrows ('right to left'), condone one rogue. Condone missing 0 and/or their 24 (at the end event) for the M mark only			
b2A1	CAO (bottom boxes)			
cB1	CAO			
d1M1	Attempts total length (accept 129 ± 13) $\div$ "38" Accept awrt 3.4 for M1			
d1A1	CAO 4 workers and correct calculation (an answer of 4 with no working scores M0)			
e1M1	Not a cascade (Gantt) chart. 5 'workers' used at most and at least 11 activities placed			
e1A1	4 workers. All 16 activities present (just once). Condone at most three errors. An activity can give rise to at most three errors; one on duration, one on time interval and only one on IPA			
e2A1	4 workers. All 16 activities present (just once). Condone one error either precedence or time interval or activity length; An activity can give rise to at most three errors; one on duration, one on time interval and only one on IPA			
e3A1	4 workers. All 16 activities present (just once). No errors.			
	The table below is helpful in checking an activities duration, time interval and IPA			
	Activity	Duration	Time Interval	IPA
	A	7	0 – 7	-
	B	5	0 – 7	-
	C	8	0 – 13	-
	D	10	7 – 17	A B
	E	9	5 – 17	B
	F	8	5 – 18	B
	G	13	5 – 21	B
	H	8	8 – 21	B C
	I	8	17 – 25	D E
	J	5	17 – 32	D E F
	K	9	17 – 27	D E F
	L	6	18 – 27	G H
	M	7	25 – 32	I
	N	9	25 – 38	I
	P	6	32 – 38	J K L M
	Q	11	26 – 38	K L

Question Number	Scheme	Marks																				
8. (a)		B1 B1 B1 (3)																				
(b)	<table><tr><th></th><th></th><th>Vertex</th><th>Value</th></tr><tr><td>$y \leq 3x + 10$</td><td>$y \geq 15$</td><td>$\left(\frac{5}{3}, 15\right)$</td><td>85</td></tr><tr><td>$y \leq 3x + 10$</td><td>$x + 4y \leq 162$</td><td>$\left(\frac{122}{13}, \frac{496}{13}\right)$</td><td>$\frac{3212}{13} = 247\frac{1}{13}$</td></tr><tr><td>$x + 4y \leq 162$</td><td>$5x + 2y \leq 200$</td><td>$\left(\frac{238}{9}, \frac{305}{9}\right)$</td><td>$\frac{2953}{9} = 328\frac{1}{9}$</td></tr><tr><td>$5x + 2y \leq 200$</td><td>$y \geq 15$</td><td>(34, 15)</td><td>279</td></tr></table> Optimal vertex is $\left(\frac{238}{9}, \frac{305}{9}\right)$			Vertex	Value	$y \leq 3x + 10$	$y \geq 15$	$\left(\frac{5}{3}, 15\right)$	85	$y \leq 3x + 10$	$x + 4y \leq 162$	$\left(\frac{122}{13}, \frac{496}{13}\right)$	$\frac{3212}{13} = 247\frac{1}{13}$	$x + 4y \leq 162$	$5x + 2y \leq 200$	$\left(\frac{238}{9}, \frac{305}{9}\right)$	$\frac{2953}{9} = 328\frac{1}{9}$	$5x + 2y \leq 200$	$y \geq 15$	(34, 15)	279	M1 A1 A1 A1 (4)
		Vertex	Value																			
$y \leq 3x + 10$	$y \geq 15$	$\left(\frac{5}{3}, 15\right)$	85																			
$y \leq 3x + 10$	$x + 4y \leq 162$	$\left(\frac{122}{13}, \frac{496}{13}\right)$	$\frac{3212}{13} = 247\frac{1}{13}$																			
$x + 4y \leq 162$	$5x + 2y \leq 200$	$\left(\frac{238}{9}, \frac{305}{9}\right)$	$\frac{2953}{9} = 328\frac{1}{9}$																			
$5x + 2y \leq 200$	$y \geq 15$	(34, 15)	279																			

(c)		$x + 4y \leq 162$	$5x + 2y \leq 200$	Y/N	Value	dM1 A1 A1
	26, 33	158	196	Y	321	
	26, 34	162	198	Y	326	
	27, 33	159	201	N		
	27, 34	163	203	N		
	Optimal solution is $x = 26, y = 34$ value 326					
						(3)
(d)	Considers limiting cases $P = kx + y$ parallel to $x + 4y = 162$ and $5x + 2y = 200$ $\frac{1}{4} < k < \frac{5}{2}$					M1 A1
						(2)
						12 marks
	Notes for Question 8					
a1B1	Two lines correctly drawn $y = 15$ should pass through two points of the form $(\dots, 15)$ $y = 3x + 10$ must pass through $(0, 10)$ and $(10, 40)$ $5x + 2y = 200$ must pass through $(24, 40)$ and $(32, 20)$ Lines should pass within one small square of these points.					
a2B1	All three lines correct					
a3B1	All lines correct and feasible region labelled with R .					
b1M1	Attempts to solve at least 3 pairs of simultaneous equations to find the coordinates of vertices (may be implied by three correct coordinate pairs)					
b1A1	2 pairs of coordinates (excluding $\left(\frac{5}{3}, 15\right)$) and their corresponding values of objective function correct (accept decimal equivalents to at least 1 decimal place)					
b2A1	All 3 pairs of coordinates (excluding $\left(\frac{5}{3}, 15\right)$) and their corresponding values of objective function correct (accept decimal equivalents to at least 1 decimal place)					
b3A1	Optimal vertex stated or clearly identified (must be exact coordinates)					

c1dM1	Dependent on obtaining an optimal vertex from a choice of at least two vertices considered in (b); in part (b) there must be working, even if incorrect, leading to identifying an optimal vertex. Considers integer solutions around their optimal point (at least 3 integer points considered). We need to see them engage with the values, not just list points around their optimal point (e.g. a rectangle with vertices labelled is not sufficient). We want to see at minimum a calculation or values embedded in the objective function for these vertices.	
c1A1	Three points correct ((27, 34) not required) – i.e the two feasible integer solutions with correct values, and a rejection of one of the coordinate(s) outside the feasible region. Accept if (27, 33) is not used at any point in calculations – we can accept this as implicit rejection of this point.	
c2A1	CAO Correct integer coordinate stated with correct value for the objective function. Accept the coordinate given in the form $x = \dots, y = \dots$ Must score the previous A mark.	
d1M1	Considers limiting cases – may be implied by correct answer. Note that both limiting cases must be considered; e.g. reaching $k < \frac{5}{2}$ only is M0. Alt Method for d): Some candidates might consider the value of the objective function at the vertices $\left(\frac{122}{13}, \frac{496}{13}\right), \left(\frac{238}{9}, \frac{305}{9}\right)$ and (34, 15) M1: Both of the following inequalities considered: $\frac{238}{9}x + \frac{305}{9} > \frac{122}{13}x + \frac{496}{13} \quad \text{and} \quad \frac{238}{9}x + \frac{305}{9} > 34x + 15$	
d1A1	CAO (Condone non-strict inequalities)	

Pearson Edexcel International Advanced Level

Monday 12 January 2026

Morning (Time: 1 hour 30 minutes)

Paper

reference

WFM01/01A

Mathematics

International Advanced Subsidiary/ Advanced Level

Further Pure Mathematics F1

Question paper

You must have:

Answer book (sent separately).

Do not return this question paper with the answer book.

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Pearson

1. Use the standard results for $\sum_{r=1}^n r$ and for $\sum_{r=1}^n r^2$ to show that, for all positive integers n ,

$$\sum_{r=1}^n r(r+3) = \frac{n}{a}(n+1)(n+b)$$

where a and b are integers to be found.

(4)

(Total for Question 1 is 4 marks)

2. **In this question you must show all stages of your working.**
Solutions relying on calculator technology are not acceptable.

$$f(z) = z^4 - 6z^3 + 38z^2 - 94z + 221$$

- (a) Given that $z = 2 + 3i$ is a root of the equation $f(z) = 0$, use algebra to find the three other roots of $f(z) = 0$

(7)

- (b) Show the four roots of $f(z) = 0$ on a single Argand diagram.

(2)

(Total for Question 2 is 9 marks)

3. **In this question you must show all stages of your working.**
Solutions relying on calculator technology are not acceptable.

The rectangular hyperbola H has parametric equations

$$x = 4t \quad y = \frac{4}{t}$$

The straight line with equation $3y - 2x = 10$ intersects H at the points A and B .

Given that the point A is above the x -axis,

- (a) find the coordinates of the point A and the coordinates of the point B .

(5)

- (b) Find the coordinates of the midpoint of AB .

(2)

(Total for Question 3 is 7 marks)



4.

**In this question you must show all stages of your working.
Solutions relying on calculator technology are not acceptable.**

Given that $z = x + iy$, where x and y are real numbers, solve the equation

$$(z - 2i)(z^* - 2i) = 21 - 12i$$

where z^* is the complex conjugate of z .

(6)

(Total for Question 4 is 6 marks)

5. The quadratic equation

$$x^2 - 2x + 3 = 0$$

has roots α and β .

Without solving the equation,

(a) (i) write down the value of $(\alpha + \beta)$ and the value of $\alpha\beta$

(ii) show that $\alpha^2 + \beta^2 = -2$

(iii) find the value of $\alpha^3 + \beta^3$

(5)

(b) (i) show that $\alpha^4 + \beta^4 = (\alpha^2 + \beta^2)^2 - 2(\alpha\beta)^2$

(ii) find a quadratic equation which has roots

$$(\alpha^3 - \beta) \text{ and } (\beta^3 - \alpha)$$

giving your answer in the form $px^2 + qx + r = 0$ where p , q and r are integers.

(6)

(Total for Question 5 is 11 marks)

6.

$$\mathbf{A} = \begin{pmatrix} 2p & 3q \\ 3p & 5q \end{pmatrix}$$

where p and q are non-zero real constants.

(a) Find $\mathbf{A}^{-1}$ in terms of p and q .

(3)

Given $\mathbf{XA} = \mathbf{B}$, where

$$\mathbf{B} = \begin{pmatrix} p & q \\ 6p & 11q \\ 5p & 8q \end{pmatrix}$$

(b) find the matrix $\mathbf{X}$, giving your answer in its simplest form.

(4)

(Total for Question 6 is 7 marks)

7.

$$f(x) = 30 + \frac{7}{\sqrt{x}} - x^5 \quad x > 0$$

The only real root, α , of the equation $f(x) = 0$ lies in the interval $[2, 2.1]$.

(a) Starting with the interval $[2, 2.1]$, use interval bisection twice to find an interval of width 0.025 that contains α .

(4)

(b) Find $f'(x)$.

(2)

(c) Taking 2 as a first approximation to α , apply the Newton–Raphson process once to $f(x)$ to find a second approximation to α , giving your answer to 2 decimal places.

(2)

(Total for Question 7 is 8 marks)



8. **In this question you must show all stages of your working.**
Solutions relying entirely on calculator technology are not acceptable.

The parabola C has equation $y^2 = 4ax$, where a is a positive constant.

The point $P(ap^2, 2ap)$ lies on the parabola C .

- (a) Use calculus to show that an equation of the tangent to C at P is

$$py = x + ap^2 \quad (4)$$

The tangent to C at the point P intersects the directrix of C at the point B and intersects the x -axis at the point D .

Given that the y -coordinate of B is $\frac{5}{6}a$ and $p > 0$

- (b) find, in terms of a , the x -coordinate of D . (6)

Given that O is the origin,

- (c) find, in terms of a , the area of the triangle OPD , giving your answer in its simplest form. (2)

(Total for Question 8 is 12 marks)

9.

$$\mathbf{A} = \begin{pmatrix} 6 & 4 \\ 1 & 1 \end{pmatrix}$$

- (a) Show that $\mathbf{A}$ is non-singular. (2)

The triangle R is transformed to the triangle S by the matrix $\mathbf{A}$.

Given that the area of the triangle R is 10 square units,

- (b) find the area of triangle S . (2)

Given that

$$\mathbf{B} = \mathbf{A}^4$$

and that the triangle R is transformed to the triangle T by the matrix $\mathbf{B}$,

- (c) find, without evaluating $\mathbf{B}$, the area of triangle T . (2)

(Total for Question 9 is 6 marks)

10. Prove by induction that, for $n \in \mathbb{Z}^+$

$$\sum_{r=1}^n r^2(2r-1) = \frac{1}{6}n(n+1)(3n^2+n-1)$$

(5)

(Total for Question 10 is 5 marks)

TOTAL FOR PAPER IS 75 MARKS



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Please check the examination details below before entering your candidate information

Candidate surname					Other names				
Centre Number					Candidate Number				

Pearson Edexcel International Advanced Level

Monday 12 January 2026

Morning (Time: 1 hour 30 minutes)

Paper reference **WFM01/01A**

Mathematics

International Advanced Subsidiary/Advanced Level

Further Pure Mathematics F1

Answer Book

You must have:

Question paper (sent separately)

Mathematical Formulae and Statistical Tables (Yellow), calculator

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 10 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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Question 1

Write the answer to Question 1 on these 2 pages

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DO NOT WRITE IN THIS AREA

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DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(Total for Question 1 is 4 marks)



Question 2

Write the answer to Question 2 on these 4 pages

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DO NOT WRITE IN THIS AREA



Question 2 continued

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(Total for Question 2 is 9 marks)



Question 3

Write the answer to Question 3 on these 2 pages

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DO NOT WRITE IN THIS AREA



Question 4

Write the answer to Question 4 on these 2 pages

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(Total for Question 4 is 6 marks)



Question 5

Write the answer to Question 5 on these 4 pages

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Question 5 continued

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(Total for Question 5 is 11 marks)



Question 6

Write the answer to Question 6 on these 2 pages

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DO NOT WRITE IN THIS AREA

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(Total for Question 6 is 7 marks)



Question 7

Write the answer to Question 7 on these 2 pages

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(Total for Question 7 is 8 marks)



Question 8

Write the answer to Question 8 on these 4 pages

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DO NOT WRITE IN THIS AREA



Question 8 continued

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DO NOT WRITE IN THIS AREA



Question 9

Write the answer to Question 9 on these 2 pages

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DO NOT WRITE IN THIS AREA



Question 10

Write the answer to Question 10 on these 3 pages

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA



Question 10 continued

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(Total for Question 10 is 5 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (Final)

January 2026

International Advanced Level in Further
Pure Mathematics F1

WFM01/01A

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January 2026

Question Paper Log Number P87589A

Publication Code WFM01_01A_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)

Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN:

- bod – benefit of doubt
 - ft – follow through
 - the symbol $\surd$ will be used for correct ft
 - cao – correct answer only
 - cso – correct solution only. There must be no errors in this part of the question to obtain this mark
 - isw – ignore subsequent working
 - awrt – answers which round to
 - SC – special case
 - oe – or equivalent (and appropriate)
 - d... or dep – dependent
 - indep – independent
 - dp – decimal places
 - sf – significant figures
 - * – The answer is printed on the paper or ag- answer given
 - $\square$ or d... – The second mark is dependent on gaining the first mark
4. All A marks are 'correct answer only' (cao), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. If you are using the annotation facility on ePEN, indicate this action by 'MR' in the body of the script.
6. If a candidate makes more than one attempt at any question:
 - a) If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - b) If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
7. Ignore wrong working or incorrect statements following a correct answer.

General Principles for Further Pure Mathematics Marking

(NB specific mark schemes may sometimes override these general principles)

Method mark for solving 3 term quadratic:

- Factorisation
 - $(x^2 + bx + c) = (x + p)(x + q)$, where $|pq| = |c|$, leading to $x = \dots$
 - $(ax^2 + bx + c) = (mx + p)(nx + q)$, where $|pq| = |c|$ and $|mn| = |a|$, leading to $x = \dots$
- Formula
 - Attempt to use the correct formula (with values for a , b and c).
- Completing the square
 - Solving $x^2 + bx + c = 0 : \left(x \pm \frac{b}{2}\right)^2 \pm q \pm c = 0, q \neq 0$, leading to $x = \dots$

Method marks for differentiation and integration:

- Differentiation
 - Power of at least one term decreased by 1. ($x^n \rightarrow x^{n-1}$)
- Integration
 - Power of at least one term increased by 1. ($x^n \rightarrow x^{n+1}$)

Use of a formula

Where a method involves using a formula that has been learnt, the advice given in recent examiners' reports is that the formula should be quoted first. Normal marking procedure is as follows:

- Method mark for quoting a correct formula and attempting to use it, even if there are small errors in the substitution of values.
- Where the formula is not quoted, the method mark can be gained by implication from correct working with values but may be lost if there is any mistake in the working.

Exact answers

Examiners' reports have emphasised that where, for example, an exact answer is asked for, or working with surds is clearly required, marks will normally be lost if the candidate resorts to using rounded decimals.

Answers without working

The rubric says that these may not gain full credit. Individual mark schemes will give details of what happens in particular cases. General policy is that if it could be done "in your head", detailed working would not be required. Most candidates do show working, but there are occasional awkward cases and if the mark scheme does not cover this, please contact your team leader for advice.

Question Number	Scheme	Marks
1.	$r(r+3) = r^2 + 3r \quad \text{so} \quad \sum_{r=1}^n r(r+3) = \sum_{r=1}^n r^2 + 3 \sum_{r=1}^n r$ $= \frac{n}{6}(n+1)(2n+1) + 3 \frac{n}{2}(n+1)$	M1A1
	$= \frac{n}{6}(n+1)[2n+1+9]$	dM1
	$\left(= \frac{n}{6}(n+1)[2n+10] \right) = \frac{n}{3}(n+1)(n+5) \quad \text{or } a = 3 \text{ and } b = 5$	A1
		(4)
		Total 4

Notes

M1: Attempts to expand and attempts to substitute **at least one correct** standard formula into their resulting expression.

A1: Correct expression (or equivalent)

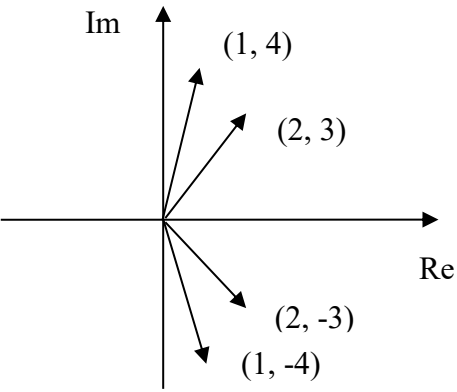
dM1: Attempt to factorise at least $n(n+1)$ **having attempted to substitute both correct** standard formulae.
May be done in stages

Dependent on the previous M mark.

A1: Correct completion with no errors and must be in terms of n

Note: Condone work in terms of r for all but the final mark.

Attempts that use induction would generally score no marks, but if there are any cases you are unsure about please send to review

Question Number	Scheme	Notes	Marks
2	$f(z) = z^4 - 6z^3 + 38z^2 - 94z + 221$ Condone consistent work in x throughout, but mixed variables which are not recovered loses final A mark		
(a)	$z = 2 - 3i$ (is also a root)		B1
	$(z - (2 + 3i))(z - (2 - 3i)) = \dots$ or $(2 + 3i) + (2 - 3i) = \dots(4)$ and $(2 + 3i)(2 - 3i) = \dots(13)$		M1
	$z^2 - 4z + 13$		A1
	$\frac{z^4 - 6z^3 + 38z^2 - 94z + 221}{z^2 - 4z + 13}$ $= az^2 + bz + c \text{ with } a \neq 0$ or $z^4 - 6z^3 + 38z^2 - 94z + 221 = (z^2 - 4z + 13)(az^2 + bz + c) \Rightarrow a = \dots, b = \dots, c = \dots$		M1
	$= z^2 - 2z + 17$		A1
	$z = \frac{2 \pm \sqrt{4 - 68}}{2} = \dots$ or $(z - 1)^2 + 16 = 0 \Rightarrow z = \dots$		M1
	$= 1 \pm 4i$		A1
			(7)
(b)	 Accept points, crosses, vectors or coordinates		B1B1ft
			(2)
			Total 9

Notes

(a)

B1: $z = 2 - 3i$ seen identified as another root anywhere in the solution for (a) or (b). May only be seen at the end but must be written down somewhere in the solution. May only be on the argand diagram for (b) which is ok

M1: Correct attempt at quadratic factor by either finding the product of the two linear factors, or using the sum and product of the known roots.

A1: $z^2 - 4z + 13$ (sight of this quadratic would score first M1A1)

M1: Correct attempt at the other quadratic factor e.g. long division/ comparing coefficients/ synthetic Division/inspection using their quadratic factor to obtain a second quadratic factor. Must be some minimal working shown.

A1: $z^2 - 2z + 17$

M1: Attempt to solve their second $3TQ = 0$ (we must see a method here as strict calculator warning- QF or completing the square)

A1: Correct roots.

Note: attempts that solve the quartic on a calculator with no other working score 0

(b)

If no working is shown in (a) they can score both marks in part (b) for plotting their roots correctly.

B1: $2 \pm 3i$ correctly plotted and labelled. Must be reasonably symmetric about the real axis.

B1ft: Their other conjugate pair correctly plotted and labelled. Must be reasonably symmetric about the real axis.

Note: For part (b) the axes don't need to be labelled, or could be labelled as 'x' and 'y' and the points can be shown with dots/crosses/vector lines/coordinates from the origin but must be clearly indicated. Accept axes labelled numerically as long as the points are identified. Condone (2, 3i) etc.

Question Number	Scheme	Marks	
3.(a)	$3\left(\frac{4}{t}\right) - 2(4t) = 10$	M1	
	$8t^2 + 10t - 12 (= 0)$	A1	
	$(8t - 6)(t + 2) = 0 \Rightarrow t = \dots$ or $(4t - 3)(2t + 4) = 0 \Rightarrow t = \dots$ or $2(4t - 3)(t + 2) = 0 \Rightarrow t = \dots$ or $t = \frac{-10 \pm \sqrt{100 + 384}}{16} = \dots \left(t = \frac{3}{4}, -2 \right)$ or $4\left(t + \frac{5}{8}\right)^2 - \frac{25}{16} - 6 = 0 \Rightarrow t = \dots \left(t = \frac{3}{4}, -2 \right)$	dM1	
	Points are $\left(3, \frac{16}{3}\right)$ and $(-8, -2)$	ddM1 A1	
		(5)	
(a) Alternative			
	$y = \frac{10 + 2x}{3}$ or $x = \frac{3y - 10}{2}$ and $xy = 16$ $\Rightarrow x^2 + 5x - 24 (= 0)$ or $3y^2 - 10y - 32 (= 0)$	M1A1	
	$x^2 + 5x - 24 = 0 \Rightarrow (x + 8)(x - 3) \Rightarrow x = \dots$ $x^2 + 5x - 24 = 0 \Rightarrow x = \frac{-5 \pm \sqrt{25 + 96}}{2} \Rightarrow x = \dots$ $x^2 + 5x - 24 = 0 \Rightarrow \left(x + \frac{5}{2}\right)^2 - \frac{121}{4} = 0 \Rightarrow x = \dots$	$3y^2 - 10y - 32 = 0 \Rightarrow (3y - 16)(y + 2) = 0 \Rightarrow y = \dots$ $3y^2 - 10y - 32 = 0 \Rightarrow y = \frac{10 \pm \sqrt{100 + 384}}{6} \Rightarrow y = \dots$ $3y^2 - 10y - 32 = 0 \Rightarrow 3\left(y - \frac{5}{3}\right)^2 - \frac{121}{3} = 0 \Rightarrow y = \dots$	dM1
	Points are $\left(3, \frac{16}{3}\right)$ and $(-8, -2)$	ddM1 A1	
(b)	$\left(\frac{3 - 8}{2}, \frac{\frac{16}{3} - 2}{2}\right) \rightarrow \left(-\frac{5}{2}, \frac{5}{3}\right)$	M1 A1	
		(2)	
		(7 marks)	
Notes			
M1:	Substitutes $x = 4t$ and $y = \frac{4}{t}$ into the printed equation to obtain an equation in t only.		
A1:	Obtains a correct three term quadratic equation.		
dM1:	Correct method (e.g. factorising, quadratic formula or completing the square) of solving a 3TQ to find $t = \dots$		
	Dependent on the previous M mark.		
ddM1:	Correct substitution for at least one of their values for t into the given parametric equations and obtains two sets of corresponding values for x and y . Could be implied by correct points provided dM1 scored.		
	Dependent on both previous M marks.		
A1:	Both correct points found. No need to label them as A and B if given in the order shown in the MS but		

if the order is reversed, they must be labelled. So $(-8, -2)$ and $\left(3, \frac{16}{3}\right)$, scores A0 unless labelled correctly.

Must also be written as coordinates.

Alternative:

M1: Solves simultaneously $3y - 2x = 10$ with $xy = k$, $k \neq 0$ to form an equation in x or y only.

A1: Obtains a correct three term quadratic equation.

dM1: Correct method (e.g. factorising, completing the square or applying the quadratic formula) of solving a 3TQ to find $x = \dots$ or $y = \dots$

Dependent on the previous M mark.

ddM1: Correct substitution for at least one of **their** values **and** obtains *two sets* of corresponding values for x and y . Could be implied by correct points provided dM1 scored.

Dependent on both previous M marks.

A1: Both correct points found. No need to label them as A and B if given in the order shown in the MS but if the order is reversed, they must be labelled. So $(-8, -2)$ and $\left(3, \frac{16}{3}\right)$, scores A0 unless labelled correctly.

Must be written as coordinates.

SC: If they show working to arrive at a correct quadratic in x , y , or t and then use a calculator to solve their quadratic, arriving at two correct points then award SC M1A1dM0ddM0A1

(b)

M1: Correct method for the midpoint of their points. Must be adding and dividing by 2

A1: Correct answer. Cannot leave unsimplified to score this mark, so they must combine the numerical values but accept e.g. $\left(-2.5, \frac{5}{3}\right)$ or $(-2.5, 1.66\cdots)$ or $\left(-2.5, 1.\dot{6}\right)$

Question Number	Scheme	Notes	Marks
4.	$(z - 2i)(z^* - 2i) = 21 - 12i$		
	$z^* = x - iy$		B1
	$(x + iy - 2i)(x - iy - 2i) = \dots$ $= x^2 - x(y + 2)i + x(y - 2)i + y^2 - 4$ $= x^2 + y^2 - 4 - 4xi$		M1
	$x^2 + y^2 - 4 = 21$ and $4x = 12$		M1
	$4x = 12 \Rightarrow x = \dots$		M1
	$x = 3$		A1
	$y = \pm 4$		A1
			(6)
			Total 6
Alternative 1			
	$(z - 2i)(z^* - 2i) = zz^* - 2i(z + z^*) - 4$		M1
	$= (x + iy)(x - iy) - 2i(x + iy + x - iy) - 4$		B1
	$= x^2 + y^2 - 4xi - 4$ $x^2 + y^2 - 4 = 21$ and $4x = 12$		M1
	$4x = 12 \Rightarrow x = \dots$		M1
	$x = 3$		A1
	$y = \pm 4$		A1
Alternative 2			
	$(z - 2i)(z^* - 2i) = zz^* - 2i(z + z^*) - 4$ $zz^* - 2i(z + z^*) - 4 = 21 - 12i$		M1
	$zz^* - 4 = 21, \quad 2(z + z^*) = 12$		M1
	$z^2 - 6z + 25 = 0 \left(\text{or } (z^*)^2 - 6z^* + 25 = 0 \right)$		B1
	$z^2 - 6z + 25 = 0 \left(\text{or } (z^*)^2 - 6z^* + 25 = 0 \right)$ $\Rightarrow z = \frac{6 \pm \sqrt{36 - 100}}{2} \Rightarrow z = \dots \text{ or } (z - 3)^2 + 16 = 0 \Rightarrow z = \dots$		M1
	$x = 3$		A1
	$y = \pm 4$		A1

	Alternative 3	
	$(z - 2i)(z^* - 2i) = zz^* - 2i(z + z^*) - 4$ $zz^* - 2i(z + z^*) - 4 = 21 - 12i$	M1
	$zz^* - 4 = 21, \quad 2(z + z^*) = 12$	M1
	$x^2 + y^2 - 4 = 21$ $\text{and } 4x = 12$	B1
	$4x = 12 \Rightarrow x = \dots$	M1
	$x = 3$	A1
	$y = \pm 4$	A1

Notes

(a)

B1: Correct complex conjugate.

M1: Substitutes for z and their z^* and attempts to expand. No need to check individual terms, but look for any attempt to multiply out the brackets

M1: Compares real **and** imaginary parts.

M1: Solves to obtain at least one value of x or y . There must be no clear use of a calculator.

A1: $x = 3$

A1: $y = \pm 4$ (accept e.g. $z = 3 \pm 4i$)

Alternative 1:

M1: Attempts to expand. No need to check individual terms, but look for any attempt to multiply out the brackets

B1: $z^* = x - iy$ (may be implied).

M1: Compares real **and** imaginary parts.

M1: Solves to obtain at least one value of x or y . There must be no clear use of a calculator.

A1: $x = 3$

A1: $y = \pm 4$ (accept e.g. $z = 3 \pm 4i$)

Alternative 2:

M1: Attempts to expand. No need to check individual terms, but look for any attempt to multiply out the brackets

M1: Compares real and imaginary parts.

B1: Correct quadratic.

M1: Solves (must see a method as strict calculator warning-see general rules on solving a 3TQ) to obtain at least one value of z or z^*

A1: $x = 3$

A1: $y = \pm 4$ (accept e.g. $z = 3 \pm 4i$)

Alternative 3:

M1: Attempts to expand. No need to check individual terms, but look for any attempt to multiply out the brackets

M1: Compares real **and** imaginary parts.

B1: Use of $z^* = x - iy$ Implied by use of $zz^* = x^2 + y^2$ or $2(z + z^*) = 4x$

M1: Solves to obtain at least one value of x or y . There must be no clear use of a calculator.

A1: $x = 3$

A1: $y = \pm 4$ (accept e.g. $z = 3 \pm 4i$)

Question Number	Scheme	Notes	Marks
5.	$x^2 - 2x + 3 = 0$		
(a)(i)	$\alpha + \beta = 2, \quad \alpha\beta = 3$		B1
(ii)	$\alpha^2 + \beta^2 = (\alpha + \beta)^2 - 2\alpha\beta = 4 - 6 = -2$		M1A1
(iii)	$\alpha^3 + \beta^3 = (\alpha + \beta)^3 - 3\alpha\beta(\alpha + \beta) = 8 - 3 \times 3 \times 2 = -10$		M1A1
			(5)
(b)(i)	$(\alpha^2 + \beta^2)^2 - 2(\alpha\beta)^2 = \alpha^4 + 2(\alpha\beta)^2 + \beta^4 - 2(\alpha\beta)^2 = \alpha^4 + \beta^4$		B1*
ALT 1	$\alpha^4 + \beta^4 = \alpha^4 + \beta^4 + 2\alpha^2\beta^2 - 2\alpha^2\beta^2 = (\alpha^2 + \beta^2)^2 - 2(\alpha\beta)^2$		B1*
ALT 2	$(\alpha + \beta)^4 = \alpha^4 + 4\alpha^3\beta + 6\alpha^2\beta^2 + 4\alpha\beta^3 + \beta^4$ $\Rightarrow \alpha^4 + \beta^4 = (\alpha + \beta)^4 - 4\alpha\beta(\alpha^2 + \beta^2) - 6\alpha^2\beta^2$ $= (\alpha + \beta)^4 - 4\alpha\beta[(\alpha + \beta)^2 - 2\alpha\beta] - 6\alpha^2\beta^2$ $= (\alpha + \beta)^4 - 4\alpha\beta(\alpha + \beta)^2 + 2\alpha^2\beta^2$ $= [(\alpha + \beta)^2 - 2\alpha\beta]^2 - 4\alpha^2\beta^2 + 2\alpha^2\beta^2$ $= (\alpha^2 + \beta^2)^2 - 2(\alpha\beta)^2$		B1*
(ii)	$\text{Sum} = \alpha^3 + \beta^3 - (\alpha + \beta) = -10 - 2 = -12$		B1
	$\text{product} = (\alpha^3 - \beta)(\beta^3 - \alpha) = (\alpha\beta)^3 - (\alpha^4 + \beta^4) + \alpha\beta = 27 - (4 - 18) + 3 = 44$		M1A1
	$\Rightarrow x^2 + 12x + 44 = 0$		M1A1
			(6)
			Total 11

Notes

- (a)(i)**
B1: Both $\alpha + \beta = 2, \quad \alpha\beta = 3$
- (ii)**
M1: Use of a correct identity for $\alpha^2 + \beta^2$ (May be implied by their work) e.g. $(\text{their sum})^2 - 2 \times \text{their product}$
A1: -2 from a correct solution only.
- (iii)**
M1: Use of a correct identity for $\alpha^3 + \beta^3$ (May be implied by their work) e.g. $(\text{their sum})^3 - 3 \times \text{their product} \times \text{their sum}$
A1: -10 from a correct solution only.

(b)(i)

B1*: Correct algebraic proof starting with RHS. Must see full correct expansion of $(\alpha^2 + \beta^2)^2$ before the printed answer and no incorrect work.

ALT 1 Starts with LHS but must see $\alpha^4 + \beta^4 = \alpha^4 + \beta^4 + 2\alpha^2\beta^2 - 2\alpha^2\beta^2$ before the printed answer and no incorrect work

ALT 2 Starts with the expansion of $(\alpha + \beta)^4$ then rearranges to obtain $\alpha^4 + \beta^4$, factorises and progresses to the correct printed answer with no errors

In all attempts accept $2\alpha^2\beta^2$ as an equivalent to $2(\alpha\beta)^2$

(ii)

NOTE: there are no ft marks available in part (b)

B1: Correct working without using explicit roots leading to a correct sum.

M1: Attempts to expand. Must have at least three correct terms to score this mark.

A1: Correct product.

M1: Applies $x^2 - (\text{sum})x + \text{product}$ (may have to check for their sum and product and $= 0$ not required for this mark)

A1: $x^2 + 12x + 44 = 0$ (must have the $= 0$ for this mark)

If p, q, r , stated but quadratic not stated then M1A0

NOTE: any attempts which try to solve the equation to find the roots will generally score zero

Question Number	Scheme	Marks
6.(a)	$\det \mathbf{A} = 2p(5q) - 3p(3q)$	B1
	$\begin{pmatrix} 2p & 3q \\ 3p & 5q \end{pmatrix} \rightarrow \begin{pmatrix} 5q & -3q \\ -3p & 2p \end{pmatrix}$	M1
	$\mathbf{A}^{-1} = \frac{1}{pq} \begin{pmatrix} 5q & -3q \\ -3p & 2p \end{pmatrix}$ or $\mathbf{A}^{-1} = \begin{pmatrix} \frac{5}{p} & -\frac{3}{p} \\ -\frac{3}{q} & \frac{2}{q} \end{pmatrix}$	A1
		(3)
(b)	$\mathbf{X} = \mathbf{BA}^{-1} = \begin{pmatrix} p & q \\ 6p & 11q \\ 5p & 8q \end{pmatrix} \frac{1}{pq} \begin{pmatrix} 5q & -3q \\ -3p & 2p \end{pmatrix} = \dots$ Or $\mathbf{X} = \mathbf{BA}^{-1} = \begin{pmatrix} p & q \\ 6p & 11q \\ 5p & 8q \end{pmatrix} \begin{pmatrix} \frac{5}{p} & -\frac{3}{p} \\ -\frac{3}{q} & \frac{2}{q} \end{pmatrix} = \dots$	M1
	$= \frac{1}{pq} \begin{pmatrix} 2pq & -pq \\ -3pq & 4pq \\ pq & pq \end{pmatrix}$ or equivalent e.g. $\begin{pmatrix} 5-3 & -3+2 \\ 30-33 & -18+22 \\ 25-24 & -15+16 \end{pmatrix}$ 4 correct elements from those above – simplified or unsimplified. The elements may not be in a matrix, or a matrix of the correct dimension.	A1
	$= \begin{pmatrix} 2 & -1 \\ -3 & 4 \\ 1 & 1 \end{pmatrix}$	dM1A1
		(4)

(b) Alternative		
	$\begin{pmatrix} a & b \\ c & d \\ e & f \end{pmatrix} \begin{pmatrix} 2p & 3q \\ 3p & 5q \end{pmatrix} = \begin{pmatrix} p & q \\ 6p & 11q \\ 5p & 8q \end{pmatrix}$ So $2a+3b=1$ and $3a+5b=1$; $a=2, b=-1$ or $2c+3d=6$ and $3c+5d=11$; $c=-3, d=4$ or $2e+3f=5$ and $3e+5f=8$; $e=1, f=1$	M1A1
	$a=2, b=-1 \quad c=-3, d=4 \quad e=1, f=1$	dM1
	$= \begin{pmatrix} 2 & -1 \\ -3 & 4 \\ 1 & 1 \end{pmatrix}$	A1

Notes

- (a)
- B1:** Correct determinant. Simplified or unsimplified.
- M1:** Interchanges elements in major diagonal and changes signs in other diagonal.
- A1:** Completely correct answer in any form, simplified or unsimplified. If the matrix is correct and they then go on to simplify incorrectly then ISW
- (b)
- M1:** Attempts $\mathbf{BA}^{-1}$ and finds at least one element using their inverse from (a). The matrix dimension may be incorrect or not shown but one correct element for their $\mathbf{BA}^{-1}$ after an attempt at $\mathbf{BA}^{-1}$ is sufficient. The element may be unsimplified.
- A1:** At least 4 elements correct. The elements may not yet be simplified.
- dM1:** Finds a 3×2 matrix of 6 elements.
- A1:** Correct simplified matrix.

Alternative:

- M1:** Attempts simultaneous equations from $\mathbf{XA} = \mathbf{B}$ and solves for at least one constant.
- A1:** At least 4 correct values.
- dM1:** Finds all 6 elements for the 3×2 matrix.
- A1:** Correct simplified matrix.

Question Number	Scheme	Marks
7.(a)	$f(2) = 2.9497...$ or $f(2.1) = -6.0105...$ and $f(2.05) = -1.3160...$	M1A1
	$f(2.025) = 0.86846...$	dM1
	Interval is (2.025, 2.05) oe	A1
		(4)
(b)	$f'(x) = -\frac{7}{2}x^{-\frac{3}{2}} - 5x^4$	M1A1
		(2)
(c)	$x_1 = 2 - \frac{f(2)}{f'(2)} = \left(2 - \frac{2.9497}{-81.237}\right) = 2.04$	M1 A1
		(2)
		Total 8

Notes

(a)

M1: Evaluates (must see numerical values) *at least one* of $f(2)$ or $f(2.1)$ **and evaluates** $f(2.05)$

A1: $f(2)$ **or** $f(2.1)$ correct awrt (or truncated) to 1 sf **and** $f(2.05)$ correct awrt (or truncated) to 1 sf

dM1: Evaluates $f(2.025)$

Dependent on the previous M mark

A1: Needs accuracy for $f(2.025)$ correct to 1 figure truncated or rounded and correct interval. Accept soft or hard brackets here or e.g. $\text{root}/\alpha/x \in (2.025, 2.05)$ or $\text{root}/\alpha/x \in [2.025, 2.05]$ or 'root belongs to (2.025, 2.05)' etc

Note:

Condone $\text{root}/\alpha/x$ is between 2.05 and 2.025 but $\text{root}/\alpha/x \in (2.05, 2.025)$ or $\text{root}/\alpha/x \in [2.05, 2.025]$ is **A0**

(b)

M1: For attempt at differentiation $\frac{7}{\sqrt{x}} \rightarrow ax^{-\frac{3}{2}}$ or $-x^5 \rightarrow bx^4$

A1: Correct derivative.

(c)

M1: For correct application of Newton - Raphson (using the correct formula) with $f(2)$ and $f'(2)$ which could be implied with their values.

$x_0 = 2$ followed by $x_1 = x_0 - \frac{f(x_0)}{f'(x_0)} = \dots$ is M1

$x = 2 - \frac{\text{their } f(2)}{\dots} = \dots$ is M1

A1: cso and needs to be given to 2dp. This mark can only be scored if full marks in (b) are scored (Newton Raphson used more than once – isw)

Question Number	Scheme	Marks
8.(a)	$y^2 = 4ax$, at $P(ap^2, 2ap)$	
	$y = 2\sqrt{a}x^{\frac{1}{2}} \Rightarrow \frac{dy}{dx} = \sqrt{a}x^{-\frac{1}{2}}$ or (implicitly) $2y\frac{dy}{dx} = 4a$ or (chain rule) $\frac{dy}{dx} = 2a \times \frac{1}{2ap}$	M1
	When $x = ap^2$, $m_T = \frac{dy}{dx} = \frac{\sqrt{a}}{\sqrt{ap^2}} = \frac{\sqrt{a}}{\sqrt{a}p} = \frac{1}{p}$ or $m_T = \frac{dy}{dx} = \frac{4a}{2(2ap)} = \frac{1}{p}$	A1
	$y - 2ap = \frac{1}{p}(x - ap^2)$ Or $y = mx + c \Rightarrow 2ap = \frac{1}{p}(ap^2) + c \Rightarrow c = \dots(ap)$	M1
	$py - 2ap^2 = x - ap^2 \Rightarrow py = x + ap^2$ Or $\Rightarrow y = \frac{1}{p}x + ap \Rightarrow py = x + ap^2$	A1 *
		(4)
(b)	$B(-a, \frac{5}{6}a) \Rightarrow p(\frac{5}{6}a) = -a + ap^2$ or $p(\frac{5}{6}a) = x + ap^2$ or $py = -a + ap^2$	M1
	$\Rightarrow 5ap = -6a + 6ap^2 (\Rightarrow 6p^2 - 5p - 6 = 0)$	A1
	$6p^2 - 5p - 6 = 0 \Rightarrow p = \dots$ leading to $p = \dots$	M1
	$\Rightarrow \left\{ p = -\frac{2}{3} \text{ (reject)} \right\} p = \frac{3}{2}$	A1
	$0 = x + a\left(\frac{3}{2}\right)^2$	M1
	$x = -\frac{9a}{4}$	A1
		(6)
(c)	When $p = \frac{3}{2}$, $y_P = 2a\left(\frac{3}{2}\right) = 3a$ $\text{Area}(OPD) = \frac{1}{2}\left(\frac{9a}{4}\right)(3a) = \frac{27a^2}{8}$ Or $\text{Area}(OPD) = \frac{1}{2} \begin{vmatrix} 0 & \frac{9a}{4} & -\frac{9a}{4} & 0 \\ 0 & 3a & 0 & 0 \end{vmatrix} = \frac{1}{2} \times 3a \times \frac{9a}{4}$	M1A1
		(2)
		Total 12

Notes

(a)

M1: $\frac{dy}{dx} = \pm kx^{-\frac{1}{2}}$ or $ky\frac{dy}{dx} = c$ or $\frac{\text{their } \frac{dy}{dx}}{\text{their } \frac{dx}{dt}}$

A1: $\frac{dy}{dx} = \frac{1}{p}$

M1: Applies $y - 2ap = (\text{their } m_T)(x - ap^2)$ Where $(\text{their } m_T)$ is a function of p and has come from calculus or applies $y = mx + c$, substitutes $P(ap^2, 2ap)$ and makes progress to find the c

A1*: Obtains the printed result with at least one line of intermediate working and no incorrect work seen.
E.g. Cannot go from $y - 2ap = \frac{1}{p}(x - ap^2)$ directly to the printed answer

(b)

M1: Substitutes $x = -a$ or $y = \frac{5}{6}a$ or both into **their** equation (or their rearranged equation) or the printed answer

A1: Correct equation **in any form** with $x = -a$ and $y = \frac{5}{6}a$

M1: Attempts to solve their 3TQ in p having substituted $x = -a$ and $y = \frac{5}{6}a$ (Note that this question has the less strict calculator warning, so that calculators may be used for general processing, but not to formulate a complete solution to the question, so we can allow a calculator to be used here to solve the 3TQ)

A1: $p = \frac{3}{2}$ (Can just be stated from a correct quadratic)

M1: Substitutes their " $p = \frac{3}{2}$ " and $y = 0$ into **their** equation (or their rearranged equation) or the printed answer

A1: $x = -\frac{9a}{4}$

Note: If two values of p are substituted and two values for x are found, and the incorrect value of x is rejected then full marks can be scored in (b). If they don't reject the incorrect value, then the last two A marks are lost.

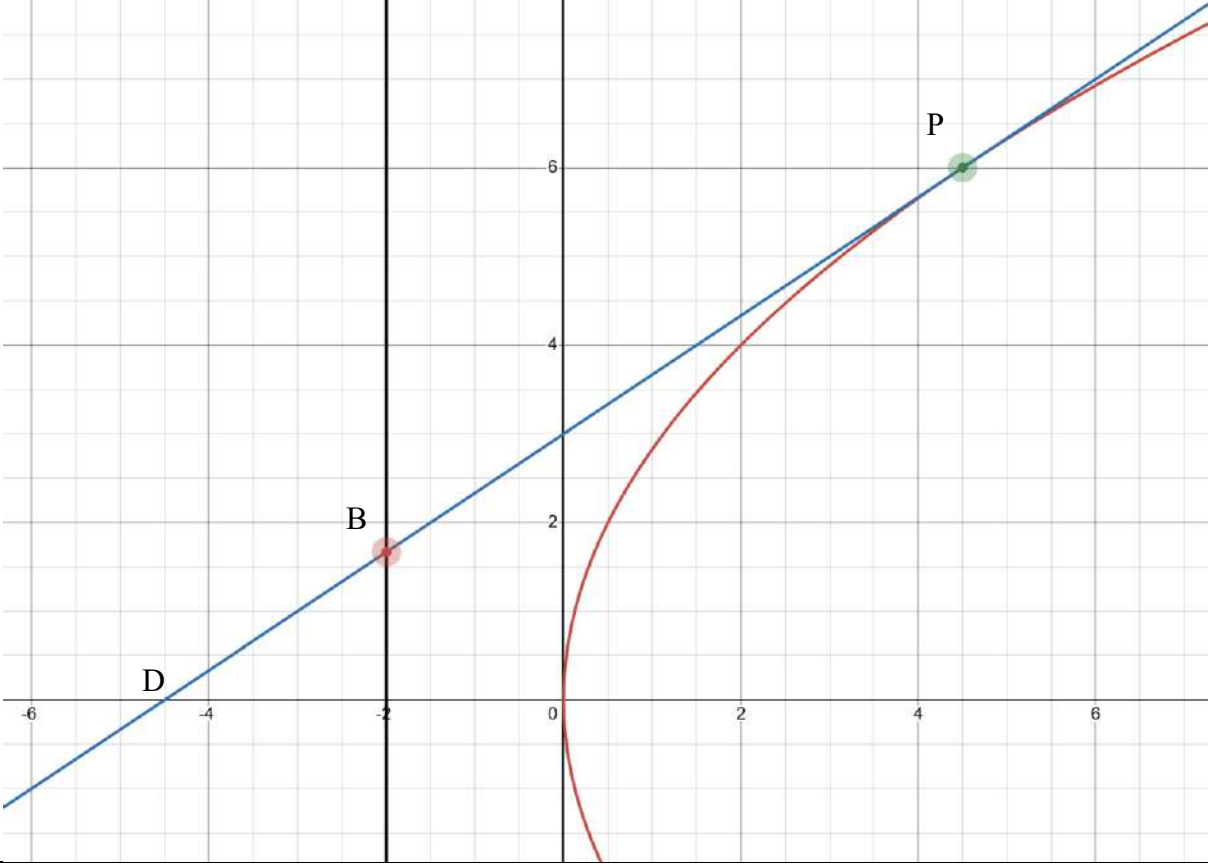
(c)

M1: Applies $\frac{1}{2}(\text{their } |OD|)(\text{their } y_p \text{ where their } y_p \neq \frac{5}{6}a)$ Allow if $OD < 0$ and a correct method in terms of a

and p e.g. $\frac{1}{2} \times -ap^2 \times 2ap$

A1: $\frac{27a^2}{8}$

Useful diagram



Question Number	Scheme	Marks
9.(a)	$\mathbf{A} = \begin{pmatrix} 6 & 4 \\ 1 & 1 \end{pmatrix}$, Area(R) = 10, $\mathbf{B} = \mathbf{A}^4$	
	$\det(\mathbf{A}) = 6(1) - 4(1)$	M1
	$\det(\mathbf{A}) \neq 0$ (so $\mathbf{A}$ is non-singular)	A1
		(2)
(b)	Area(S) = 2(10) = 20	M1A1
		(2)
(c)	Area(T) = $2^4(10)$; = 160	M1A1
		(2)
		Total 6

Notes

(a)
M1: Correct attempt at the determinant. The working for the determinant must be seen in part (a)
A1: $\det(\mathbf{A}) = 2$ or $(6 - 4)$ **and** some reference to not being zero e.g. $2 \neq 0$ is sufficient
 Stating e.g. $\det(\mathbf{A}) > 0$ etc is insufficient for this mark

(b)
M1: their $\det(\mathbf{A}) \times 10$ ($10 \div$ their $\det(\mathbf{A})$ is M0)
A1: 20

(c)
M1: (their $\det(\mathbf{A})$)⁴ $\times 10$ ($10 \div$ (their $\det(\mathbf{A})$)⁴ is M0)
A1: 160

Accept use of $\mathbf{A}^2$

e.g. $\mathbf{A}^2 = \begin{pmatrix} 40 & 28 \\ 7 & 5 \end{pmatrix} \Rightarrow |\mathbf{A}^2| = 4 \Rightarrow \text{Area}(T) = 4^2(10); = 160$ Is acceptable

M1: (their $\det(\mathbf{A}^2)$)² $\times 10$
A1: 160

BUT there must be no attempt to evaluate $\mathbf{A}^4$ to give $\det \mathbf{A}^4 = 16$

If they think $\det(\mathbf{A}) = \frac{1}{\det(\mathbf{A})}$ then no marks in (a) but allow M's in (b) and (c).

So e.g. if they have $\det(\mathbf{A}) = \frac{1}{6-4} = \frac{1}{2}$ in (a) then M0A0 in (a)

But if they then have $10 \times \frac{1}{2}$ in (b) this can score M1A0 in (b)

If they have $10 \times \left(\frac{1}{2}\right)^4$ in (c) then this can score M1A0 in (c)

$$\text{NB } \mathbf{A}^4 = \begin{pmatrix} 6 & 4 \\ 1 & 1 \end{pmatrix}^4 = \begin{pmatrix} 1796 & 1260 \\ 315 & 221 \end{pmatrix}$$

Question Number	Scheme	Marks
	Condone working in other letters such as n etc	
10	If $n = 1$, $\sum_{r=1}^n r^2(2r-1) = 1$ and $\frac{1}{6}n(n+1)(3n^2+n-1) = 1$, (LHS=RHS) (so true for $n = 1$).	B1
	$\sum_{r=1}^{k+1} r^2(2r-1) = \frac{1}{6}k(k+1)(3k^2+k-1) + (k+1)^2(2(k+1)-1)$	M1
	$= \frac{1}{6}(k+1)(3k^3+13k^2+17k+6)$ or $= \frac{1}{6}(k^2+3k+2)(3k^2+7k+3)$	A1
	$= \frac{1}{6}(k+1)(k+2)(3k^2+7k+3) = \frac{1}{6}(k+1)((k+1)+1)(3(k+1)^2+(k+1)-1)$	A1
	True for $n = k + 1$ if true for $n = k$, and as true for $n = 1$ true (by induction) for all n. (true for $n = 1$ may be stated at the start and not at the end which is fine)	A1cso
		(5)
		(Total 5)

Notes

The conclusion may be given as a narrative throughout the question, or it may be stated at the end, but the statements in bold are required somewhere in the solution

In all working condone the occasional missing bracket etc if recovered

- B1:** Shows true for $n = 1$. Don't need to see the substitution explicitly, but need to see that both sides have been evaluated when $n = 1$ and arrive at 1 for both sides- getting 1 for both sides is sufficient. Don't need to explicitly say LHS = RHS but must show clearly that both sides are equivalent by evidence of evaluating both.
- M1:** Adds the $(k + 1)^{\text{th}}$ term to the sum of the first k terms.
- A1:** Obtains $\frac{1}{6}(k+1)(3k^3+13k^2+17k+6)$ **or** $= \frac{1}{6}(k^2+3k+2)(3k^2+7k+3)$ from correct work (i.e. extracts 'first' linear factor or expresses as the product of two quadratics, and allow one term to be unsimplified after the $1/6$ has been extracted).
- A1:** Achieves this result with no errors and $3k^2+7k+3$ seen (i.e. extracts 'second' linear factor and progresses to showing the correct form required with $n = k + 1$). Condone ' $k + 2$ ' in place of ' $(k + 1) + 1$ '
- Allow work that shows equivalence between**
e.g. $\frac{1}{6}(k+1)(3k^3+13k^2+17k+6)$ and $\frac{1}{6}(k+1)(k+2)(3(k+1)^2+(k+1)-1)$
- A1:** Full conclusion and all previous marks scored. As long as the conclusion is conveyed throughout the solution then this mark can be scored if all previous marks are scored.

For the final mark

True for $n = k \Rightarrow$ true for $n = k + 1$, and as/if true for $n = 1$, true for all $n \in \mathbb{N}$ (or $n \in \mathbb{Z}^+$ or integers)

Or

True for $n = k + 1$ when true for $n = k$ and as/if true for $n = 1$, true for all $n \in \mathbb{N}$ (or $n \in \mathbb{Z}^+$ or integers)

Condone 'true for all $n \in \mathbb{Z}$ ' but do not allow 'true for $n \in \mathbb{R}$ ' or just 'true'

Accept 'correct/it works for' in place of 'true'

Note that some candidates may resort to 'assume true for $n = k + 1$ and show true for $n = k + 2$ etc which marks the same way as above

$$\mathbf{M1:} \sum_{r=1}^{k+2} r^2(2r-1) = \frac{1}{6}(k+1)(k+2)(3(k+1)^2 + (k+1) - 1) + (k+2)^2(2(k+2) - 1)$$

$$\mathbf{A1:} = \frac{1}{6}(k+2)(3k^3 + 22k^2 + 52k + 39)$$

$$\mathbf{A1:} = \frac{1}{6}(k+2)(k+3)(3k^2 + 13k + 13) = \frac{1}{6}(k+2)(k+3)(3(k+2)^2 + (k+2) - 1)$$

A1: Full conclusion and all previous marks scored.

If there are any attempts you are not sure about, please send to review

Any attempts which do not use proof by induction score 0 marks

Please check the examination details below before entering your candidate information

Candidate surname		Other names	
Centre Number		Candidate Number	

Pearson Edexcel International Advanced Level

Monday 12 January 2026

Morning (Time: 1 hour 30 minutes) **Paper reference** **WFM01/01**

Mathematics ▲ ▲

International Advanced Subsidiary/ Advanced Level

Further Pure Mathematics F1

You must have:
Mathematical Formulae and Statistical Tables (Yellow), calculator

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 10 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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1.

$$f(x) = 3\sqrt{x} - \frac{1}{x} - 5 \quad x > 0$$

The equation $f(x) = 0$ has a root α in the interval $[3, 3.8]$

- (a) Starting with the end points of this interval, use interval bisection to determine α to one decimal place.

(4)

- (b) (i) Determine $f'(x)$

(2)

- (ii) Using your answer to part (a) as a first approximation to α , apply the Newton-Raphson process once to calculate a further approximation for α , giving your answer to 4 decimal places.

(2)



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Question 1 continued

(Total for Question 1 is 8 marks)



2.

$$f(z) = z^4 + \lambda z^3 + 14z^2 + 9\lambda z + 45 \quad \lambda \in \mathbb{R}$$

(a) Show that $f(3i) = 0$ (2)

(b) Hence determine the exact range of values of λ for which the equation $f(z) = 0$ has no real solutions. (5)



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Question 2 continued

Handwriting practice area with horizontal lines.

(Total for Question 2 is 7 marks)



3. Given that $\mathbf{A}$ and $\mathbf{B}$ are non-singular matrices and $\mathbf{BAB} = \mathbf{I}$, where $\mathbf{I}$ is the identity matrix,

(a) show that $\mathbf{A} = \mathbf{B}^{-1} \mathbf{B}^{-1}$

(1)

Given also that $\mathbf{B} = \begin{pmatrix} 3 & k \\ -4 & -2k \end{pmatrix}$ where k is a non-zero constant,

(b) determine $\mathbf{A}$ in terms of k

(4)



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Question 3 continued

Handwriting practice area with horizontal lines.

(Total for Question 3 is 5 marks)



4. The parabola C has equation $y^2 = 8x$

The line l

- passes through the focus of C
- has gradient $\frac{8}{15}$
- meets C at the point G where $y > 0$
- meets C at the point H where $y < 0$

- (a) Determine the coordinates of G and the coordinates of H

(6)

The midpoint of the line segment GH is M

- (b) Determine the shortest distance from M to the directrix of C

(2)



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Question 4 continued

Lined area for writing the answer to Question 4.



Question 4 continued

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Question 4 continued

(Total for Question 4 is 8 marks)



5.

$$\mathbf{A} = \begin{pmatrix} \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{pmatrix}$$

- (a) Describe fully the single geometric transformation represented by the matrix $\mathbf{A}$ (2)

The matrix $\mathbf{B}$ represents an enlargement with centre $(0,0)$ and scale factor $2\sqrt{2}$

- (b) Write down matrix $\mathbf{B}$ (1)

Given that

- $\mathbf{I}$ is the identity matrix
- the transformation represented by $(\mathbf{A} + \mathbf{I})$ followed by the transformation represented by $\mathbf{B}$ is represented by the matrix $\mathbf{C}$
- the triangle T is transformed by $\mathbf{C}$ to the triangle T'
- T' has an area of $12(1 + \sqrt{2})$

- (c) determine, in simplest form, the exact area of T



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Question 5 continued

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Question 6 continued

(Total for Question 6 is 7 marks)



7.

$$z = \frac{3 + (k\sqrt{3})i}{2 + (\sqrt{3})i} \quad k \in \mathbb{Z}$$

(a) Express z in the form $a + bi$ where a and b are real functions of k .

(3)

Given that $\arg z = \frac{\pi}{6}$

(b) determine the exact value of $|z|$

(5)



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Question 7 continued

(Total for Question 7 is 8 marks)



8. (a) Use the standard results for summations to show that

$$\sum_{r=1}^n (2r-1)^2 = \frac{n}{3}(An^2 + B)$$

where A and B are integers to be determined.

(5)

- (b) Use the answer to part (a) to determine the value of

$$25^2 + 27^2 + 29^2 + \dots + 95^2$$

You must make your method clear.

(3)



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Question 9 continued

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Question 9 continued

(Total for Question 9 is 11 marks)



10. A sequence of numbers $u_1, u_2, u_3, \dots$ is defined by

$$u_1 = 8 \quad u_2 = 10$$

$$u_{n+2} = u_{n+1} + 2u_n \quad n \in \mathbb{Z}^+$$

Prove by induction that, for $n \in \mathbb{Z}^+$

$$u_n = 3 \times 2^n - 2 \times (-1)^n \quad (6)$$



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Question 10 continued

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(Total for Question 10 is 6 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (Final)

January 2026

Pearson Edexcel International Advanced Level in Pure
Mathematics

WFM01/01

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Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus

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January 2026

Question Paper Log Number P78907A

Publication Code WFM01_01_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)

Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN:

- bod – benefit of doubt
 - ft – follow through
 - the symbol $\checkmark$ will be used for correct ft
 - cao – correct answer only
 - cso – correct solution only. There must be no errors in this part of the question to obtain this mark
 - isw – ignore subsequent working
 - awrt – answers which round to
 - SC – special case
 - oe – or equivalent (and appropriate)
 - d... or dep – dependent
 - indep – independent
 - dp – decimal places
 - sf – significant figures
 - * – The answer is printed on the paper or ag- answer given
 - $\square$ or d... – The second mark is dependent on gaining the first mark
4. All A marks are 'correct answer only' (cao), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. If you are using the annotation facility on ePEN, indicate this action by 'MR' in the body of the script.
6. If a candidate makes more than one attempt at any question:
 - a) If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - b) If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
7. Ignore wrong working or incorrect statements following a correct answer.

Question Number	Scheme	Marks
1	$f(x) = 3\sqrt{x} - \frac{1}{x} - 5$ [3, 3.8]	
(a)	$f(3) = -0.1371809...$ (awrt -0.14 or -0.13). [$f(3.8) = 0.5849187...$ (awrt 0.58)] $f(3.4) = 0.2376090...$ (awrt 0.24 or 0.23 or just 0.2)	M1 A1
	$f(3.2) = 0.0540631...$ (awrt 0.05) $f(3.1) = -0.0405355...$ (awrt -0.04)	dM1
	$f(3.15) = 0.007011487...$ (awrt 0.007) $\Rightarrow \alpha \approx 3.1$	A1
		(4)
(b)(i)	$f'(x) = \frac{3}{2}x^{-\frac{1}{2}} + x^{-2}$ or e.g., $\frac{3}{2\sqrt{x}} + \frac{1}{x^2}$	M1 A1
		(2)
(b)(ii)	$\{x_0 = "3.1", \alpha = \}$ $"3.1" - \frac{f("3.1")}{f'("3.1")} = 3.1 - \frac{3\sqrt{3.1} - \frac{1}{3.1} - 5}{\frac{3}{2\sqrt{3.1}} + \frac{1}{3.1^2}} = ...$	M1
	$\left\{ = 3.1 - \frac{-0.0405...}{0.95600...} \right\} = 3.1424(01196)$	A1
		(2)

Total 8

Notes

(a) NB Use of linear interpolation will score no marks for part (a).
M1: Attempts a value for $f(3.4)$ **and** either $f(3)$ or $f(3.8)$ with one correct to 2dp (rounded or truncated)
A1: Correct value for $f(3.4)$ to at least 1s.f. which may be rounded or truncated if full figure not seen.
dM1: Requires previous M mark. Proceeds to calculate values for $f(3.2)$ and then $f(3.1)$, or appropriate evaluations for their results to narrow to within a 0.1 range, with at least one correct evaluation.
Useful values: $f(3.3) = 0.1464...$ $f(3.5) = 0.3267...$, $f(3.6) = 0.4143...$, $f(3.7) = 0.5003...$
A1: 3.1 following calculation of $f(3.15)$ and all correct values. May use x or “root” = There is no requirement for “ $f(x)$ continuous” or “sign change” or any reasoning. Ignore if they proceed with further evaluations (e.g. $f(3.125)$).
SC: 3.1 following signs of values only (e.g., “ $f(3) = -ve...$ ”) is max 1010

(b)(i)
M1: For either $3x^{\frac{1}{2}} \rightarrow px^{-\frac{1}{2}}$ or $x^{-1} \rightarrow qx^{-2}$ oe
A1: Fully correct differentiation (any equivalent form)

(ii)
M1: Applies correct Newton-Raphson formula with their 3.1 or other appropriate value and their $f'(x)$ and obtains a value. Accept for method seen a correct statement of the formula followed by a value (no need to see the substitution but the formula must be shown).
This mark can be implied by awrt 3.1424 as long as the answer to (a) was 3.1 and (b)(i) was correct, otherwise working must be seen.
If there was no answer to part (a) allow for a correct application with their chosen starting value, but method must be seen. Allow if they use an unrounded value from (a) etc.
A1: awrt 3.1424 following a correct derivative and 3.1 used and ignore further iterations (isw).
Note the exact root is 3.1426 [3.142593527]

Question Number	Scheme	Marks
2	$f(z) = z^4 + \lambda z^3 + 14z^2 + 9\lambda z + 45$	
(a)	$\{f(3i) = (3i)^4 + \lambda(3i)^3 + 14(3i)^2 + 9\lambda(3i) + 45$ $= 81i^4 + 27\lambda i^3 + 126i^2 + 27\lambda i + 45$ $= 81 - 27\lambda i - 126 + 27\lambda i + 45$ $= 0^*$	M1 A1*
		(2)
(b)	$(z + 3i)(z - 3i) = z^2 + 9$	B1
	$\Rightarrow z^2 + \lambda z + 5$	M1 A1
	$b^2 - 4ac < 0 \Rightarrow \lambda^2 - 20 < 0$	M1
	$-2\sqrt{5} < \lambda < 2\sqrt{5}$	A1
		(5)
Total 7		
Notes		
(a) M1: Attempts $f(3i)$ and obtains 2 of the first 4 terms on line 3 in the box for (a) (ie with the powers of i dealt with correctly in two of the first four terms) A1*: Obtains 0 from correct work. (No need for a concluding comment.) (b) B1: Obtains $z^2 + 9$, may be implied (e.g. by use of product and sum of roots to directly deduce the other factor). M1: Uses $z^2 \pm kz \pm 9$ and $f(z)$ to attempt a further quadratic with real coefficients, finding at least two terms. Ignore remainder if long division used. Correct first and last terms achieved can imply the mark. If the quadratic is never directly given but working to find the middle coefficient is shown then allow the mark. A1: Correct factor. Condone work in x M1: Uses $b^2 - 4ac < 0$ or with their 3TQ. Condone ≤ 0 used for the M mark. A1: Correct exact range. Any equivalent notation e.g., $\lambda < \sqrt{20}$, or if using interval notation accept $(-2\sqrt{5}, 2\sqrt{5})$ Condone being given as separate inequalities. Must not be in terms of a variable other than λ SC 1 If they obtain an incorrect factor $z^2 - \lambda z + 5$ they could still obtain the correct final answer and we will allow B1M1A0M1A1 in such cases. SC 2 Some are finding a quadratic factor $z^2 + bz + 5$ without finding b in terms of λ, going to apply $b^2 - 20 < 0$ and only changing b to λ later without any clear justification. We will allow SC max B1M1A0M1A1 for such cases.		

Question Number	Scheme	Marks
3	$BAB = I$ $B = \begin{pmatrix} 3 & k \\ -4 & -2k \end{pmatrix}$	
(a)	$B^{-1}BAB B^{-1} = B^{-1}IB^{-1} \Rightarrow A = B^{-1}B^{-1}$	B1*
(1)		
(b)	$\det B (= -6k + 4k) = -2k$	B1
	$\text{Adj}(B) = \begin{pmatrix} -2k & -k \\ 4 & 3 \end{pmatrix}$	B1
	$A = B^{-1}B^{-1} = \begin{pmatrix} -\frac{1}{2k} \end{pmatrix} \begin{pmatrix} -2k & -k \\ 4 & 3 \end{pmatrix} \begin{pmatrix} -\frac{1}{2k} \end{pmatrix} \begin{pmatrix} -2k & -k \\ 4 & 3 \end{pmatrix} = \dots$	M1
	$\frac{1}{4k^2} \begin{pmatrix} 4k^2 - 4k & 2k^2 - 3k \\ -8k + 12 & -4k + 9 \end{pmatrix}$ or $\begin{pmatrix} 1 - \frac{1}{k} & \frac{1}{2} - \frac{3}{4k} \\ \frac{3}{k^2} - \frac{2}{k} & \frac{9}{4k^2} - \frac{1}{k} \end{pmatrix}$ oe	A1
(4)		
Total 5		

Notes
(a) B1*: Correct proof. Minimum as shown. May be done in stages but the multiplications must be on consistent sides in such cases. The $B^{-1}B$ and BB^{-1} must be seen or explained. (b) B1: $\det B = -2k$ must be simplified but may be implied. B1: Correct $\text{Adj}(B)$. Ignore any incorporated determinant. M1: Attempts $B^{-1}B^{-1}$ with their $B^{-1} = \frac{1}{\text{their } \det B} \begin{pmatrix} \text{changed} \\ \text{matrix} \end{pmatrix}$ using row by column multiplication (evidenced in at least two entries). Note they may start with this line. A1: Correct A from correct work. Any equivalent and isw any incorrect simplifications. Condone missing closing bracket. SC if $\frac{1}{\det B}$ in a stated formula becomes $-2k$ in error, treat this as a correct determinant but incorrect application of the determinant for B1B1M0A0. Alt: May find B^2 first and then find the inverse of this. Allow B1 for correct squared matrix $\begin{pmatrix} 9 - 4k & 3k - 2k^2 \\ -12 + 8k & -4k + 4k^2 \end{pmatrix}$, B1ft for correct unsimplified determinant of their squared matrix $(9 - 4k)(4k^2 - 4k) - (12 - 8k)(2k^2 - 3k)$, M1 for correct attempt at inverse and A1 for correct answer $\frac{1}{(9 - 4k)(4k^2 - 4k) - (12 - 8k)(2k^2 - 3k)} \begin{pmatrix} -4k + 4k^2 & -3k + 2k^2 \\ 12 - 8k & 9 - 4k \end{pmatrix}$. May see some unsimplified discriminants this method.

Question Number	Scheme	Marks
4(a)	Focus is (2, 0)	B1
	$y - 0 = \frac{8}{15}(x - 2)$ or $y = \frac{8}{15}x + c \Rightarrow c = -\frac{8}{15} \times 2 = \dots$	M1
	$y = \frac{8}{15}x - \frac{16}{15}, \quad y^2 = 8x$ $\Rightarrow y^2 = 15y + 16 \Rightarrow y^2 - 15y - 16 = 0$ or $\frac{64}{225}x^2 - \frac{256}{225}x + \frac{256}{225} = 8x \Rightarrow 8x^2 - 257x + 32 = 0$	M1
	$(y + 1)(y - 16) = 0 \Rightarrow y = -1, 16$ or $(8x - 1)(x - 32) = 0 \Rightarrow x = \frac{1}{8}, 32$	M1
	$\left(\frac{1}{8}, -1\right) \quad (32, 16)$	A1 A1
(6)		
(b)	$\frac{"32" + "\frac{1}{8}"}{2} + 2 = \dots$	M1
	$\frac{289}{16}$	A1
(2)		
Total 8		
Notes		
(a) B1: Correct focus seen or used. M1: Forms the equation of l correctly with their focus. M1: Eliminates x or y to obtain a 3TQ in y or x. Alt: you may see $y = (\pm)\sqrt{8}\sqrt{x} \Rightarrow \sqrt{8}\sqrt{x} = \frac{8}{15}x - \frac{16}{15} \Rightarrow 8t^2 \pm 15\sqrt{8}t - 16 = 0$ where $t = \sqrt{x}$, which is also fine for the M. Accept if only the positive root is considered, the correct points are recovered when t is squared. M1: Solves their 3TQ (usual rules, and accept if just one correct root is given for their 3TQ if no working – you may need to check). A1: One correct point, allow if not paired but at least one pair of coordinates are correct implicitly. A1: Both correct points. Accept listed rather than as coordinates as long as they are correctly paired. (b) M1: Adds 2 to the mean of their positive and distinct x coordinates. A1: $\frac{289}{16}$ or $18\frac{1}{16}$ or 18.0625 from correct x coordinates.		

Question Number	Scheme	Marks
5(a)	Rotation...	M1
	...of 45° or $\frac{\pi}{4}$ [or 315° or $\frac{7\pi}{4}$ clockwise] about (0,0)/O/the origin	A1
(2)		
(b)	$\mathbf{B} = \begin{pmatrix} 2\sqrt{2} & 0 \\ 0 & 2\sqrt{2} \end{pmatrix}$	B1
(1)		
(c)	$\mathbf{C} = \begin{pmatrix} 2\sqrt{2} & 0 \\ 0 & 2\sqrt{2} \end{pmatrix} \begin{pmatrix} \frac{1}{\sqrt{2}} + 1 & -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} + 1 \end{pmatrix} = \begin{pmatrix} 2+2\sqrt{2} & -2 \\ 2 & 2+2\sqrt{2} \end{pmatrix}$ or $\det \mathbf{B} = (2\sqrt{2})(2\sqrt{2}) - (0)(0) = 8$ and $\det(\mathbf{A} + \mathbf{I}) = \left(\frac{1}{\sqrt{2}} + 1 \right) \left(\frac{1}{\sqrt{2}} + 1 \right) - \left(\frac{1}{\sqrt{2}} \right) \left(-\frac{1}{\sqrt{2}} \right) = 2 + \sqrt{2}$	M1
	$\det \mathbf{C} = (2+2\sqrt{2})(2+2\sqrt{2}) - 2(-2) \text{ or } 8(2+\sqrt{2})$	M1
	$\text{area of } T = \frac{12(1+\sqrt{2})}{16+8\sqrt{2}}$	M1
	$\frac{3\sqrt{2}}{4}$	A1

(4)**Total 7****Notes**

- (a)**
M1: Identifies the transformation as a rotation.
A1: Fully correct description including angle and centre of rotation. Assume anticlockwise unless otherwise stated. Condone phrases such as “through the origin”.
- (b)**
B1: Correct **B**
- (c)**
M1: Attempts $\mathbf{C} = \mathbf{B}(\mathbf{A} + \mathbf{I})$ – may use $\mathbf{BA} + \mathbf{B}$ – **or** attempts both $\det \mathbf{B}$ and $\det \mathbf{A} + \mathbf{I}$. Must see evidence of the correct identity matrix. **See special case for use of $\mathbf{C} = (\mathbf{A} + \mathbf{I})\mathbf{B}$**
M1: Attempts the determinant of their **C** or via the product of their $\det \mathbf{B}$ and $\det \mathbf{A} + \mathbf{I}$. May be implied by dividing by the two determinants in turn.
M1: Correct method for the area, $12(1 + \sqrt{2}) \div |\text{their } \det \mathbf{C}|$ – must be a positive value, but allow recovery if they make the answer positive in the final line.
A1: Any correct exact value in simplest form. Allow $\frac{3}{2\sqrt{2}}$
SC: Allow M0M1M1A1 if $\mathbf{C} = (\mathbf{A} + \mathbf{I})\mathbf{B}$ is clearly used, which gives the same **C** but from incorrect order of composition. But allow full marks bod in cases where it is unclear or approaches via finding the determinants first then multiplying them in any order.

Question Number	Scheme	Marks
6	$x^2 + qx + r = 0 \quad \frac{1}{\alpha} + \frac{1}{\beta} = \frac{1}{2} \quad \alpha^2 + \beta^2 = 5$	
(a)	$\alpha + \beta = -q \quad \alpha\beta = r$	B1
		(1)
(b)	$\frac{\alpha + \beta}{\alpha\beta} = \frac{1}{2} \left\{ = \frac{"-q"}{"r"} \right\}$	M1
	$(\alpha + \beta)^2 - 2\alpha\beta = 5 \left\{ = (" - q")^2 - 2"r" = 5 \right\}$	M1
	$\alpha + \beta = \frac{1}{2}\alpha\beta \Rightarrow \frac{1}{4}(\alpha\beta)^2 - 2\alpha\beta = 5 \Rightarrow (\alpha\beta)^2 - 8\alpha\beta - 20 = 0$ or $-q = \frac{1}{2}r \Rightarrow \left(\frac{1}{2}r\right)^2 - 2r = 5$ $\Rightarrow r^2 - 8r - 20 = 0$	A1
		(3)
(c)	$(r+2)(r-10)=0 \quad \text{or} \quad (\alpha\beta+2)(\alpha\beta-10)=0$ $\Rightarrow r \quad \text{or} \quad \alpha\beta = -2, 10$	M1
	$(r = -2, 10 \Rightarrow q = 1, -5$ $\text{or} \quad \alpha\beta = -2, 10 \Rightarrow \alpha + \beta = -1, 5)$	
	$\Rightarrow \{f(x)\} \quad x^2 + x - 2, \quad x^2 - 5x + 10$	M1 A1
		(3)
		Total 7
Notes		
(a) B1: Both correct, may be indicated by (i) and (ii) if not explicitly labelled. (b) M1: States or uses $\frac{1}{\alpha} + \frac{1}{\beta} = \frac{\alpha + \beta}{\alpha\beta}$ M1: States or uses $\alpha^2 + \beta^2 = (\alpha + \beta)^2 - 2\alpha\beta$ or equivalent work A1: Obtains $r^2 - 8r - 20 = 0$ (c) M1: Solves their 3TQ (usual rules). Allow for solving a 3TQ in q if they eliminate r instead of q in (b). M1: Finds a value of q or $\alpha + \beta$ for one of their non-zero r or $\alpha\beta$ values (or vice versa) and substitutes correctly into $x^2 + qx + r$ or $x^2 - (\alpha + \beta)x + \alpha\beta$ A1: Correct expressions (and no others).		

Question Number	Scheme	Marks
7(a)	$z = \frac{3 + (k\sqrt{3})i}{2 + (\sqrt{3})i} \times \frac{2 - (\sqrt{3})i}{2 - (\sqrt{3})i}$	M1
	$= \frac{6 + (2k\sqrt{3})i - (3\sqrt{3})i + 3k}{7}$	dM1
	$= \frac{6 + 3k}{7} + \frac{\sqrt{3}(2k - 3)}{7}i$	A1
(3)		
(b)		
	$\frac{\sqrt{3}(2k - 3)}{6 + 3k} = \frac{\sqrt{3}}{3}$	M1
	$6k - 9 = 6 + 3k \Rightarrow k = 5$	M1A1
	$\Rightarrow z = 3 + (\sqrt{3})i \Rightarrow z = \sqrt{3^2 + (\sqrt{3})^2} = \dots$	M1
	$\sqrt{12} \text{ or } 2\sqrt{3}$	A1
(5)		
Alt	$z = r\left(\cos\frac{\pi}{6} + i\sin\frac{\pi}{6}\right) = r\frac{\sqrt{3}}{2} + \frac{1}{2}ri$	M1
	$\Rightarrow 6 + 3k = \frac{7r}{2}\sqrt{3}, \quad \sqrt{3}(2k - 3) = \frac{7r}{2}$	M1A1
	$\Rightarrow k = \frac{1}{3}\left(\frac{7r}{2}\sqrt{3} - 6\right) \Rightarrow r = \frac{2}{7}\left(\sqrt{3}\left(\frac{2}{3}\left(\frac{7r}{2}\sqrt{3} - 6\right) - 3\right)\right) \Rightarrow r = \dots$	M1
	$r = 2\sqrt{3}$	A1
(5)		
Total 8		
Notes		
(a) M1: A correct rationalising multiplier seen or implied dM1: Obtains denominator of 7 (need not be fully simplified) and numerator of the correct form with the i^2 processed to give two real terms and two imaginary terms. A1: Any correct expression in $a + bi$ form (with single i term) or expressions for a and b. Terms in i must be factored out. (b) M1: Uses their $\frac{b}{a} = \frac{\sqrt{3}}{3}$ or $\frac{1}{\sqrt{3}}$ to form an equation in k. Condone if by error only one component of z contained a k. M0 if they leave i in the equation and never recover but allow if they later realise it should not be there and drop the i. M1: Solves for k from an equation that had at least two k's in (both components of z must have been in terms of k). Must achieve a real value, but accept any real value following a suitable equation having been set up.. A1: Correct k Allow from an incorrect denominator in (a) if all else was correct. M1: Correct method to find a value for z using their real k. E.g. uses k to find z and applies modulus, or via use of the numerator and denominator of original z and taking ratio of moduli, or may find z in		

terms of k first and then substitute for k . Must be correct application of the modulus in whichever method.

A1: Either correct exact value

Alt:

M1: Attempts to evaluate the polar form using $\arg z = \frac{\pi}{6}$ with evaluated trig terms.

M1: Equates coefficients to produce two equations in r and k .

A1: Correct equations.

M1: Solves the equations to find the value for r (if k is found first they must proceed to find r to score this mark).

A1: Correct answer, either form as per main scheme.

Question Number	Scheme	Marks
8(a)	$\sum_{r=1}^n (2r-1)^2 = 4 \sum_{r=1}^n r^2 - 4 \sum_{r=1}^n r + \sum_{r=1}^n 1$	M1
	$= 4 \times \frac{n}{6}(n+1)(2n+1) - 4 \times \frac{n}{2}(n+1) + n$	M1 A1
	$= n \left(\frac{2}{3}(n+1)(2n+1) - 2(n+1) + 1 \right) \text{ or } \frac{n}{3}(4n^2 + 6n + 2 - 6n - 6 + 3)$	M1
	$= \frac{n}{3}(4n^2 - 1)$	A1
(5)		
(b)	smallest = $25^2 = 13^{\text{th}}$ term or largest = $95^2 = 48^{\text{th}}$ term	B1
	$\frac{48}{3}(4 \times 48^2 - 1) - \frac{12}{3}(4 \times 12^2 - 1)$	M1
	145 140	A1
(3)		
Total 8		
Notes		
(a) M1: Expands and splits summation to obtain two correct terms. (Limits need not be shown.) M1: Uses any two of $\sum_{r=1}^n r^2 = \frac{n}{6}(n+1)(2n+1)$ or $\sum_{r=1}^n r = \frac{n}{2}(n+1)$ or $\sum_{r=1}^n 1 = n$ A1: Fully correct expression. M1: Extracts a common factor of $\frac{n}{3}$ or n from all three terms in their expression (n must be a factor), allow one slip on one term. Do not accept attempts to solve the cubic via a calculator and “build up” the solution. A1: Achieve the correct expression following the award of all the previous marks. (b) B1: Identifies either 25^2 as u_{13} or 95^2 as u_{48} M1: Attempts $f(a) - f(b)$ with their f and $a = 48$ or 47 & $b = 12$ or 13. Substitution must be seen A1: 145 140 only		

Question Number	Scheme	Marks
9(a)	$y = \frac{c^2}{x} \Rightarrow \frac{dy}{dx} = -\frac{c^2}{x^2}$ or $x \frac{dy}{dx} + y = 0$ or $\frac{dy}{dx} = \frac{\frac{dy}{dt}}{\frac{dx}{dt}} = \frac{-ct^{-2}}{c}$	B1
	$y - \frac{c}{t} = -\frac{1}{t^2}(x - ct)$ or $y = -\frac{1}{t^2}x + b \Rightarrow \frac{c}{t} = -\frac{1}{t^2}(ct) + b \Rightarrow b = \dots$	M1
	$t^2y - ct = -x + ct$ or $y = -\frac{1}{t^2}x + \frac{2c}{t} \Rightarrow t^2y = -x + 2ct$ $\Rightarrow x + t^2y = 2ct^*$	A1*
(3)		
(b)	$y - \frac{c}{t} = t^2(x - ct)$ or $y = t^2x + b \Rightarrow \frac{c}{t} = ct^3 + b \Rightarrow b = \dots \Rightarrow y = t^2x + \frac{c}{t} - ct^3$	B1ft
(1)		
(c)	At X, $y = 0 \Rightarrow x = 2ct$; At Y, $x = 0 \Rightarrow y = \frac{2c}{t}$	B1
	At Z, $x = 0 \Rightarrow y = \frac{c}{t} - ct^3$	M1
	E.g. Area $\Delta XYZ = \frac{1}{2} \left(\frac{2c}{t} - \left(\frac{c}{t} - ct^3 \right) \right) \times 2ct$	M1
	$= ct \left(\frac{c}{t} + ct^3 \right) = c^2(1 + t^4)^*$	A1*
(4)		
(d)	$c^2(1 + 3^4) = 410 \Rightarrow c = \sqrt{5} \Rightarrow P \left(3\sqrt{5}, \frac{\sqrt{5}}{3} \right)$	B1
	$PQ = 2 \times \sqrt{(3\sqrt{5})^2 + \left(\frac{\sqrt{5}}{3} \right)^2}$	M1
	$\frac{2\sqrt{410}}{3}$	A1
(3)		
Total 11		
Notes		
(a) B1: Any correct equation in $\frac{dy}{dx}$ M1: Correct straight line method with their tangent gradient in terms of t and/or c A1: Achieves given answer with an intermediate step and no errors. Accept $t^2y + x = 2ct$ No calculus can score 011 max		

(b)

B1ft: Correct equation with the negative reciprocal of their tangent gradient in terms of t and/or c . If $y = mx + b$ is used b must be correct for their t^2 and they must proceed to give the equation of the line.

(c)

B1: Correct x coordinate of X and correct y coordinate of Y . Allow if they mix up X and Y but the coordinates are correct.

M1: Uses $x = 0$ in their normal to find an expression for y at Z

M1: Correct full method for area of triangle XYZ with their coordinates. Condone for the M if they subtract y coordinates the wrong way and work with a “negative length” (but must treat the coordinate of Z correctly if combining separate triangles). Note that other methods are possible here, any correct full method is sufficient.

A1: Fully correct proof with intermediate step. Accept if the y coordinates were subtracted the wrong way but are later made positive.

Some alternative methods for the triangle area:

Using XY as base and PZ as height,

$$\begin{aligned}\text{Area } \Delta XYZ &= \frac{1}{2} XY \times PZ = \frac{1}{2} \sqrt{(2ct)^2 + \left(\frac{2c}{t}\right)^2} \sqrt{(ct)^2 + \left(\frac{c}{t} - \frac{c}{t} + ct^3\right)^2} \\ &= \frac{1}{2} 2c \sqrt{t^2 + \frac{1}{t^2}} \cdot c \sqrt{t^2 + t^6} = c^2 \sqrt{\frac{t^4 + 1}{t^2}} \sqrt{t^2(t^4 + 1)} = c^2(t^4 + 1)\end{aligned}$$

Shoelace approach,

$$\text{Area } \Delta XYZ = \frac{1}{2} \begin{vmatrix} 2ct & 0 & 0 \\ 0 & \frac{2c}{t} & \frac{c}{t} - ct^3 \end{vmatrix} = \frac{1}{2} \left(2ct \times \frac{2c}{t} - 2ct \left(\frac{c}{t} - ct^3 \right) \right) = \frac{1}{2} (4c^2 - 2c^2 + 2ct^4) = c^2(1 + t^4)$$

Separate triangles,

$$\text{Area } \Delta XYZ = \frac{1}{2} y_Y \times x_X - \frac{1}{2} y_Z \times x_X \quad \text{follows main scheme once factorised.}$$

Other combinations are possible.

(d)

B1: Correct coordinates of P

M1: Correct attempt at PQ for their P or any other full method. May find Q and then distance PQ directly for example. They may identify Q by symmetry or via a longer approach finding the equation of the line through O and P and then finding where this intersects the hyperbola again.

A1: Correct exact value

Question Number	Scheme	Marks
10	$u_1 = 8 \quad u_2 = 10 \quad u_{n+2} = u_{n+1} + 2u_n \quad n \in \mathbb{Z}^+ \quad u_n = 3 \times 2^n - 2 \times (-1)^n$	
	$n = 1 \Rightarrow u_1 = 3 \times 2^1 - 2 \times (-1)^1 = 8$ $n = 2 \Rightarrow u_2 = 3 \times 2^2 - 2 \times (-1)^2 = 10$	B1
	$u_k = 3 \times 2^k - 2 \times (-1)^k \quad u_{k+1} = 3 \times 2^{k+1} - 2 \times (-1)^{k+1}$ $u_{k+2} = u_{k+1} + 2u_k = 3 \times 2^{k+1} - 2 \times (-1)^{k+1} + 2(3 \times 2^k - 2 \times (-1)^k)$	M1 A1
	$= 3 \times 2^{k+1} - 2 \times (-1)^{k+1} + 6 \times 2^k - 4 \times (-1)^k$ $= 3 \times 2^{k+1} + 2 \times (-1)^{k+2} + 3 \times 2^{k+1} - 4 \times (-1)^{k+2}$ $= 6 \times 2^{k+1} - 2 \times (-1)^{k+2}$	M1
	$= 3 \times 2^{k+2} - 2 \times (-1)^{k+2}$	A1
	True for $n = 1$ and $n = 2$, true for $n = k + 2$ when assumed true for $n = k$ and $n = k + 1$, true for all $n \in \mathbb{Z}^+$	A1

(6)

Total 6

Notes

- B1: Uses general formula to obtain $u_1 = 8$ and $u_2 = 10$ with substitution seen, as a minimum accept $u_1 = 3 \times 2 - 2 \times -1 = 8$ and $u_2 = 3 \times 4 - 2 \times 1 = 10$. No need to state true for $n = 1$ and $n = 2$ here, but if it is stated it can count as part of the conclusion. Ignore attempts at further terms.
- M1: Begins the inductive step by attempting the recurrence relation with expressions from the formula for u_k and u_{k+1} . No required to state the assumption. They may work from k to $k - 2$ rather than $k + 2$ to k , or even $k + 1$ to $k - 1$ and accept if they are working in n instead of k . Allow slips as long as they are trying to substitute in the correct places.
- A1: Correct expression for u_{k+2} or their appropriate term in terms of k (or n) only, condoning for this mark if they have e.g. (-1^k) instead of $(-1)^k$ as slip.
- M1: Combines terms to $p \times 2^{\dots} + q \times (-1)^{\dots}$ where ... are functions of k (or n) by *matching the powers* before the target expression. The indices need not be the required ones at this stage e.g. reaching $6 \times 2^{k+1} - 2 \times (-1)^k$ is fine. Not dependent on the previous M but some attempt at the using the recurrence relation must have been made.
- A1: Correct expression from fully correct work. Must have the correct powers, $k + 2$ or appropriate for their step. Bracketing around the (-1) 's must have been correct.
- A1: Requires all previous marks. Correct conclusion given, which may be in stages. E.g. "True for $n = 1$ and $n = 2$ " may have been given at the start, but the "if true for $n = k + 1$ and $n = k$ then shown true for $n = k + 2$ " and "true for all n " must be given in the final conclusion. Must have both preceding cases including, though strong induction may be used (ie "if true for all $k < n$ then true for n "). The logic in the conclusion must be correct, so stating "true for $n = k, k + 1$ and $k + 2$ " or similar without the "if.. then" connotation is A0.

Pearson Edexcel International Advanced Level

Friday 16 January 2026

Morning (Time: 1 hour 30 minutes)

Paper

reference

WFM02/01A

Mathematics

International Advanced Subsidiary/Advanced Level

Further Pure Mathematics F2

Question paper

You must have: Answer book (sent separately).

Do not return this question paper with the answer book.

Turn over ►

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Pearson

1. Solve the equation

$$z^5 = 32$$

Give your answers in the form $r(\cos \theta + i \sin \theta)$, where $r > 0$ and $0 \leq \theta < 2\pi$

(5)

(Total for Question 1 is 5 marks)

2. **In this question you must show all stages of your working.**
Solutions relying entirely on calculator technology are not acceptable.

Use algebra to find the set of values of x for which

$$|x^2 - 9| < |1 - 2x|$$

(6)

(Total for Question 2 is 6 marks)

3.

$$(\cos x) \frac{dy}{dx} + (\sin x)y = 2 \cos^3 x \sin x - 3 \quad 0 \leq x < \frac{\pi}{2}$$

(a) Find the general solution of this differential equation.
Give your answer in the form $y = f(x)$.

(7)

(b) Find the particular solution of this differential equation for
which $y = 3\sqrt{3}$ at $x = \frac{\pi}{3}$

Give your answer in the form $y = f(x)$.

(3)

(Total for Question 3 is 10 marks)



4. (a) Express $\frac{4r+2}{r(r+1)(r+2)}$ in partial fractions. (3)

(b) Hence, using the method of differences, prove that

$$\sum_{r=1}^n \frac{4r+2}{r(r+1)(r+2)} = \frac{n(an+b)}{2(n+1)(n+2)}$$

where a and b are constants to be found. (5)

(Total for Question 4 is 8 marks)

5. Given that

$$(2-x^2)\frac{d^2y}{dx^2} + 5x\left(\frac{dy}{dx}\right)^2 = 3y$$

(a) show that

$$\frac{d^3y}{dx^3} = \frac{1}{(2-x^2)} \left(2x \frac{d^2y}{dx^2} \left(1 - 5 \frac{dy}{dx} \right) - 5 \left(\frac{dy}{dx} \right)^2 + 3 \frac{dy}{dx} \right) \quad (5)$$

Given also that $y = 3$ and $\frac{dy}{dx} = \frac{1}{4}$ at $x = 0$

- (b) obtain a series solution for y in ascending powers of x with simplified coefficients, up to and including the term in x^3 (4)

(Total for Question 5 is 9 marks)

6. (a) Find the general solution of the differential equation

$$\frac{d^2y}{dx^2} - 6\frac{dy}{dx} + 8y = 2x^2 + x \quad (8)$$

(b) Find the particular solution of this differential equation for which

$$y = 1 \text{ and } \frac{dy}{dx} = 0 \text{ when } x = 0 \quad (5)$$

(Total for Question 6 is 13 marks)

7. (a) Show that

$$\left(z + \frac{1}{z}\right)^3 \left(z - \frac{1}{z}\right)^3 = z^6 - \frac{1}{z^6} - k \left(z^2 - \frac{1}{z^2}\right)$$

where k is a constant to be found.

(3)

Given that $z = \cos \theta + i \sin \theta$, where θ is real,

(b) show that

(i) $z^n + \frac{1}{z^n} = 2 \cos n\theta$

(ii) $z^n - \frac{1}{z^n} = 2i \sin n\theta$

(3)

(c) Hence show that

$$\cos^3 \theta \sin^3 \theta = \frac{1}{32} (3 \sin 2\theta - \sin 6\theta)$$

(4)

(d) Use algebraic integration to find the exact value of

$$\int_0^{\frac{\pi}{8}} \cos^3 \theta \sin^3 \theta d\theta$$

(4)

(Total for Question 7 is 14 marks)



8.

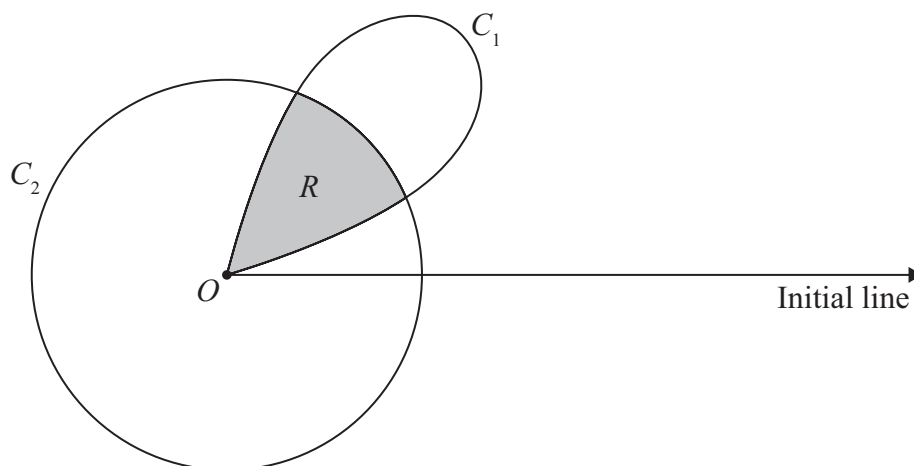


Figure 1

**In this question you must show all stages of your working.
Solutions relying entirely on calculator technology are not acceptable.**

Figure 1 shows the curve C_1 with polar equation $r = 2a \sin 2\theta$, $0 \leq \theta \leq \frac{\pi}{2}$, and the circle C_2 with polar equation $r = a$, $0 \leq \theta \leq 2\pi$, where a is a positive constant.

- (a) Find, in terms of a , the polar coordinates of the points where the curve C_1 meets the circle C_2 (3)

The regions enclosed by the curve C_1 and the circle C_2 overlap and the common region R is shaded in Figure 1.

- (b) Use algebraic integration to find the area of the shaded region R , giving your answer in the form $\frac{1}{12}a^2(p\pi + q\sqrt{3})$, where p and q are integers. (7)

(Total for Question 8 is 10 marks)

TOTAL FOR PAPER IS 75 MARKS

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Please check the examination details below before entering your candidate information

Candidate surname					Other names				
Centre Number					Candidate Number				

Pearson Edexcel International Advanced Level

Friday 16 January 2026

Morning (Time: 1 hour 30 minutes) **Paper reference** **WFM02/01A**

Mathematics

International Advanced Subsidiary/Advanced Level

Further Pure Mathematics F2

Answer Book

You must have:

Question paper (sent separately)

Mathematical Formulae and Statistical Tables (Yellow), calculator

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 8 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

P87655A

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C:1/



Question 1

Write the answer to Question 1 on these 2 pages

DO NOT WRITE IN THIS AREA

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DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA

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(Total for Question 1 is 5 marks)



P 8 7 6 5 5 A 0 3 2 8

Question 2

Write the answer to Question 2 on these 2 pages

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(Total for Question 2 is 6 marks)



Question 3

Write the answer to Question 3 on these 4 pages

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P 8 7 6 5 5 A 0 7 2 8

Question 3 continued

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(Total for Question 3 is 10 marks)



Question 4

Write the answer to Question 4 on these 4 pages

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Question 4 continued

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(Total for Question 4 is 8 marks)



Question 5

Write the answer to Question 5 on these 4 pages

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Question 5 continued

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(Total for Question 5 is 9 marks)



Question 6

Write the answer to Question 6 on these 4 pages

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Question 6 continued

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Question 7

Write the answer to Question 7 on these 4 pages

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DO NOT WRITE IN THIS AREA



Question 7 continued

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(Total for Question 7 is 14 marks)



Question 8

Write the answer to Question 8 on these 3 pages

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DO NOT WRITE IN THIS AREA



Question 8 continued

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DO NOT WRITE IN THIS AREA

(Total for Question 8 is 10 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (Results)

January 2026

International Advanced Level in Further Pure Mathematics
F2

WFM02/01A

Edexcel and BTEC Qualifications

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January 2026

Question Paper Log Number P87590A

Publication Code WFM02_01A_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)

Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN:

- bod – benefit of doubt
- ft – follow through
 - the symbol $\checkmark$ will be used for correct ft
- cao – correct answer only
- cso – correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC – special case
- oe – or equivalent (and appropriate)
- d... or dep – dependent
- indep – independent
- dp – decimal places
- sf – significant figures
- * – The answer is printed on the paper or ag – answer given
- $\square$ or d... – The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread

however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. If you are using the annotation facility on ePEN, indicate this action by 'MR' in the body of the script.
6. If a candidate makes more than one attempt at any question:
 - a) If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - b) If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
7. Ignore wrong working or incorrect statements following a correct answer.

EDEXCEL IAL MATHEMATICS

General Principles for Further Pure Mathematics Marking

(NB specific mark schemes may sometimes override these general principles)

Method mark for solving 3 term quadratic:

- Factorisation
 - $(x^2 + bx + c) = (x + p)(x + q)$, where $|pq| = |c|$, leading to $x = \dots$
 - $(ax^2 + bx + c) = (mx + p)(nx + q)$, where $|pq| = |c|$ and $|mn| = |a|$, leading to $x = \dots$
- Formula
 - Attempt to use the correct formula (with values for a , b and c).
- Completing the square
 - Solving $x^2 + bx + c = 0$: $\left(x \pm \frac{b}{2}\right)^2 \pm q \pm c = 0$, $q \neq 0$, leading to $x = \dots$

Method marks for differentiation and integration:

- Differentiation
 - Power of at least one term decreased by 1. ($x^n \rightarrow x^{n-1}$)
- Integration
 - Power of at least one term increased by 1. ($x^n \rightarrow x^{n+1}$)

Use of a formula

Where a method involves using a formula that has been learnt, the advice given in recent examiners' reports is that the formula should be quoted first. Normal marking procedure is as follows:

- Method mark for quoting a correct formula and attempting to use it, even if there are small errors in the substitution of values.
- Where the formula is not quoted, the method mark can be gained by implication from correct working with values but may be lost if there is any mistake in the working.

Exact answers

Examiners' reports have emphasised that where, for example, an exact answer is asked for, or working with surds is clearly required, marks will normally be lost if the candidate resorts to using rounded decimals.

Answers without working

The rubric says that these may not gain full credit. Individual mark schemes will give details of what happens in particular cases. General policy is that if it could be done "in your head", detailed working would not be required. Most candidates do show working, but there are occasional awkward cases and if the mark scheme does not cover this, please contact your team leader for advice.

1. Solve the equation

$$z^5 = 32$$

Give your answers in the form $r(\cos \theta + i \sin \theta)$, where $r > 0$ and $0 \leq \theta < 2\pi$

(5)

(Total for Question 1 is 5 marks)

Question Number	Scheme	Marks
1	$r = 2$	B1
	At least one of $\theta = 0, \frac{2\pi}{5}, \frac{4\pi}{5}, \frac{6\pi}{5}, \frac{8\pi}{5}$ oe	B1
	At least 3 of $\theta = 0, \frac{2\pi}{5}, \frac{4\pi}{5}, \frac{6\pi}{5}, \frac{8\pi}{5}$ oe	M1
	$r = 2$, and at least 3 of: $\theta = 0, \frac{2\pi}{5}, \frac{4\pi}{5}, \frac{6\pi}{5}, \frac{8\pi}{5}$	A1
	All correct: $r = 2, \theta = 0, \frac{2\pi}{5}, \frac{4\pi}{5}, \frac{6\pi}{5}, \frac{8\pi}{5}$	A1
		(5)

Notes

B1: $r = 2$ which may be implied by their answers.

B1: For at least **one** correct argument e.g. one of $\theta = 0, \frac{2\pi}{5}, \frac{4\pi}{5}, \frac{6\pi}{5}, \frac{8\pi}{5}$ but allow a correct value out of range e.g. at least one of $-\frac{2\pi}{5}, -\frac{4\pi}{5}, -\frac{6\pi}{5}, -\frac{8\pi}{5}$ which may be implied by their answers.

Note that $z = 2$ implies both B marks.

M1: For at least 3 correct and **distinct arguments** which may be out of range as above. May be implied by their answers. Allow r to be incorrect for this mark.

A1: For the correct value of r and at least 3 correct and distinct arguments **in range**.

e.g. $r = 2$ with any 3 of $\theta = 0, \frac{2\pi}{5}, \frac{4\pi}{5}, \frac{6\pi}{5}, \frac{8\pi}{5}$ which may be implied by their answers.

A1: For the correct value of r and all correct arguments **in range**.

e.g. $r = 2$ with $\theta = 0, \frac{2\pi}{5}, \frac{4\pi}{5}, \frac{6\pi}{5}, \frac{8\pi}{5}$ which may be implied by their answers.

Ignore extra answers outside the range.

For a fully correct solution that has extra solutions in range, deduct the final A mark.

Answers in **degrees**: Penalise once the first time it occurs but do not penalise 0°

For reference: Angles in degrees are: 0, 72, 144, 216, 288

If they subsequently convert the angles to radians then allow recovery.

Note that answers in a general form can score full marks if correct.

e.g. these score full marks:

$$z = 2 \left(\cos \frac{2k\pi}{5} + i \sin \frac{2k\pi}{5} \right), (k = 0, 1, 2, 3, 4): r = 2, \theta = 0, \frac{2\pi}{5}, \frac{4\pi}{5}, \frac{6\pi}{5}, \frac{8\pi}{5}$$

$$(z =) 2e^{i \frac{2k\pi}{5}}, (k = 0, 1, 2, 3, 4)$$

But

$$z = 2 \left(\cos \frac{2k\pi}{5} + i \sin \frac{2k\pi}{5} \right) \text{ scores B1 only.}$$

Note that if $r = 2$ with $\theta = 0, \frac{2\pi}{5}, \frac{4\pi}{5}, \frac{6\pi}{5}, \frac{8\pi}{5}$ is found and the solutions are then formed

incorrectly e.g. $z = 2 \left(\cos \frac{2\pi}{5} + i \sin \frac{2\pi}{5} \right)$ or e.g. $2e^{i \frac{2\pi}{5}}$ then isw can be applied.

2.

**In this question you must show all stages of your working.
Solutions relying entirely on calculator technology are not acceptable.**

Use algebra to find the set of values of x for which

$$|x^2 - 9| < |1 - 2x|$$

(6)

(Total for Question 2 is 6 marks)

Question Number	Scheme	Marks
2	$ x^2 - 9 < 1 - 2x $ (ignore use of any strict/non-strict inequalities instead of “=” when finding cv’s)	
	$x^2 - 9 = 1 - 2x \Rightarrow x^2 + 2x - 10 = 0 \Rightarrow x = \dots$ or $x^2 - 9 = -1 + 2x \Rightarrow x^2 - 2x - 8 = 0 \Rightarrow x = \dots$	M1
	$x = \frac{-2 \pm \sqrt{44}}{2}$ or $x = -2, 4$	A1
	$x^2 - 9 = 1 - 2x \Rightarrow x^2 + 2x - 10 = 0 \Rightarrow x = \dots$ and $x^2 - 9 = -1 + 2x \Rightarrow x^2 - 2x - 8 = 0 \Rightarrow x = \dots$	dM1
	$x = \frac{-2 \pm \sqrt{44}}{2}$ and $x = -2, 4$	A1
	One of: $-1 + \sqrt{11} < x < 4$ or $-1 - \sqrt{11} < x < -2$	A1
	Both $-1 + \sqrt{11} < x < 4$ and $-1 - \sqrt{11} < x < -2$	A1
		(6)
Notes M1: Attempts to solve $x^2 - 9 = 1 - 2x$ oe or $x^2 - 9 = -1 + 2x$ oe to obtain 2 non-zero values of x. Must be solving a 3TQ – see general guidance but also allow calculator solutions so this mark may be implied by correct values for their 3TQ (you may need to check). A1: One correct pair of values. May be seen embedded in an inequality or e.g. on a sketch. Allow the irrational roots to be at least as given here or $-1 \pm \sqrt{11}$ or awrt 2.3, -4.3 or truncated 2.3..., -4.3... dM1: Attempts to solve $x^2 - 9 = 1 - 2x$ oe and $x^2 - 9 = -1 + 2x$ oe to obtain 4 non-zero values of x. Must be solving a 3TQ – see general guidance but also allow calculator solutions so this mark may be implied by correct values for their 3TQ (you may need to check). Depends on the first method mark. A1: Both pairs of values correct. May be seen embedded in an inequality or e.g. on a sketch. Allow the irrational roots to be at least as given here or $-1 \pm \sqrt{11}$ or awrt 2.3, -4.3 or truncated 2.3..., -4.3... For the final 2 marks (which must follow both previous method marks): For $-1 + \sqrt{11}$ allow $\frac{-2 + \sqrt{44}}{2}$, for $-1 - \sqrt{11}$ allow $\frac{-2 - \sqrt{44}}{2}$ but must be exact here. Allow alternative notation e.g. $(-1 + \sqrt{11}, 4)$, $(-1 - \sqrt{11}, -2)$, $4 > x > -1 + \sqrt{11}$, $x > -1 + \sqrt{11}$ and $x < 4$, $-2 > x > -1 - \sqrt{11}$, $x > -1 - \sqrt{11}$ and $x < -2$ A1: One correct inequality. A1: Both inequalities correct. Allow the inequalities to be written separately or with “,” or “or” or “and” or $\cup$ between them but not $\cap$ between them. In an otherwise fully correct solution, if any extra incorrect regions are given, deduct the final A mark.		

	Q2 Alternative by squaring (ignore use of any strict/non-strict inequalities instead of “=” when finding cv’s)	
	$(x^2 - 9)^2 = (1 - 2x)^2 \Rightarrow x^4 - 18x^2 + 81 = 1 - 4x + 4x^2$	
	$x^4 - 22x^2 + 4x + 80 = 0 \Rightarrow x = \dots$	M1
	$x = \frac{-2 \pm \sqrt{44}}{2}$ or $x = -2, 4$	A1
	$x = \frac{-2 \pm \sqrt{44}}{2}$ and $x = -2, 4$	dM1A1
	$-1 + \sqrt{11} < x < 4$ or $-1 - \sqrt{11} < x < -2$	A1
	$-1 + \sqrt{11} < x < 4$ and $-1 - \sqrt{11} < x < -2$	A1

Notes

M1: Attempts to square both sides, collect terms, rearrange and solve a quartic equation to obtain at least 2 values of x that are non-zero. Allow calculator solutions so this mark may be implied by correct values for their quartic (you may need to check).

A1: **One** correct pair of values. It is for $-2, 4$ or $-1 \pm \sqrt{11}$. May be seen embedded in an inequality or e.g. on a sketch.

Allow the irrational roots to be at least as given here or $-1 \pm \sqrt{11}$ or awrt 2.3, -4.3 or truncated 2.3..., -4.3...

dM1: Obtains 4 non-zero values of x . Allow calculator solutions so this mark may be implied by correct values for their quartic (you may need to check).

Depends on the first method mark.

A1: **Both** pairs of values correct. May be seen embedded in an inequality or e.g. on a sketch.

Allow the irrational roots to be at least as given here or $-1 \pm \sqrt{11}$ or awrt 2.3, -4.3 or truncated 2.3..., -4.3...

For the final 2 marks (which must follow both previous method marks):

For $-1 + \sqrt{11}$ allow $\frac{-2 + \sqrt{44}}{2}$, for $-1 - \sqrt{11}$ allow $\frac{-2 - \sqrt{44}}{2}$ but must be exact here.

Allow alternative notation e.g. $(-1 + \sqrt{11}, 4)$, $(-1 - \sqrt{11}, -2)$, $4 > x > -1 + \sqrt{11}$, $x > -1 + \sqrt{11}$ **and** $x < 4$,
 $-2 > x > -1 - \sqrt{11}$, $x > -1 - \sqrt{11}$ **and** $x < -2$

A1: One correct inequality.

A1: Both inequalities correct. Allow the inequalities to be written separately or with “,” or “or” or “and” or $\cup$ between them but not $\cap$ between them.

In an otherwise fully correct solution, if any extra incorrect regions are given, deduct the final A mark.

3.

$$(\cos x) \frac{dy}{dx} + (\sin x)y = 2 \cos^3 x \sin x - 3 \quad 0 \leq x < \frac{\pi}{2}$$

- (a) Find the general solution of this differential equation.

Give your answer in the form $y = f(x)$.

(7)

- (b) Find the particular solution of this differential equation for

which $y = 3\sqrt{3}$ at $x = \frac{\pi}{3}$

Give your answer in the form $y = f(x)$.

(3)

(Total for Question 3 is 10 marks)

Question Number	Scheme	Marks
3. (a)	$\frac{dy}{dx} + (\tan x)y = 2 \cos^2 x \sin x - 3 \sec x$	M1
	Integrating Factor: $I = e^{\int \tan x \, dx}$	dM1
	$I = \sec x$	A1
	$y \sec x = \int \sec x (2 \cos^2 x \sin x - 3 \sec x) (dx)$ or $\frac{d}{dx}(y \sec x) = \sec x (2 \cos^2 x \sin x - 3 \sec x)$	M1
	$\int 2 \cos x \sin x \, dx = \sin^2 x \text{ or } -\cos^2 x \text{ or } -\frac{1}{2} \cos 2x$ Must follow the previous method mark	A1
	$\int -3 \sec^2 x \, dx = -3 \tan x$ Must follow the previous method mark	A1
	Follow through their integration and their integrating factor: i.e. $y = \text{their}(\sin^2 x - 3 \tan x + k) \div \text{their} \sec x$ Examples of a correct answer: $y = \cos x \sin^2 x - 3 \sin x + k \cos x$ or $y = -\frac{1}{2} \cos x \cos 2x - 3 \sin x + k \cos x$ or $y = -\cos^3 x - 3 \sin x + k \cos x$	A1ft
		(7)

Notes

M1: Attempt to divide through by $\cos x$. If the intention is not clear must see at least 2 terms divided by $\cos x$. May be implied by a correct integrating factor.

dM1: $I = e^{\int \pm \text{their } P(x) (dx)}$ from $\frac{dy}{dx} + Py = \dots$

Dependent on the first method mark. May be implied by use of $\sec x$ or as the integrating factor.

A1: $\frac{1}{\cos x}$ or $(\cos x)^{-1}$ or $\sec x$ and condone $\cos^{-1} x$ if the intention is clear.

M1: Attempts to use their integrating factor correctly e.g.

$$y \times \text{their IF} = \int Q(x) \times \text{their IF} (dx) \text{ or } \frac{d}{dx}(y \times \text{their IF}) = Q(x) \times \text{their IF}$$

$$\text{from their } \frac{dy}{dx} + P(x)y = Q(x)$$

If there is any doubt, must multiply at least one of their $Q(x)$ terms by their IF

A1: Correct integration of $2 \cos x \sin x$. **Must follow the previous method mark.**

A1: Correct integration of $-3 \sec^2 x$. **Must follow the previous method mark.**

A1ft: Follow through their integration (must be a changed function and not just and their $Q(x) \times \text{their IF}$) and their integrating factor but must be $y = \dots$ with the constant dealt with correctly. **Depends on the third method mark.**

Allow any equivalent correct or correct ft expressions which may be unsimplified so allow

$$\text{e.g. } -3 \frac{\tan x}{\sec x} \text{ for } -3 \sin x$$

(b)	e.g. $3\sqrt{3} = -\frac{1}{2}\cos\frac{\pi}{3}\cos 2\frac{\pi}{3} - 3\sin\frac{\pi}{3} + k\cos\frac{\pi}{3} \Rightarrow k = \dots$	M1
	$y = \cos x \sin^2 x - 3\sin x + k \cos x$ $\Rightarrow 3\sqrt{3} = \frac{1}{2} \cdot \left(\frac{\sqrt{3}}{2}\right)^2 - 3\frac{\sqrt{3}}{2} + k\frac{1}{2} \Rightarrow k = \left(9\sqrt{3} - \frac{3}{4}\right) \text{ oe}$ $y = -\frac{1}{2}\cos x \cos 2x - 3\sin x + k \cos x$ $\Rightarrow 3\sqrt{3} = -\frac{1}{2} \cdot \frac{1}{2} \left(-\frac{1}{2}\right) - 3\frac{\sqrt{3}}{2} + k\frac{1}{2} \Rightarrow k = \left(9\sqrt{3} - \frac{1}{4}\right) \text{ oe}$ $y = -\cos^3 x - 3\sin x + k \cos x$ $\Rightarrow 3\sqrt{3} = -\left(\frac{1}{2}\right)^3 - 3\frac{\sqrt{3}}{2} + k\frac{1}{2} \Rightarrow k = \left(9\sqrt{3} + \frac{1}{4}\right) \text{ oe}$	A1
	$y = \cos x \sin^2 x - 3\sin x + \left(9\sqrt{3} - \frac{3}{4}\right)\cos x \text{ oe}$ or $y = -\frac{1}{2}\cos x \cos 2x - 3\sin x + \left(9\sqrt{3} - \frac{1}{4}\right)\cos x \text{ oe}$ or $y = -\cos^3 x - 3\sin x + \left(9\sqrt{3} + \frac{1}{4}\right)\cos x \text{ oe}$	A1
		(3)
		Total 10
Notes M1: Substitutes the given conditions into their $y = f(x)$ and attempts to find a value for their constant. A1: Correct constant for their method from a correct function in part (a). A1: Correct equation or equivalent correct equation but must be $y = \dots$		

4. (a) Express $\frac{4r+2}{r(r+1)(r+2)}$ in partial fractions. (3)

(b) Hence, using the method of differences, prove that

$$\sum_{r=1}^n \frac{4r+2}{r(r+1)(r+2)} = \frac{n(an+b)}{2(n+1)(n+2)}$$

where a and b are constants to be found.

(5)

(Total for Question 4 is 8 marks)

Question Number	Scheme	Marks
4(a)	$\frac{4r+2}{r(r+1)(r+2)} \equiv \frac{A}{r} + \frac{B}{r+1} + \frac{C}{r+2} \rightarrow A = \dots \text{ or } B = \dots \text{ or } C = \dots$	M1
	$\frac{1}{r} + \frac{2}{(r+1)} - \frac{3}{(r+2)}$	A1 A1
		(3)
Notes M1: Correct partial fractions method e.g. substitution or compares coefficients to obtain one of A, B or C for $\frac{A}{r}, \frac{B}{(r+1)}, \frac{C}{(r+2)}$ A1: 2 Correct fractions (or values) A1: Fully correct partial fractions. It is not for just the correct values unless the correct fractions are seen in (b). Correct answer with no working scores full marks in (a)		

NB use of e.g.
$$\frac{4r+2}{r(r+1)(r+2)} \equiv \frac{A}{r(r+1)} + \frac{B}{(r+1)(r+2)} \rightarrow \frac{1}{r(r+1)} + \frac{3}{(r+1)(r+2)}$$

Scores no marks in part (a) unless the fractions are split further.

(b)	Must have partial fractions of the form $\frac{A}{r}, \frac{B}{(r+1)}, \frac{C}{(r+2)}$ $A, B, C \neq 0$ to score the <u>first M mark in (b)</u>	
	$\sum_{r=1}^n = \left(\frac{1}{1} + \frac{2}{2} - \frac{3}{3}\right) + \left(\frac{1}{2} + \frac{2}{3} - \frac{3}{4}\right) + \dots + \left(\frac{1}{n-1} + \frac{2}{n} - \frac{3}{n+1}\right) + \left(\frac{1}{n} + \frac{2}{n+1} - \frac{3}{n+2}\right)$	M1
	$= \frac{1}{1} + \frac{2}{2} + \frac{1}{2} - \frac{3}{n+1} + \frac{2}{n+1} - \frac{3}{n+2}$	A1 A1
	$= \frac{5(n+1)(n+2) - 2(n+2) - 6(n+1)}{2(n+1)(n+2)}$	dM1
	$\frac{n(5n+7)}{2(n+1)(n+2)}$	A1
		(5)
		Total 8

Notes

M1: Attempts at least the first 2 groups of terms and the last 2 groups of terms **which may be implied by their fractions identified below provided all the necessary terms (algebraic and constant) are seen**
 Allow other letters for n (most likely to be r) except for the final mark – see below
 If terms are found beyond the limits of the summation e.g. $r = 0, r = n + 1$, these can be ignored for this mark as long as at least the terms for $r = 1, 2, n - 1$ and n are seen.
 No cancelling needs to be seen at this stage.

A1: $\frac{1}{1} + \frac{2}{2} + \frac{1}{2} \left(= \frac{5}{2} \right)$ identified as the only constant terms.

A1: $-\frac{3}{n+1} + \frac{2}{n+1} - \frac{3}{n+2}$ oe e.g. $-\frac{1}{n+1} - \frac{1}{n+2} - \frac{2}{n+2}$ identified as the only algebraic terms.

dM1: Attempt common denominator from terms of the form $A, \frac{B}{n+1}, \frac{C}{n+2}$ only.

Must see $(n+1)(n+2)$ in the denominator and an unsimplified or simplified polynomial of order 2 in the numerator.

Depends on the first method mark.

A1: Correct expression. Must be in terms of n for this mark.

Allow recovery in (b) from e.g.

$$\frac{4r+2}{r(r+1)(r+2)} \equiv \frac{A}{r(r+1)} + \frac{B}{(r+1)(r+2)} \rightarrow \frac{1}{r(r+1)} + \frac{3}{(r+1)(r+2)}$$

$$\frac{4r+2}{r(r+1)(r+2)} \equiv \frac{1}{r(r+1)} + \frac{3}{(r+1)(r+2)} = \frac{1}{r} - \frac{1}{r+1} + \frac{3}{r+1} - \frac{3}{r+2} \text{ etc.}$$

Note that there will be other correct approaches in (b):

Alternative 1: using change of summation limits:

$$\begin{aligned}\sum_{r=1}^n \frac{1}{r} + \frac{2}{(r+1)} - \frac{3}{(r+2)} &= \sum_{r=1}^n \frac{1}{r} + \sum_{r=1}^n \frac{2}{(r+1)} - \sum_{r=1}^n \frac{3}{(r+2)} = \sum_{r=1}^n \frac{1}{r} + \sum_{r=2}^{n+1} \frac{2}{r} - \sum_{r=3}^{n+2} \frac{3}{r} \\ &= -2 + \frac{2}{n+1} + 3 + \frac{3}{2} - \frac{3}{n+1} - \frac{3}{n+2} + \sum_{r=1}^n \frac{1}{r} + \sum_{r=1}^n \frac{2}{r} - \sum_{r=1}^n \frac{3}{r} = \frac{5}{2} - \frac{1}{n+1} - \frac{3}{n+2} \text{ etc.}\end{aligned}$$

Score as follows:

M1: for an attempt to change all summations to $\sum_r \dots$ and add/subtract terms to compensate.

A1: for $-2 + 3 + \frac{3}{2}$ oe **A1:** for $\frac{2}{n+1} - \frac{3}{n+1} - \frac{3}{n+2}$ oe

M1A1: As main scheme.

If you are unsure if an attempt deserves credit use Review.

Alternative 2: grouping terms:

$$\begin{aligned}\sum_{r=1}^n \frac{1}{r} + \frac{2}{(r+1)} - \frac{3}{(r+2)} &= \sum_{r=1}^n \frac{1}{r} - \frac{1}{(r+2)} + \sum_{r=1}^n \frac{2}{r+1} - \frac{2}{(r+2)} \\ &= \left(1 - \frac{1}{3} + \frac{1}{2} - \frac{1}{4} + \dots + \frac{1}{n-1} - \frac{1}{n+1} + \frac{1}{n} - \frac{1}{n+2}\right) + 2\left(\frac{1}{2} - \frac{1}{3} + \frac{1}{3} - \frac{1}{4} + \dots + \frac{1}{n} - \frac{1}{n+1} + \frac{1}{n+1} - \frac{1}{n+2}\right) \\ &= \left(1 + \frac{1}{2} - \frac{1}{n+1} - \frac{1}{n+2}\right) + 2\left(\frac{1}{2} - \frac{1}{n+2}\right)\end{aligned}$$

Score as follows:

M1: for an attempt to group terms and consider at least 2 terms at the start and at least 2 terms at the end for each group.

A1: for $1 + \frac{1}{2} + \frac{2}{2}$ oe **A1:** for $-\frac{1}{n+1} - \frac{1}{n+2} - \frac{2}{n+2}$ oe

M1A1: As main scheme.

5. Given that

$$(2 - x^2) \frac{d^2 y}{dx^2} + 5x \left(\frac{dy}{dx} \right)^2 = 3y$$

(a) show that

$$\frac{d^3 y}{dx^3} = \frac{1}{(2 - x^2)} \left(2x \frac{d^2 y}{dx^2} \left(1 - 5 \frac{dy}{dx} \right) - 5 \left(\frac{dy}{dx} \right)^2 + 3 \frac{dy}{dx} \right) \quad (5)$$

Given also that $y = 3$ and $\frac{dy}{dx} = \frac{1}{4}$ at $x = 0$

(b) obtain a series solution for y in ascending powers of x with simplified coefficients, up to and including the term in x^3 (4)

(Total for Question 5 is 9 marks)

Note that part (a) is now being marked as MdMAddMA not MMABA

Question Number	Scheme	Marks
5(a)	$(2-x^2)\frac{d^2y}{dx^2} \rightarrow -2x\frac{d^2y}{dx^2} + (2-x^2)\frac{d^3y}{dx^3}$ or $5x\left(\frac{dy}{dx}\right)^2 \rightarrow 5\left(\frac{dy}{dx}\right)^2 + 5x \times 2\frac{dy}{dx}\frac{d^2y}{dx^2}$	M1
	$(2-x^2)\frac{d^2y}{dx^2} \rightarrow -2x\frac{d^2y}{dx^2} + (2-x^2)\frac{d^3y}{dx^3}$ and $5x\left(\frac{dy}{dx}\right)^2 \rightarrow 5\left(\frac{dy}{dx}\right)^2 + 5x \times 2\frac{dy}{dx}\frac{d^2y}{dx^2}$	dM1
	$-2x\frac{d^2y}{dx^2} + (2-x^2)\frac{d^3y}{dx^3} + 5\left(\frac{dy}{dx}\right)^2 + 5x \times 2\frac{dy}{dx}\frac{d^2y}{dx^2} = 3\frac{dy}{dx}$	A1
	$\Rightarrow (2-x^2)\frac{d^3y}{dx^3} = 2x\frac{d^2y}{dx^2} - 5\left(\frac{dy}{dx}\right)^2 - 5x \times 2\frac{dy}{dx}\frac{d^2y}{dx^2} + 3\frac{dy}{dx}$ $\Rightarrow \frac{d^3y}{dx^3} = \frac{1}{(2-x^2)}\left(2x\frac{d^2y}{dx^2}\left(1-5\frac{dy}{dx}\right) - 5\left(\frac{dy}{dx}\right)^2 + 3\frac{dy}{dx}\right)*$	ddM1A1*
		(5)

Notes (Now marked as MdMAddMA not MMABA)

M1: Differentiates $(2-x^2)\frac{d^2y}{dx^2}$ using the product rule to obtain $\dots x\frac{d^2y}{dx^2} + (2-x^2)\frac{d^3y}{dx^3}$

May be implied by e.g. $(2-x^2)\frac{d^2y}{dx^2} = 2\frac{d^2y}{dx^2} - x^2\frac{d^2y}{dx^2}$ and $-x^2\frac{d^2y}{dx^2} \rightarrow -2x\frac{d^2y}{dx^2} - x^2\frac{d^3y}{dx^3}$

i.e. $x^2\frac{d^2y}{dx^2} \rightarrow \dots x\frac{d^2y}{dx^2} + \dots x^2\frac{d^3y}{dx^3}$

Or Differentiates $5x\left(\frac{dy}{dx}\right)^2$ using the product rule to obtain $\dots\left(\frac{dy}{dx}\right)^2 + \dots x\frac{dy}{dx}\frac{d^2y}{dx^2}$

It must be clear that the expressions are not simply a result of expanding the given answer.

dM1: Differentiates $(2-x^2)\frac{d^2y}{dx^2}$ using the product rule to obtain $\dots x\frac{d^2y}{dx^2} + (2-x^2)\frac{d^3y}{dx^3}$

May be implied by e.g. $(2-x^2)\frac{d^2y}{dx^2} = 2\frac{d^2y}{dx^2} - x^2\frac{d^2y}{dx^2}$ and $-x^2\frac{d^2y}{dx^2} \rightarrow -2x\frac{d^2y}{dx^2} - x^2\frac{d^3y}{dx^3}$

i.e. $x^2\frac{d^2y}{dx^2} \rightarrow \dots x\frac{d^2y}{dx^2} + \dots x^2\frac{d^3y}{dx^3}$

And Differentiates $5x\left(\frac{dy}{dx}\right)^2$ using the product rule to obtain $\dots\left(\frac{dy}{dx}\right)^2 + \dots x\frac{dy}{dx}\frac{d^2y}{dx^2}$

Depends on the first method mark.

A1: Fully correct differentiation e.g. $-2x\frac{d^2y}{dx^2} + (2-x^2)\frac{d^3y}{dx^3} + 5\left(\frac{dy}{dx}\right)^2 + 5x \times 2\frac{dy}{dx}\frac{d^2y}{dx^2} = 3\frac{dy}{dx}$

ddM1: Rearranges to make $\frac{d^3y}{dx^3}$ the subject. **Depends on both previous method marks.**

A1*: Obtains the printed answer from **fully correct** working.

(a) Alternative 1: Makes $\frac{d^2y}{dx^2}$ the subject first and then quotient rule.

$$\frac{d^2y}{dx^2} = \frac{3y - 5x\left(\frac{dy}{dx}\right)^2}{(2-x^2)}$$

$$\frac{d^3y}{dx^3} = \frac{\left[3\frac{dy}{dx} - 5\left(\frac{dy}{dx}\right)^2 - 5x \times 2\frac{dy}{dx}\frac{d^2y}{dx^2}\right](2-x^2) - \left[3y - 5x\left(\frac{dy}{dx}\right)^2\right](-2x)}{(2-x^2)^2}$$

M1dM1A1

$$\begin{aligned} \frac{d^3y}{dx^3} &= \frac{\left[3\frac{dy}{dx} - 5\left(\frac{dy}{dx}\right)^2 - 5x \times 2\frac{dy}{dx}\frac{d^2y}{dx^2}\right](2-x^2) - \left[3y - 5x\left(\frac{dy}{dx}\right)^2\right](-2x)}{(2-x^2)^2} \\ &= \frac{\left[3\frac{dy}{dx} - 5\left(\frac{dy}{dx}\right)^2 - 5x \times 2\frac{dy}{dx}\frac{d^2y}{dx^2}\right](2-x^2) - \left[(2-x^2)\frac{d^2y}{dx^2} + 5x\left(\frac{dy}{dx}\right)^2 - 5x\left(\frac{dy}{dx}\right)^2\right](-2x)}{(2-x^2)^2} \\ &= \frac{\left[3\frac{dy}{dx} - 5\left(\frac{dy}{dx}\right)^2 - 10x\frac{dy}{dx}\frac{d^2y}{dx^2}\right](2-x^2) + 2x(2-x^2)\frac{d^2y}{dx^2}}{(2-x^2)^2} \\ \frac{d^3y}{dx^3} &= \frac{1}{(2-x^2)} \left(2x\frac{d^2y}{dx^2}\left(1-5\frac{dy}{dx}\right) - 5\left(\frac{dy}{dx}\right)^2 + 3\frac{dy}{dx}\right) * \end{aligned}$$

ddM1A1*

Notes (Now marked as MdMAddMA not MMABA)

M1: Attempts the quotient rule on $\frac{3y - 5x\left(\frac{dy}{dx}\right)^2}{(2-x^2)}$ Award for the form

$$\frac{(2-x^2)\left(3y - 5x\left(\frac{dy}{dx}\right)^2\right)' \pm (2-x^2)' \left(3y - 5x\left(\frac{dy}{dx}\right)^2\right)}{(2-x^2)^2} \text{ where } \left(3y - 5x\left(\frac{dy}{dx}\right)^2\right)' \text{ and } (2-x^2)' \text{ are}$$

attempts to differentiate these expressions and includes an attempt to differentiate $5x\left(\frac{dy}{dx}\right)^2$

using the product rule to obtain $\dots\left(\frac{dy}{dx}\right)^2 + \dots x\frac{dy}{dx}\frac{d^2y}{dx^2}$

dM1: Complete attempt at the quotient rule to obtain:

$$\frac{d^3y}{dx^3} = \frac{\left[\dots\frac{dy}{dx} + \dots\left(\frac{dy}{dx}\right)^2 + \dots x\frac{dy}{dx}\frac{d^2y}{dx^2}\right](2-x^2) \pm \dots x\left[3y - 5x\left(\frac{dy}{dx}\right)^2\right]}{(2-x^2)^2}$$

A1: Fully correct differentiation in any form.

ddM1: Replaces $3y$ with $(2-x^2)\frac{d^2y}{dx^2} + 5x\left(\frac{dy}{dx}\right)^2$ and cancels through by $(2-x^2)$

A1*: Obtains the printed answer from **fully correct** working.

(a) Alternative 2: Makes $\frac{d^2y}{dx^2}$ the subject first and then product rule.

$$\frac{d^2y}{dx^2} = \frac{3y - 5x\left(\frac{dy}{dx}\right)^2}{(2-x^2)} = \left(3y - 5x\left(\frac{dy}{dx}\right)^2\right)(2-x^2)^{-1}$$

$$\frac{d^3y}{dx^3} = \left[3\frac{dy}{dx} - 5\left(\frac{dy}{dx}\right)^2 - 5x \times 2\frac{dy}{dx}\frac{d^2y}{dx^2} \right](2-x^2)^{-1} + \left[3y - 5x\left(\frac{dy}{dx}\right)^2 \right] \times -(2-x^2)^{-2} \times -2x$$

M1dM1A1

$$\frac{d^3y}{dx^3} = \left[3\frac{dy}{dx} - 5\left(\frac{dy}{dx}\right)^2 - 5x \times 2\frac{dy}{dx}\frac{d^2y}{dx^2} \right](2-x^2)^{-1} + 2x(2-x^2)^{-2} \left[3y - 5x\left(\frac{dy}{dx}\right)^2 \right]$$

$$\frac{d^3y}{dx^3} = \left[3\frac{dy}{dx} - 5\left(\frac{dy}{dx}\right)^2 - 5x \times 2\frac{dy}{dx}\frac{d^2y}{dx^2} \right](2-x^2)^{-1} + 2x(2-x^2)^{-2} \left[(2-x^2)\frac{d^2y}{dx^2} + 5x\left(\frac{dy}{dx}\right)^2 - 5x\left(\frac{dy}{dx}\right)^2 \right]$$

$$= \frac{\left[3\frac{dy}{dx} - 5\left(\frac{dy}{dx}\right)^2 - 10x\frac{dy}{dx}\frac{d^2y}{dx^2} \right](2-x^2) + 2x(2-x^2)\frac{d^2y}{dx^2}}{(2-x^2)^2}$$

$$\frac{d^3y}{dx^3} = \frac{1}{(2-x^2)} \left(2x\frac{d^2y}{dx^2} \left(1 - 5\frac{dy}{dx} \right) - 5\left(\frac{dy}{dx}\right)^2 + 3\frac{dy}{dx} \right) *$$

ddM1A1*

Notes (Now marked as MdMAddMA not MMABA)

M1: Attempts the product rule on $\left(3y - 5x\left(\frac{dy}{dx}\right)^2\right)(2-x^2)^{-1}$ Award for the form

$(2-x^2)^{-1} \left(3y - 5x\left(\frac{dy}{dx}\right)^2\right)' + \left((2-x^2)^{-1}\right)' \left(3y - 5x\left(\frac{dy}{dx}\right)^2\right)$ where $\left(3y - 5x\left(\frac{dy}{dx}\right)^2\right)'$ and $\left((2-x^2)^{-1}\right)'$ are

attempts to differentiate these expressions and includes an attempt to differentiate $5x\left(\frac{dy}{dx}\right)^2$

using the product rule to obtain $\dots\left(\frac{dy}{dx}\right)^2 + \dots x\frac{dy}{dx}\frac{d^2y}{dx^2}$

dM1: Complete attempt at the product rule to obtain:

$$\frac{d^3y}{dx^3} = \left[\dots\frac{dy}{dx} + \dots\left(\frac{dy}{dx}\right)^2 + \dots x\frac{dy}{dx}\frac{d^2y}{dx^2} \right](2-x^2)^{-1} + \dots x(2-x^2)^{-2} \left[3y - 5x\left(\frac{dy}{dx}\right)^2 \right]$$

A1: Fully correct differentiation in any form.

ddM1: Replaces $3y$ with $(2-x^2)\frac{d^2y}{dx^2} + 5x\left(\frac{dy}{dx}\right)^2$ and cancels through by $(2-x^2)$ or equivalent work.

A1*: Obtains the printed answer from **fully correct** working.

(a) Alternative 3: Makes $\frac{d^2y}{dx^2}$ the subject first, splits and then uses the quotient rule on both terms.

	$\frac{d^2y}{dx^2} = \frac{3y}{(2-x^2)} - \frac{5x\left(\frac{dy}{dx}\right)^2}{(2-x^2)^2}$	
	$\frac{d^3y}{dx^3} = \frac{3\left(\frac{dy}{dx}\right)(2-x^2) - 3y(-2x)}{(2-x^2)^2} - \frac{\left[5\left(\frac{dy}{dx}\right)^2 + 5x \times 2\left(\frac{dy}{dx}\right)\left(\frac{d^2y}{dx^2}\right)\right](2-x^2) - 5x\left(\frac{dy}{dx}\right)^2(-2x)}{(2-x^2)^2}$	M1dM1A1
	$= \frac{3\frac{dy}{dx}(2-x^2) - \left(\left(2-x^2\right)\frac{d^2y}{dx^2} + 5x\left(\frac{dy}{dx}\right)^2\right)(-2x)}{(2-x^2)^2}$ $- \frac{\left[5\left(\frac{dy}{dx}\right)^2 + 5x \times 2\frac{dy}{dx}\frac{d^2y}{dx^2}\right](2-x^2) - 5x\left(\frac{dy}{dx}\right)^2(-2x)}{(2-x^2)^2}$ $= \frac{3\frac{dy}{dx}(2-x^2) + 2x(2-x^2)\frac{d^2y}{dx^2} - \left[5\left(\frac{dy}{dx}\right)^2 + 5x \times 2\frac{dy}{dx}\frac{d^2y}{dx^2}\right](2-x^2)}{(2-x^2)^2}$ $= \frac{3\frac{dy}{dx} + 2x\frac{d^2y}{dx^2} - \left[5\left(\frac{dy}{dx}\right)^2 + 5x \times 2\frac{dy}{dx}\frac{d^2y}{dx^2}\right]}{(2-x^2)}$ $= \frac{1}{(2-x^2)} \left(2x\frac{d^2y}{dx^2} \left(1 - 5\frac{dy}{dx}\right) - 5\left(\frac{dy}{dx}\right)^2 + 3\frac{dy}{dx} \right) *$	ddM1A1*

Notes (Now marked as MdMAddMA not MMABA)

M1: Attempts the quotient rule on $\frac{3y}{(2-x^2)}$ and $\frac{5x\left(\frac{dy}{dx}\right)^2}{(2-x^2)^2}$

Award for the forms $\frac{(2-x^2)(3y)' \pm 3y(2-x^2)'}{(2-x^2)^2}$ and $\frac{(2-x^2)\left(5x\left(\frac{dy}{dx}\right)^2\right)' \pm (2-x^2)'\left(5x\left(\frac{dy}{dx}\right)^2\right)}{(2-x^2)^2}$

where $(3y)'$, $\left(5x\left(\frac{dy}{dx}\right)^2\right)'$ and $(2-x^2)'$ are attempts to differentiate these expressions and includes an attempt to differentiate $5x\left(\frac{dy}{dx}\right)^2$ using the product rule to obtain $\dots\left(\frac{dy}{dx}\right)^2 + \dots x \frac{dy}{dx} \frac{d^2y}{dx^2}$

dM1: Complete attempt at both quotient rules to obtain:

$$\frac{d^3y}{dx^3} = \frac{\dots\left(\frac{dy}{dx}\right)(2-x^2) \pm \dots xy}{(2-x^2)^2} - \frac{\left[\dots\left(\frac{dy}{dx}\right)^2 + \dots x\left(\frac{dy}{dx}\right)\left(\frac{d^2y}{dx^2}\right)\right](2-x^2) \pm \dots x^2\left(\frac{dy}{dx}\right)^2}{(2-x^2)^2}$$

A1: Fully correct differentiation in any form.

ddM1: Combines both fractions with a common denominator of $(2-x^2)^2$, replaces $3y$ with $(2-x^2)\frac{d^2y}{dx^2} + 5x\left(\frac{dy}{dx}\right)^2$ and cancels through by $(2-x^2)$

A1*: Obtains the printed answer from **fully correct** working.

Other methods e.g. rearranges, splits and uses 2 products can be marked in a similar way.

If you are unsure if a particular approach deserves credit use Review.

(b)	$\frac{d^2y}{dx^2} = \frac{9}{2}$	B1
	$\frac{d^3y}{dx^3} = \frac{1}{2} \left(-5 \left(\frac{dy}{dx} \right)^2 + 3 \frac{dy}{dx} \right) = \frac{1}{2} \left(-5 \times \frac{1}{16} + \frac{3}{4} \right) = \frac{7}{32}$	M1
	$(y=) 3 + \frac{1}{4}x + \frac{9}{2} \frac{x^2}{2!} + \frac{7}{32} \frac{x^3}{3!}$	M1
	$(y=) 3 + \frac{1}{4}x + \frac{9}{4}x^2 + \frac{7}{192}x^3$	A1
		(4)
		Total 9
Notes		
B1:	Correct value for $\frac{d^2y}{dx^2}$	
M1:	Attempts to find a value for $\frac{d^3y}{dx^3}$. Working need not be seen/checked as long as a value is obtained and a value may just be written down.	
M1:	Correct application of Taylor's series using their values for the derivatives (accept 2! or 2 and 3! or 6)	
A1:	Correct simplified series. The "y =" is not required.	

6. (a) Find the general solution of the differential equation

$$\frac{d^2y}{dx^2} - 6\frac{dy}{dx} + 8y = 2x^2 + x \quad (8)$$

- (b) Find the particular solution of this differential equation for which

$$y = 1 \text{ and } \frac{dy}{dx} = 0 \text{ when } x = 0 \quad (5)$$

(Total for Question 6 is 13 marks)

Question Number	Scheme	Marks
6(a)	$m^2 - 6m + 8 = 0 \Rightarrow (m-2)(m-4) = 0, m = 2, 4$	M1
	(CF =) $Ae^{2x} + Be^{4x}$	A1
	PI: ($y =$) $\alpha x^2 + \beta x + \gamma$	B1
	$y' = 2\alpha x + \beta \quad y'' = 2\alpha$ $2\alpha - 6(2\alpha x + \beta) + 8(\alpha x^2 + \beta x + \gamma) = 2x^2 + x$	M1
	$8\alpha = 2, -12\alpha + 8\beta = 1, 2\alpha - 6\beta + 8\gamma = 0 \Rightarrow \alpha = \dots, \beta = \dots, \gamma = \dots$	dM1
	$\alpha = \frac{1}{4}, \beta = \frac{1}{2}, \gamma = \frac{5}{16}$	A1A1
	$y = Ae^{2x} + Be^{4x} + \frac{1}{4}x^2 + \frac{1}{2}x + \frac{5}{16}$	A1ft
		(8)

Notes

M1: Attempts to solve $m^2 - 6m + 8 = 0$ by any valid method including a calculator so may be implied by correct values or the correct CF

A1: Correct CF (“y =” not required)

B1: Correct form for the PI (“y =” not required)

M1: Differentiates their PI twice and attempts to substitute into the given differential equation. There must be evidence of $x^n \rightarrow x^{n-1}$ at least once.

The PI must be a quadratic expression with at least 2 terms and at least 2 unknowns.

dM1: Compares coefficients and solves to find values for their α , β and γ from a PI of

$$y = \alpha x^2 + \beta x + \gamma, \alpha, \beta, \gamma \neq 0.$$

You do not need to check their working and they may just write down values.

Depends on the previous M mark only.

A1: Any 2 values correct **following the award of both previous method marks.**

A1: All correct **following the award of both previous method marks.**

A1ft: A complete solution, follow through their CF and PI.

Must be $y = \dots$ or $y = \dots$ must be seen at some point for their GS e.g. they may start $y = \text{PI} + \text{CF}$

All 3 M marks must have been earned.

6(b)	$y = Ae^{2x} + Be^{4x} + \frac{1}{4}x^2 + \frac{1}{2}x + \frac{5}{16}$	
	$1 = A + B + \frac{5}{16}$	M1
	$\frac{dy}{dx} = 2Ae^{2x} + 4Be^{4x} + \frac{1}{2}x + \frac{1}{2} \quad 0 = 2A + 4B + \frac{1}{2}$	M1
	$A = \frac{13}{8} \quad B = -\frac{15}{16} \quad \text{oe}$	ddM1A1
	$y = \frac{13}{8}e^{2x} - \frac{15}{16}e^{4x} + \frac{1}{4}x^2 + \frac{1}{2}x + \frac{5}{16} \quad \text{oe}$	A1ft
		(5)
		Total 13

Notes

M1: Substitutes $y = 1$ and $x = 0$ in their GS from (a) to obtain an equation in 2 unknowns.

M1: Differentiates their GS and substitutes $\frac{dy}{dx} = 0, x = 0$ to obtain another equation in 2 unknowns.

You do not need to be concerned about the detail of their differentiation provided there is an attempt and their derivative is not their original function.

ddM1: Solves their 2 equations in 2 unknowns to obtain a value for both constants. You do not need to check their working and they may just write down values.

Depends on both previous M marks.

A1: Both values correct from a correct GS and fully correct work.

A1ft: Correct particular solution. Follow through their A and B and their PI from (a).

Must be $y = \dots$ or $y = \dots$ must be seen at some point for their GS but do not penalise its omission if already penalised in part (a).

Depends on all 3 previous M marks.

7. (a) Show that

$$\left(z + \frac{1}{z}\right)^3 \left(z - \frac{1}{z}\right)^3 = z^6 - \frac{1}{z^6} - k \left(z^2 - \frac{1}{z^2}\right)$$

where k is a constant to be found.

(3)

Given that $z = \cos \theta + i \sin \theta$, where θ is real,

(b) show that

$$(i) \quad z^n + \frac{1}{z^n} = 2 \cos n\theta$$

$$(ii) \quad z^n - \frac{1}{z^n} = 2i \sin n\theta$$

(3)

(c) Hence show that

$$\cos^3 \theta \sin^3 \theta = \frac{1}{32} (3 \sin 2\theta - \sin 6\theta)$$

(4)

(d) Use algebraic integration to find the exact value of

$$\int_0^{\frac{\pi}{8}} \cos^3 \theta \sin^3 \theta \, d\theta$$

(4)

(Total for Question 7 is 14 marks)

Question Number	Scheme	Marks
7(a)	$\left(z + \frac{1}{z}\right)^3 \left(z - \frac{1}{z}\right)^3 = \left(z^2 - \frac{1}{z^2}\right)^3 = z^6 - 3z^2 + \frac{3}{z^2} - z^{-6}$	M1A1
	$= z^6 - \frac{1}{z^6} - 3\left(z^2 - \frac{1}{z^2}\right)$	A1
		(3)
(a) Alternative		
	$\left(z + \frac{1}{z}\right)^3 = z^3 + 3z + \frac{3}{z} + \frac{1}{z^3}, \left(z - \frac{1}{z}\right)^3 = z^3 - 3z + \frac{3}{z} - \frac{1}{z^3}$	M1A1
	$\left(z + \frac{1}{z}\right)^3 \left(z - \frac{1}{z}\right)^3 = \left(z^3 + 3z + \frac{3}{z} + \frac{1}{z^3}\right) \left(z^3 - 3z + \frac{3}{z} - \frac{1}{z^3}\right) = \dots$ $= z^6 - \frac{1}{z^6} - 3\left(z^2 - \frac{1}{z^2}\right)$	A1
(a) Notes		
M1:	Writes $\left(z + \frac{1}{z}\right)^3 \left(z - \frac{1}{z}\right)^3$ as $\left(z^2 - \frac{1}{z^2}\right)^3$ and expands to obtain at least 3 terms of the correct form e.g. 3 from $\dots z^6, \dots z^2, \dots z^{-2}, \dots z^{-6}$	
A1:	For $\left(z^2 - \frac{1}{z^2}\right)^3 = z^6 - 3z^2 + \frac{3}{z^2} - z^{-6}$	
A1:	$z^6 - \frac{1}{z^6} - 3\left(z^2 - \frac{1}{z^2}\right)$ Condone $z^6 - z^{-6} - 3(z^2 - z^{-2})$	
	Correct answer with no errors seen. The " $\left(z + \frac{1}{z}\right)^3 \left(z - \frac{1}{z}\right)^3 =$ " does not need to be seen.	
Alternative:		
M1:	Attempt to expand both cubic brackets to obtain at least 3 terms of the correct form in both cases e.g. 3 from $\dots z^3, \dots z, \dots z^{-1}, \dots z^{-3}$	
A1:	Both expansions correct.	
A1:	Expands, collects terms and obtains the correct answer with no errors seen.	
	Condone $z^6 - z^{-6} - 3(z^2 - z^{-2})$ for $z^6 - \frac{1}{z^6} - 3\left(z^2 - \frac{1}{z^2}\right)$	
	The " $\left(z + \frac{1}{z}\right)^3 \left(z - \frac{1}{z}\right)^3 =$ " does not need to be seen.	
(b)(i)(ii)	$z^n = \cos n\theta + i \sin n\theta$	B1
	$z^{-n} = \cos(-n\theta) + i \sin(-n\theta) \text{ or } = \cos n\theta - i \sin n\theta$	M1
	$z^n + \frac{1}{z^n} = 2 \cos n\theta^*, z^n - \frac{1}{z^n} = 2i \sin n\theta^*$	A1*
		(3)
Notes		
B1:	$z^n = \cos n\theta + i \sin n\theta$ seen anywhere.	
M1:	States or uses $z^{-n} = \cos(-n\theta) + i \sin(-n\theta)$ (with or without the brackets) or $z^{-n} = \cos n\theta - i \sin n\theta$	
A1*:	Both correct results obtained following sight of $z^{-n} = \cos n\theta - i \sin n\theta$	

(c)	$\left(z + \frac{1}{z}\right)^3 \left(z - \frac{1}{z}\right)^3 = (2\cos\theta)^3 (2i\sin\theta)^3$ oe e.g. $-2^6 i \cos^3 \theta \sin^3 \theta$	B1
	$z^6 - \frac{1}{z^6} - 3\left(z^2 - \frac{1}{z^2}\right) = 2i\sin 6\theta - 6i\sin 2\theta$ oe	B1ft
	$(2\cos\theta)^3 (2i\sin\theta)^3 = 2i\sin 6\theta - 6i\sin 2\theta$ $\Rightarrow 8\cos^3 \theta \times (-8i\sin^3 \theta) = 2i\sin 6\theta - 6i\sin 2\theta$ $-64i\sin^3 \theta \cos^3 \theta = 2i\sin 6\theta - 6i\sin 2\theta$	dM1
	$\cos^3 \theta \sin^3 \theta = \frac{1}{32}(3\sin 2\theta - \sin 6\theta) *$	A1*
		(4)

(c) Notes

B1: Uses $z + \frac{1}{z} = 2\cos\theta$ and $z - \frac{1}{z} = 2i\sin\theta$ to express $\left(z + \frac{1}{z}\right)^3 \left(z - \frac{1}{z}\right)^3$ correctly in terms of $\sin\theta$ and

$\cos\theta$. May be implied by e.g. $\text{lhs} = \left(\frac{1}{2}\left(z + \frac{1}{z}\right)\right)^3 \left(\frac{1}{2i}\left(z - \frac{1}{z}\right)\right)^3$.

May be seen in a rearranged form e.g. $\frac{-1}{64i}\left(z + \frac{1}{z}\right)^3 \left(z - \frac{1}{z}\right)^3 = \cos^3 \theta \sin^3 \theta$

B1ft: Uses $z^6 - \frac{1}{z^6} = 2i\sin 6\theta$ and $z^2 - \frac{1}{z^2} = 2i\sin 2\theta$ to express their $z^6 - \frac{1}{z^6} - 3\left(z^2 - \frac{1}{z^2}\right)$ correctly in terms of $\sin\theta$ and $\cos\theta$. Follow through their k from part (a).

dM1: Equates both expressions and attempts to simplify $2^3 \times (2i)^3$ to obtain αi which may be implied.

Depends on both B marks.

A1*: Reaches the printed answer with no errors.

(d)	$\int \cos^3 \theta \sin^3 \theta d\theta = \int \frac{1}{32} (3 \sin 2\theta - \sin 6\theta) d\theta$ $= \frac{1}{32} \left[-\frac{3}{2} \cos 2\theta + \frac{1}{6} \cos 6\theta \right]$	M1A1
	$= \frac{1}{32} \left[-\frac{3}{2} \cos 2\theta + \frac{1}{6} \cos 6\theta \right]_0^{\frac{\pi}{8}}$ $= \frac{1}{32} \left[\left(-\frac{3}{2\sqrt{2}} - \frac{1}{6\sqrt{2}} \right) - \left(-\frac{3}{2} + \frac{1}{6} \right) \right] = \frac{1}{32} \left(\frac{4}{3} - \frac{5\sqrt{2}}{6} \right)$	dM1A1
		(4)
		Total 14
(d) Notes M1: Substitutes and integrates to obtain $p \cos 2\theta + q \cos 6\theta$ A1: Fully correct integration including the $\frac{1}{32}$ dM1: Substitutes both the given limits and subtracts the correct way round. Do not allow if working in decimals. There must be some evidence of both trigonometric terms evaluated with $\theta = \frac{\pi}{8}$ to give an expression containing $\sqrt{2}$ and both trigonometric terms evaluated with $\theta = 0$ to give a rational number. A1: Correct exact value with terms collected e.g. $\frac{1}{32} \left(\frac{4}{3} - \frac{5\sqrt{2}}{6} \right)$ or any exact equivalent e.g. $\frac{1}{24} - \frac{5\sqrt{2}}{192}$		

8.

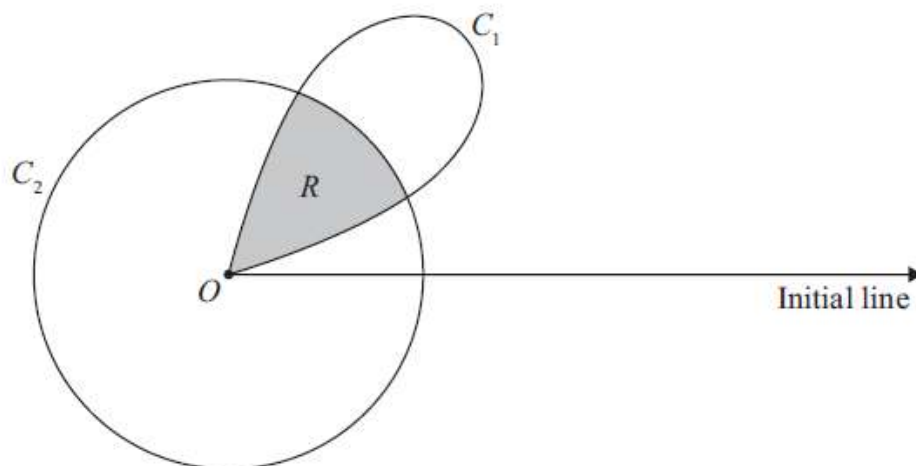


Figure 1

**In this question you must show all stages of your working.
Solutions relying entirely on calculator technology are not acceptable.**

Figure 1 shows the curve C_1 with polar equation $r = 2a \sin 2\theta$, $0 \leq \theta \leq \frac{\pi}{2}$, and the circle C_2 with polar equation $r = a$, $0 \leq \theta \leq 2\pi$, where a is a positive constant.

- (a) Find, in terms of a , the polar coordinates of the points where the curve C_1 meets the circle C_2 (3)

The regions enclosed by the curve C_1 and the circle C_2 overlap and the common region R is shaded in Figure 1.

- (b) Use algebraic integration to find the area of the shaded region R , giving your answer in the form $\frac{1}{12}a^2(p\pi + q\sqrt{3})$, where p and q are integers. (7)

(Total for Question 8 is 10 marks)

Question Number	Scheme	Marks
8(a)	$a = 2a \sin 2\theta \Rightarrow \sin 2\theta = \frac{1}{2} \Rightarrow 2\theta = \dots$	M1
	$\sin 2\theta = \frac{1}{2} \Rightarrow 2\theta = \frac{\pi}{6}, \frac{5\pi}{6}$	A1
	$\left(a, \frac{\pi}{12}\right), \left(a, \frac{5\pi}{12}\right)$	A1
		(3)
(a) Notes M1: Sets $a = 2a \sin 2\theta$ and attempts to solve for 2θ A1: Obtains $2\theta = \frac{\pi}{6}$ or $\frac{5\pi}{6}$ which may be implied. A1: Both points correct. Can be written as e.g. $r = a, \theta = \frac{\pi}{12}, \frac{5\pi}{12}$ Apply isw once the correct r and θ are seen for both points and condone coordinates written the wrong way round.		

(b)	$\frac{1}{2} \times a^2 \times \frac{\pi}{3}$ oe	B1
	$\left(\frac{1}{2}\right) \int r^2 (d\theta) = \left(\frac{1}{2}\right) \int (2a \sin 2\theta)^2 (d\theta)$	M1
	$\cos 4\theta = 1 - 2 \sin^2 2\theta \Rightarrow \sin^2 2\theta = \frac{1}{2}(1 - \cos 4\theta)$	M1
	$\int (1 - \cos 4\theta)(d\theta) = \theta - \frac{1}{4} \sin 4\theta$ or $2 \int (1 - \cos 4\theta)(d\theta) = 2\theta - \frac{1}{2} \sin 4\theta$	A1
	$I = a^2 \left[\theta - \frac{1}{4} \sin 4\theta \right]_0^{\frac{\pi}{12}} = a^2 \left\{ \left(\frac{\pi}{12} - \frac{1}{4} \sin 4 \cdot \frac{\pi}{12} \right) - (0) \right\}$	ddM1
	$R = 2I + \frac{a^2 \pi}{6} = 2a^2 \left(\frac{\pi}{12} - \frac{\sqrt{3}}{8} \right) + \frac{a^2 \pi}{6}$	dM1
	$R = \frac{1}{12} a^2 (4\pi - 3\sqrt{3})$	A1
		(7)
		Total 10

(b) Notes

B1: Any correct expression for the sector area in any form.

May be seen from an **evaluated** integral e.g. $\frac{1}{2} \int_{\frac{\pi}{12}}^{\frac{5\pi}{12}} a^2 d\theta = \frac{1}{2} \left[a^2 \theta \right]_{\frac{\pi}{12}}^{\frac{5\pi}{12}} = \frac{1}{2} a^2 \left(\frac{5\pi}{12} - \frac{\pi}{12} \right)$

M1: Attempts to use $\int r^2 d\theta$ with $r = 2a \sin 2\theta$. Condone the omission of “dθ”

Limits not needed (ignore any shown) and the $\frac{1}{2}$ may be missing.

M1: Uses $\sin^2 2\theta = \frac{\pm 1 \pm \cos 4\theta}{2}$ in an attempt to reach an integrable form.

Allow equivalent work e.g. uses $\sin^2 2\theta = 1 - \cos^2 2\theta$ and then $\cos^2 2\theta = \frac{\pm 1 \pm \cos 4\theta}{2}$.

A1: Fully correct integration. Condone the omission of “dθ” earlier and condone the omission of the a^2 . Limits not needed (ignore any shown) and the $\frac{1}{2}$ may be missing.

ddM1: An attempt to find one or both of the regions either side of the sector.

ie uses limits 0 and their $\frac{\pi}{12}$ and/or their $\frac{5\pi}{12}$ and $\frac{\pi}{2}$ both limits to be substituted and subtracted (if non-zero after substitution).

Limits to be used the correct way round. If two integrals seen award mark if either correct.

Depends on both previous method marks.

dM1: Fully correct strategy for the complete area (their sector + 2I or their sector + I if the $\frac{1}{2}$ was missing throughout.) All areas must be positive.

Depends on all the previous method marks.

A1: Correct expression in the required form.

Please check the examination details below before entering your candidate information

Candidate surname					Other names				
Centre Number					Candidate Number				

Pearson Edexcel International Advanced Level

Friday 16 January 2026

Morning (Time: 1 hour 30 minutes)

Paper reference **WFM02/01**

Mathematics

International Advanced Subsidiary/ Advanced Level

Further Pure Mathematics F2

You must have:
Mathematical Formulae and Statistics Tables (Yellow), calculator

Total Marks

Candidates may use any calculator allowed by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear.
Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 9 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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1. (a) Express

$$\frac{1}{(3n-1)(3n+5)}$$

in partial fractions.

(2)

(b) Hence, using the method of differences, show that for all positive integer values of n ,

$$\sum_{r=1}^n \frac{20}{(3r-1)(3r+5)} \equiv \frac{n(An+B)}{(3n+C)(3n+D)}$$

where A , B , C and D are integers to be determined.

(4)



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Question 1 continued

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Question 1 continued

(Total for Question 1 is 6 marks)



2.

$$y = (1 - 3x)^A + e^{Bx}$$

where A and B are non-zero constants.

- (a) Determine $\frac{d^3y}{dx^3}$ in terms of A , B and x . (3)

Given that the Maclaurin series expansion for y in ascending powers of x , up to and including the term in x^3 , is

$$y = 2 + kx^3$$

where k is a constant,

- (b) determine the value of A and the value of B . (4)
- (c) Hence determine the value of k , giving your answer as a fully simplified fraction. (3)



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Question 2 continued

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Question 2 continued

(Total for Question 2 is 10 marks)



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Question 3 continued

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Question 3 continued

(Total for Question 3 is 10 marks)



$$\frac{d^2y}{dx^2} = x^2y + \frac{dy}{dx}$$
$$\frac{d^4 y}{dx^4} = \frac{d^3 y}{dx^3} + Ax^2 \frac{d^2 y}{dx^2} + Bx \frac{dy}{dx} + Cy$$

(4)

(4)

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Question 4 continued

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Question 4 continued

(Total for Question 4 is 8 marks)



5. In this question you must show all stages of your working.
Solutions relying entirely on calculator technology are not acceptable.

Use algebra to determine the values of x for which

$$\left| \frac{x^2 + 5x - 2}{x^2 + 1} \right| < 2 \quad x \in \mathbb{R}$$

(6)



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Question 5 continued

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(Total for Question 5 is 6 marks)



6. The transformation T from the z -plane, where $z = x + iy$, to the w -plane, where $w = u + iv$, is given by

$$w = \frac{z + 2}{3z + 4} \quad z \neq -\frac{4}{3}$$

The circle C in the z -plane has equation

$$(x + 1)^2 + (y - 1)^2 = 1$$

Given that T maps C to the circle D in the w -plane, determine the equation of D , giving your answer in the form

$$u^2 + v^2 + au + bv + c = 0$$

where a , b and c are real numbers.

(7)



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Question 6 continued

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Question 6 continued

(Total for Question 6 is 7 marks)



7. Given that

$$\sin \theta = \frac{1}{2i}(e^{i\theta} - e^{-i\theta})$$

(a) show that

$$\sin^4 \theta = \frac{1}{8}(A \cos 4\theta + B \cos 2\theta + C)$$

where A , B and C are integers to be determined.

(4)

Using $\cos \theta \equiv \sin\left(\frac{1}{2}\pi - \theta\right)$ and the result from part (a),

(b) determine an expression for $\cos^4 \theta$ in terms of $\cos 4\theta$ and $\cos 2\theta$

(2)

(c) Hence determine

$$\int (\sin^4 \theta + \cos^4 \theta) d\theta$$

(2)



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Question 7 continued

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Question 7 continued

(Total for Question 7 is 8 marks)



8. (a) Given that $u = xy$, where u is a function of x ($x > 0$), show that

$$\frac{d^2 y}{dx^2} = \frac{1}{x} \left(\frac{d^2 u}{dx^2} - 2 \frac{dy}{dx} \right) \quad (3)$$

- (b) Hence show that the transformation $u = xy$ transforms the differential equation

$$x \frac{d^2 y}{dx^2} + 2(2x + 1) \frac{dy}{dx} + 13xy = 17e^{3x} - 4y \quad (\text{I})$$

into the differential equation

$$\frac{d^2u}{dx^2} + 4\frac{du}{dx} + 13u = 17e^{3x} \quad (II)$$

- (c) Solve differential equation (II) to determine a general solution for u in terms of x . (5)
- (d) Hence determine the general solution of differential equation (I). (1)



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Question 8 continued

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Question 8 continued

(Total for Question 8 is 11 marks)



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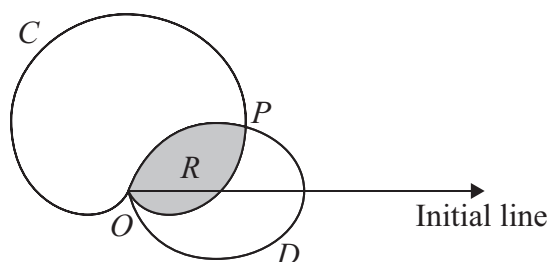


Figure 1

**In this question you must show all stages of your working.
Solutions relying entirely on calculator technology are not acceptable.**

Figure 1 shows a sketch of the curve C with polar equation

$$r = 1 + \sin \theta \quad -\frac{\pi}{2} \leq \theta \leq \frac{3\pi}{2}$$

and a sketch of the curve D with polar equation

$$r = 1 + \cos 2\theta \quad -\frac{\pi}{2} \leq \theta \leq \frac{\pi}{2}$$

The curves intersect at the pole O and at the point P as shown.

(a) Determine the polar coordinates of P .

(3)

The finite region R , shown shaded in Figure 1, is bounded by C and D .

(b) Use algebraic integration to show that the area of R is

$$a\pi + b\sqrt{3}$$

where a and b are rational numbers to be determined.

(6)



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Question 9 continued

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Question 9 continued

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(Total for Question 9 is 9 marks)

TOTAL FOR PAPER IS 75 MARKS



Mark Scheme (Results)

January 2026

International Advanced Level in Further Pure

Mathematics WFM02/01

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January 2026

Question paper Log Number P78990

Publication Code WFM02_01_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: Method marks are awarded for 'knowing a method and completing an attempt to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)
 - Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

1. ft – follow through
 2. cao – correct answer only
 3. cso - correct solution only. There must be no clear errors in this part of the question to obtain this mark
 4. isw – ignore subsequent working
 5. awrt – answers which round to
 6. SC: special case
 7. oe – or equivalent
 8. dM – dependent method mark
 9. dp decimal places
 10. sf significant figures
 11. ✱ The answer is given on the paper – apply cso
 12. d... Dependent mark
-
4. All A marks are 'correct answer only' (cao), unless shown, for example, as A1ft to indicate that previous wrong working is to be followed through.
 5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
 - If all but one attempt is crossed out, mark the attempt which is NOT crossed out provided it is not cursory.
 - either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
7. Ignore wrong working or incorrect statements following a correct answer unless the mark scheme indicates otherwise.
8. Mark question parts separately unless the mark scheme indicates otherwise.

Method mark for solving a 3 term quadratic:

(Note: There may be other schemes where the below does not apply)

1. Factorisation

$$(x^2 + bx + c) = (x + p)(x + q), \text{ where } |pq| = |c|, \text{ leading to } x = \dots$$

$$(ax^2 + bx + c) = (mx + p)(nx + q), \text{ where } |pq| = |c| \text{ and } |mn| = |a|, \text{ leading to } x = \dots$$

2. Formula

Correct attempt to use the correct formula leading to
 $x = \dots$ (unsimplified). There is no credit just for quoting the correct
 formula if it is incorrectly used or if only a simplified calculator answer is
 seen.

**3. Completing the square (where $a = 1$; if $a \neq 1$ must divide by a first
 but allow equivalent work e.g., if a is a perfect square)**

$$\text{Solving } x^2 + bx + c = 0 : \left(x \pm \frac{b}{2} \right)^2 \pm q \pm c = 0, \quad q \neq 0, \text{ leading to } x = \dots$$

Question Number	Scheme	Notes	Marks
1(a)	$\frac{1}{(3n-1)(3n+5)} \equiv \frac{A}{3n-1} + \frac{B}{3n+5}$ $\Rightarrow A = \dots \left\{ \frac{1}{6} \right\}, B = \dots \left\{ -\frac{1}{6} \right\}$	Uses correct partial fractions and finds values for both A and B	M1
	$\equiv \frac{1}{6(3n-1)} - \frac{1}{6(3n+5)}$	Correct partial fractions in any form e.g., $\frac{1}{18n-6} - \frac{1}{18n+30}, \frac{\frac{1}{6}}{3n-1} - \frac{\frac{1}{6}}{3n+5}, \frac{1}{6} \left(\frac{1}{3n-1} + \frac{-1}{3n+5} \right)$	A1
			(2)
(b)	Allow the M marks if r is used for n Ignore errors with terms that are cancelled		
	$\frac{20}{6} \sum_{r=1}^n \left(\frac{1}{3n-1} - \frac{1}{3n+5} \right) =$ $\frac{20}{6} \left(\frac{1}{2} - \frac{1}{8} + \frac{1}{5} - \frac{1}{11} + \frac{1}{8} - \frac{1}{14} + \dots + \frac{1}{3n-7} - \frac{1}{3n-1} + \frac{1}{3n-4} - \frac{1}{3n+2} + \frac{1}{3n-1} - \frac{1}{3n+5} \right)$ Uses the method of differences for at least the first and last rows. Must attempt to put their rows together. Allow with their partial fractions provided there are two which form a difference and have different 2 term linear denominators in n and numeric numerators. Ignore errors/omission with the 20 or the "$\frac{1}{6}$". Allow this mark to be implied if their 4 terms in the correct positions are the only ones that result.		M1
	$= \frac{20}{6} \left(\frac{1}{2} + \frac{1}{5} - \frac{1}{3n+2} - \frac{1}{3n+5} \right)$	Any correct expression for the required sum. The "20" may appear later - allow this mark if a correct sum without the 20 was seen but is then misprocessed before the 20 is reapplied.	A1
	$= \frac{20}{6} \left(\frac{7(3n+2)(3n+5) - 10(6n+7)}{10(3n+2)(3n+5)} \right)$	Achieves a consistent single fraction expression. Must come from adding 4 fractions - 2 numeric and 2 with different two term linear denominators and numeric numerators. Ignore omission/error with the 20 and/or the " $\frac{1}{6}$ ".	dM1
	$= \frac{1}{3} \left(\frac{63n^2 + 87n}{(3n+2)(3n+5)} \right) = \frac{n(21n+29)}{(3n+2)(3n+5)}$	Correct expression in the correct form. Not just values for the constants unless form is seen	A1
			(4)
			Total 6

Question Number	Scheme	Notes	Marks
2(a)	$y = (1-3x)^A + e^{Bx} \Rightarrow \frac{dy}{dx} = -3A(1-3x)^{A-1} + Be^{Bx}$	Correct first derivative. Accept unsimplified	B1
	$\frac{d^2y}{dx^2} = 9A(A-1)(1-3x)^{A-2} + B^2e^{Bx}$ $\frac{d^3y}{dx^3} = -27A(A-1)(A-2)(1-3x)^{A-3} + B^3e^{Bx} \quad \text{or e.g., } -27(A^3 - 3A^2 + 2A)(1-3x)^{A-3} + B^3e^{Bx}$ M1: Obtains $\frac{d^3y}{dx^3} = g(A)(1-3x)^{A-3} + h(B)e^{Bx}$ A1: Fully correct third derivative. Could be unsimplified. Condone poor bracketing unless further work confirms error. If $g(A)$ is only seen expanded then it must be correct		M1 A1
			(3)
(b)	$f'(0) = -3A + B = 0$	Substitutes $x = 0$ into their first derivative and sets $= 0$ and achieves a linear equation in A and B	M1
	$f''(0) = 9A(A-1) + B^2 = 0$ $\Rightarrow 9A^2 - 9A + (3A)^2 = 0$ or $\Rightarrow 9\left(\frac{B}{3}\right)\left(\frac{B}{3} - 1\right) + B^2 = 0$	Substitutes $x = 0$ into their second derivative, sets $= 0$ and obtains a quadratic equation in A (or B) only	dM1
	$18A^2 - 9A = 0 \Rightarrow 9A(2A-1) = 0 \Rightarrow A = \dots$ or $2B^2 - 3B = 0 \Rightarrow B(2B-3) = 0 \Rightarrow B = \dots$	Solves for A and B . No working is required but must get real values and neither can be 0 unless the zero solution is additional	ddM1
	$A = \frac{1}{2}, B = \frac{3}{2}$	Both correct values. Accept equivalent fractions/decimals. Ignore extra zero solution	A1
	Allow all marks in (b) even if full marks were not obtained in (a)		(4)
(c)	$\frac{d^3y}{dx^3} = -27A(A-1)(A-2)(1-3x)^{A-3} + B^3e^{Bx}$ $\left(\frac{d^3y}{dx^3}\right)_{x=0} = -27\left(\frac{1}{2}\right)\left(\frac{1}{2}-1\right)\left(\frac{1}{2}-2\right) + \left(\frac{3}{2}\right)^3 = \dots \left(-\frac{27}{4}\right)$ Substitutes their A and their B and $x = 0$ into their 3rd derivative and obtains a value. A and B must be non-zero and must have come from simultaneous equations (one linear, one quadratic). If $k = \dots$ they must have divided by 6		M1
	$k = -\frac{27}{4} \div 6 = \dots$ Divides their value by 6 or 3! to find a value for k. These two M marks are likely to be scored at the same time. If just a value is given without a substitution attempt it must be consistent.		dM1
	$k = -\frac{9}{8}$	Correct value for k . This fraction or $-1\frac{1}{8}$ This mark requires a fully correct solution.	A1
			(3)
			Total 10
	Alternative for (b) & (c) by series expansions: $y = (1-3x)^A + e^{Bx} = 1 - 3Ax + \frac{A(A-1)}{2}(-3x)^2 + \frac{A(A-1)(A-2)}{3!}(-3x)^3 + \dots + 1 + Bx + \frac{(Bx)^2}{2} + \frac{(Bx)^3}{3!} + \dots$ $= 2 + kx^3 + \dots \Rightarrow -3A + B = 0 \quad (\text{M1})$ $\frac{9A(A-1)}{2} + \frac{B^2}{2} = 0 \Rightarrow 9A^2 - 9A + 9A^2 = 0 \quad (\text{dM1})$ $2A^2 - A = A(2A-1) = 0 \Rightarrow A = \frac{1}{2}, B = \frac{3}{2} \quad (\text{ddM1A1})$ $k = -\frac{9}{2}A(A-1)(A-2) + \frac{B^3}{6} \quad (\text{M1}) \Rightarrow k = -\frac{9}{2}\left(\frac{1}{2}\right)\left(-\frac{1}{2}\right)\left(-\frac{3}{2}\right) + \frac{1}{6}\left(\frac{3}{2}\right)^3 = \dots, -\frac{9}{8} \quad (\text{dM1, A1})$		

Question Number	Scheme	Notes	Marks
3(a)	$4 \frac{dy}{dx} = y - 2xy^5 \quad u = y^{-4} \quad \left\{ y = u^{-\frac{1}{4}} \right\}$		
	e.g., $\frac{du}{dx} = -\frac{4}{y^5} \frac{dy}{dx}, \quad \frac{dy}{dx} = -\frac{1}{4} u^{-\frac{5}{4}} \frac{du}{dx}$	Correct differentiation of $u = y^{-4}$ to obtain an equation in $\frac{du}{dx}$ and $\frac{dy}{dx}$ May be implied by later work	B1
	$4 \left(-\frac{y^5}{4} \right) \frac{du}{dx} = y - 2xy^5, \quad -u^{-\frac{5}{4}} \frac{du}{dx} = y - 2xy^5$	Use the given differential equation and substitutes. Requires a correct form from differentiation of $u = y^{-4}$	M1
	$4 \left(-\frac{y^5}{4} \right) \frac{du}{dx} = y - 2xy^5 \Rightarrow \frac{du}{dx} + \frac{1}{y^4} = 2x \Rightarrow \frac{du}{dx} + u = 2x^*$ or, e.g., $-u^{-\frac{5}{4}} \frac{du}{dx} = y - 2xy^5 \Rightarrow \frac{du}{dx} = 2u^{\frac{5}{4}} xy^5 - u^{\frac{5}{4}} y$ or $2x - u \Rightarrow \frac{du}{dx} + u = 2x^*$ Achieves the given answer with no errors and an intermediate step after substitution shown		A1*
			(3)
(b)	$I = e^{\int dx} = e^x$	Correct integrating factor	B1
	$ue^x = \int 2xe^x dx$	For $Iu = \int 2xI dx$ Allow with y for u . I must be a function of x	M1
	Note that a tabular "DI" approach may be used for parts. dM1 for a correct form		
	$ue^x = 2xe^x - \int 2e^x dx$	Applies parts to RHS and achieves correct form - allow with y for u and condone + used for - in the parts formula	dM1
	$ue^x = 2xe^x - 2e^x (+c)$	Correct equation with or without a constant of integration. Must have u	A1
	$u = 2x - 2 + ce^{-x}$	Any correct equation with " $u=...$ " and the constant correctly placed	A1
	If a 2nd order method is used, CF: $\{A\} e^{-x}$ (B1), PF: $\lambda x + \mu$ (M1), valid method for λ and μ (dM1), A marks as above		(5)
(c)	$1 = c - 2 \Rightarrow c = 3$	Uses the given conditions ($y=1$ or $u=1$ and $x=0$) to find the constant of integration. Condone poor algebra e.g., $\frac{1}{a} + \frac{1}{b}$ used for $\frac{1}{a+b}$	M1
	$y^4 = \frac{1}{2x - 2 + 3e^{-x}}$	Any correct equation in the required $y^4 = ...$ form e.g., $y^4 = \frac{1}{2(x-1) + \frac{3}{e^x}}$ Allow $y^4 = \frac{1}{2x - 2 + ce^{-x}}, c = 3$	A1
			(2)
			Total 10

Question Number	Scheme/Notes	Marks
4(a)	$\frac{d^2 y}{dx^2} = x^2 y + \frac{dy}{dx} \Rightarrow \frac{d^3 y}{dx^3} = 2xy + x^2 \frac{dy}{dx} + \frac{d^2 y}{dx^2}$ M1: Differentiates $x^2 y$ to $Axy + Bx^2 \frac{dy}{dx}$ A1: Any correct expression for the 3rd derivative	M1 A1
	$\frac{d^4 y}{dx^4} = 2y + 2x \frac{dy}{dx} + x^2 \frac{d^2 y}{dx^2} + 2x \frac{dy}{dx} + \frac{d^3 y}{dx^3}$ Differentiates again to obtain an expression of the form $\frac{d^4 y}{dx^4} = Cy + Dx \frac{dy}{dx} + x^2 \frac{d^2 y}{dx^2} + \frac{d^3 y}{dx^3}$ Terms may be uncollected	dM1
	$\frac{d^4 y}{dx^4} = \frac{d^3 y}{dx^3} + x^2 \frac{d^2 y}{dx^2} + 4x \frac{dy}{dx} + 2y$ Fully correct 4th derivative in correct form	A1
		(4)
(b)	$\frac{dy}{dx} = 3 \text{ and } y = 1 \text{ at } x = 1 \Rightarrow \frac{d^2 y}{dx^2} = 1 + 3 = 4$ Correct value for the 2nd derivative	B1
	$\left(\frac{d^3 y}{dx^3} \right)_{x=1} = 2(1)(1) + 1 \times 3 + 4 = 9, \quad \left(\frac{d^4 y}{dx^4} \right)_{x=1} = 9 + 4 + 4 \times 3 + 2 = 27$ Finds values for their 3rd and 4th derivatives at $x = 1$. Allow slips	M1
	$\{y=\} 1 + 3(x-1) + \frac{4(x-1)^2}{2!} + \frac{9(x-1)^3}{3!} + \frac{27(x-1)^4}{4!} + \dots$ Applies Taylor's expansion correctly with their 3 values. There is no credit for quoting a correct formula - it must be applied appropriately	dM1
	$\{y=\} 1 + 3(x-1) + 2(x-1)^2 + \frac{3(x-1)^3}{2} + \frac{9(x-1)^4}{8} + \dots$ Correct series with simplified coefficients	A1
		(4)
		Total 8

Question Number	Scheme	Notes	Marks
5	"Solutions relying entirely on calculator technology are not acceptable"		
	$\left \frac{x^2 + 5x - 2}{x^2 + 1} \right < 2 \Rightarrow x^2 + 5x - 2 < 2(x^2 + 1)$ $x^2 + 5x - 2 = 2(x^2 + 1) \Rightarrow x = \dots$ or $x^2 + 5x - 2 = -2(x^2 + 1) \Rightarrow x = \dots$	Multiplies through by $x^2 + 1$ and attempts to find at least one pair of cvs from an initially correct equation (no fraction). Usual rules (2 solutions) if 3TQ with solving method seen. If 2TQ allow $ax^2 + bx = 0 \Rightarrow \{x = 0, \} \quad x = \pm \frac{b}{a} \text{ and}$ condone this without factorisation seen	M1
	$x^2 - 5x + 4 = (x - 1)(x - 4) \Rightarrow x = 1, 4 \quad \text{or} \quad 3x^2 + 5x \{= x(3x + 5)\} = 0 \Rightarrow x = 0, -\frac{5}{3}$ Identifies 1 correct pair of cvs. The "0" may appear later		A1
	$x^2 + 5x - 2 = 2(x^2 + 1) \Rightarrow x = \dots$ and $x^2 + 5x - 2 = -2(x^2 + 1) \Rightarrow x = \dots$	Complete method to find all 4 cvs (rules as previous M1)	dM1
	$x^2 - 5x + 4 = (x - 1)(x - 4) \Rightarrow x = 1, 4 \quad \text{or} \quad 3x^2 + 5x \{= x(3x + 5)\} = 0 \Rightarrow x = 0, -\frac{5}{3}$ All 4 cvs correct. The "0" may appear later. Ignore extra cvs but no further marks unless they are disregarded.		A1
	$x < -\frac{5}{3}, \quad 0 < x < 1, \quad x > 4$	M1: With 4 cvs a, b, c, d where $a < b < c < d$ identifies $x < a, \quad b < x < c, \quad x > d$ Condone non-strict inequalities. A1: Fully correct. Allow any equivalent correct notation e.g. $\left(-\infty, -\frac{5}{3}\right) \cup (0, 1) \cup (4, \infty)$ Condone "and" but do not allow $\cap$ for this last mark	M1 A1
Note that if no 3TQ solving method is seen 110011 is possible but the last two marks cannot be scored if there is no algebra at all. Condone use of a calculator for the last two marks provided there has been some algebra at some point. If squaring is used this leads to: $3x^4 - 10x^3 - 13x^2 + 20x = x(3x^3 - 10x^2 - 13x + 20) = x(3x + 5)(x - 1)(x - 4)$ but the first 2 M marks are only scored if there is clear evidence of a non-calculator method for factorising (e.g., factor theorem, grid, etc.) You may also see the difference of two squares e.g., $2^2(x^2 + 1)^2 - (x^2 + 5x - 2)^2 = (3x^2 + 5x)(x^2 - 5x + 4) = x(3x + 5)(x - 1)(x - 4) = 0 \Rightarrow \dots$ We must see the factorisation of the 3TQ as with the main scheme			(6)
			Total 6

Question Number	Scheme	Notes	Marks
6	$(x+1)^2 + (y-1)^2 = 1 \Rightarrow z - (-1+i) = 1$	Correct locus e.g., $ z+1-i = 1$	B1
	$w = \frac{z+2}{3z+4} \Rightarrow z = \frac{2-4w}{3w-1}$	M1: Attempts to make z the subject A1: Any correct rearrangement	M1 A1
	$ z - (-1+i) = 1 \Rightarrow \left \frac{2-4w}{3w-1} + 1 - i \right = 1$	Uses a locus of the form $ z \pm 1 \pm i = 1$ and their expression for z in terms of w and sets $= 1$	dM1
	$\Rightarrow \left \frac{2-4w+3w-3wi-1+i}{3w-1} \right = 1 \Rightarrow 1-w-3wi+i = 3w-1 $ $\Rightarrow 1-u-iv-3ui+i+3v = 3u+3iv-1 $ M1: Finds common denominator, multiplies up and introduces $w = u + iv$		ddM1
	$(1-u+3v)^2 + (1-v-3u)^2 = (3u-1)^2 + 9v^2$	Applies Pythagoras correctly to obtain an equation in u and v	dddM1
	$u^2 + v^2 - 2u + 4v + 1 = 0$	Correct equation in this form	A1
			(7)
	There may be various alternatives. If using the main scheme above benefits the learners for any different approaches then please use that. Approaches which attempt to map points can access the first mark as above (or by choosing three correct points (or complex numbers) for the circle). The remaining marks would score as follows: M1 for transforming 3 points using the given transformation A1: 3 correct points dM1ddM1dddM1: For a complete valid method to establish the equation of circle D Could find the intersection point of two perpendicular bisectors and then find the radius and produce a circle equation, or use the transformed points in a general circle equation and solve the 3 simultaneous equations involving 3 unknowns and produce a circle equation A1: Correct equation Another possibility is: $u + iv = \frac{x + iy + 2}{3(x + iy) + 4} \text{ or } x + iy = \frac{2 - 4(u + iv)}{3(u + iv) - 1} \text{ (the latter could get M1A1 already)}$ $\Rightarrow x = \frac{-12u^2 - 12v^2 + 10u - 2}{(3u-1)^2 + 9v^2} \quad y = \frac{-2v}{(3u-1)^2 + 9v^2} \quad (\text{M1A1})$ Could write this as $x + iy$ and note that $(3u-1)^2 + 9v^2 = 9u^2 - 6u + 1 + 9v^2$ $\left(\frac{-12u^2 - 12v^2 + 10u - 2}{(3u-1)^2 + 9v^2} + 1 \right)^2 + \left(\frac{-2v}{(3u-1)^2 + 9v^2} - 1 \right)^2 = 1 \quad (\text{dM1ddM1dddM1, B1 if all correct})$ $u^2 + v^2 - 2u + 4v + 1 = 0 \quad (\text{A1})$		

Question Number	Scheme	Notes	Marks
7(a)	$\sin \theta = \frac{1}{2i}(e^{i\theta} - e^{-i\theta})$ $\Rightarrow \sin^4 \theta = \left\{ \frac{1}{(2i)^4} \right\} \left((e^{i\theta})^4 + 4(e^{i\theta})^3(-e^{-i\theta}) + 6(e^{i\theta})^2(-e^{-i\theta})^2 + 4e^{i\theta}(-e^{-i\theta})^3 + (e^{-i\theta})^4 \right)$ Expands $(e^{i\theta} - e^{-i\theta})^4$ or squares twice. Allow slips but must have at least 4 terms and include an attempt at binomial coefficients which may be uncalculated e.g., $\binom{4}{3}$... $\text{Allow via } \left\{ \frac{1}{(2i)^4} \right\} \left(z - \frac{1}{z} \right)^4 = \left\{ \frac{1}{16} \right\} (z^4 - 4z^2 + 6 - 4z^{-2} + z^{-4})$		M1
	$= \frac{1}{16}(e^{4i\theta} - 4e^{2i\theta} + 6 - 4e^{-2i\theta} + e^{-4i\theta}) \text{ or } \frac{1}{16}(z^4 - 4z^2 + 6 - 4z^{-2} + z^{-4})$ Correct simplified expansion. The $\frac{1}{16}$ may be applied later		A1
	$= \frac{1}{16}(\cos 4\theta + i \sin 4\theta + \cos 4\theta - i \sin 4\theta - 4(\cos 2\theta + i \sin 2\theta + \cos 2\theta - i \sin 2\theta) + 6)$ or $= \frac{1}{16}(e^{4i\theta} + e^{-4i\theta} - 4(e^{2i\theta} + e^{-2i\theta}) + 6) = \frac{1}{16}(2 \cos 4\theta - 4(2 \cos 2\theta) + 6)$ Completes an attempt to use $e^{n\theta i} = \cos n\theta + i \sin n\theta$ or $\cos n\theta = \frac{1}{2}(e^{in\theta} + e^{-in\theta})$ to express the expansion in terms of trig functions. The $\frac{1}{16}$ may be incorrect or missing		dM1
	$\frac{1}{16}(2 \cos 4\theta - 8 \cos 2\theta + 6) \Rightarrow \frac{1}{8}(\cos 4\theta - 4 \cos 2\theta + 3)$ Correct expression in the required form		A1
			(4)
(b)	$\Rightarrow \sin^4 \left(\frac{1}{2}\pi - \theta \right) = \frac{1}{8} \left(\cos 4 \left(\frac{1}{2}\pi - \theta \right) - 4 \cos 2 \left(\frac{1}{2}\pi - \theta \right) + 3 \right)$ $\cos^4 \theta = \frac{1}{8} \left(\cos 4 \left(\frac{1}{2}\pi - \theta \right) - 4 \cos 2 \left(\frac{1}{2}\pi - \theta \right) + 3 \right)$ $= \frac{1}{8}(\cos(2\pi - 4\theta) - 4 \cos(\pi - 2\theta) + 3)$ $= \frac{1}{8}(\cos 4\theta + 4 \cos 2\theta + 3) \text{ oe e.g., } \frac{1}{8} \cos 4\theta + \frac{1}{2} \cos 2\theta + \frac{3}{8}$ M1: $\sin^4 \theta = A \cos 4\theta + B \cos 2\theta + C \Rightarrow \cos^4 \theta = D \cos 4\theta + E \cos 2\theta + F$ Do not allow if something other than $\cos \theta = \sin \left(\frac{\pi}{2} - \theta \right)$ is clearly being used A1: Any correct expression in terms of $\cos 4\theta$ and $\cos 2\theta$ (not fortuitous)		M1 A1
			(2)
(c)	$\int (\sin^4 \theta + \cos^4 \theta) d\theta = \int \left(\frac{1}{8}(\cos 4\theta - 4 \cos 2\theta + 3) + \frac{1}{8}(\cos 4\theta + 4 \cos 2\theta + 3) \right) d\theta$ $\left\{ = \int \left(\frac{1}{4} \cos 4\theta + \frac{3}{4} \right) d\theta \text{ or e.g., } \frac{1}{8} \int (2 \cos 4\theta + 6) d\theta \right\}$ Uses their expressions from (a) and (b) both of correct form and different and substitutes correctly within an integral. M0 if expression would reduce to just k. Must be consistent if only seen with terms collected		M1
	$= \frac{1}{16} \sin 4\theta + \frac{3}{4} \theta (+c)$	Correct 2 term result with or without $+c$	A1
			(2)
			Total 8

Question Number	Scheme	Notes	Marks
8(a)	e.g., $u = xy \Rightarrow \frac{du}{dx} = x \frac{dy}{dx} + y$ or $y = ux^{-1} \Rightarrow \frac{dy}{dx} = -ux^{-2} + x^{-1} \frac{du}{dx}$ or $\frac{dy}{dx} = \frac{x \frac{du}{dx} - u}{x^2}$ Differentiates $u = xy$ oe to obtain any correct equation in $\frac{du}{dx}$ and $\frac{dy}{dx}$		B1
	$\frac{du}{dx} = x \frac{dy}{dx} + y \Rightarrow \frac{d^2u}{dx^2} = x \frac{d^2y}{dx^2} + \frac{dy}{dx} + \frac{dy}{dx}$ or e.g., $\frac{d^2y}{dx^2} = -x^{-2} \frac{du}{dx} + 2x^{-3}u - x^{-2} \frac{du}{dx} + x^{-1} \frac{d^2u}{dx^2} \Rightarrow -2x^{-2} \left(x \frac{dy}{dx} + y \right) + 2x^{-2}y + x^{-1} \frac{d^2u}{dx^2}$ Differentiates again and obtains an equation of the correct form before given answer i.e., $A \frac{d^2u}{dx^2} = Bx \frac{d^2y}{dx^2} + C \frac{dy}{dx} \text{ oe}$ Allow if there are clearly cancelling terms involving other variables/derivatives or the work makes completely clear how the given answer is reached		M1
	$\Rightarrow \frac{d^2y}{dx^2} = \frac{1}{x} \left(\frac{d^2u}{dx^2} - 2 \frac{dy}{dx} \right) *$	Obtains the given answer with no errors. No intermediate step is required	A1*
			(3)
(b)	$x \frac{d^2y}{dx^2} + 2(2x+1) \frac{dy}{dx} + 13xy = 17e^{3x} - 4y$ $\Rightarrow x \frac{1}{x} \left(\frac{d^2u}{dx^2} - 2 \frac{dy}{dx} \right) + 4x \frac{1}{x} \left(\frac{du}{dx} - y \right) + 2 \frac{dy}{dx} + 13xy = 17e^{3x} - 4y$ Substitutes the given second derivative and their first derivative into DE (I)		M1
	$\Rightarrow \frac{d^2u}{dx^2} + 4 \frac{du}{dx} - 4y + 13u = 17e^{3x} - 4y$ $\Rightarrow \frac{d^2u}{dx^2} + 4 \frac{du}{dx} + 13u = 17e^{3x} *$	Obtains the given answer with an intermediate step after substitution and no errors	A1*
			(2)
(c)	$m^2 + 4m + 13 = 0 \Rightarrow m = -2 \pm 3i$	Solves $m^2 + 4m + 13 = 0$ (allow miscopy and apply usual rules if necessary but may use calculator but if so must get a correct root for their 3TQ)	M1
	$\{u\} = e^{-2x} (A \cos 3x + B \sin 3x)$	Correct CF	A1
	Note other CFs are possible: $\{u\} = Ae^{(-2+3i)x} + Be^{(-2-3i)x}, Ae^{-2x} \cos(3x+B)$		
	$u = \lambda e^{3x} \Rightarrow \frac{du}{dx} = 3\lambda e^{3x} \Rightarrow \frac{d^2u}{dx^2} = 9\lambda e^{3x}$ $\Rightarrow \frac{d^2u}{dx^2} + 4 \frac{du}{dx} + 13u = (9\lambda + 12\lambda + 13\lambda) e^{3x}$	Starts with the correct PI form, differentiates twice (obtaining correct (changed) forms) and substitutes into LHS	M1
	$\Rightarrow 9\lambda + 12\lambda + 13\lambda = 17 \Rightarrow \lambda = \dots$	Solves to find the unknown in the PI	dM1
	$u = e^{-2x} (A \cos 3x + B \sin 3x) + \frac{1}{2} e^{3x}$	Correct GS of equation (II). Must be $u = \dots$	A1
(d)			(5)
	$y = \frac{1}{x} \left(e^{-2x} (A \cos 3x + B \sin 3x) + \frac{1}{2} e^{3x} \right)$	Correct follow through equation. Allow with their CF + PI provided both are functions of x (allow e.g., CF with no constant, PI with constant) Must be $y = \dots$	B1ft
			(1)
			Total 11

Question Number	Scheme	Notes	Marks
9	"Solutions relying entirely on calculator technology are not acceptable"		
(a)	$1 + \sin \theta = 1 + \cos 2\theta \Rightarrow \sin \theta = 1 - 2 \sin^2 \theta \Rightarrow 2 \sin^2 \theta + \sin \theta - 1 = 0$ Sets $1 + \sin \theta = 1 + \cos 2\theta$ and obtains a 3TQ in $\sin \theta$ (terms may not all be on one side) by using $\cos 2\theta = \pm 1 \pm 2 \sin^2 \theta$ or equivalent work condoning sign errors only in identities		M1
	$2 \sin^2 \theta + \sin \theta - 1 = 0 \Rightarrow (2 \sin \theta - 1)(\sin \theta + 1) = 0$ $\Rightarrow \sin \theta = \frac{1}{2} \Rightarrow \theta = \dots$	Solves 3TQ in $\sin \theta$ for θ Must see factorisation or equivalent work	dM1
	$\left(\frac{3}{2}, \frac{\pi}{6}\right)$ Allow $r = \frac{3}{2}, \theta = \frac{\pi}{6}$ even if followed by $\left(\frac{\pi}{6}, \frac{3}{2}\right)$ Correct polar coordinates. Ignore extra coordinate pairs unless correct P is rejected		A1
			(3)

(b)	Note that the $\frac{1}{2}$ s may have already been applied		
	$\int (1 + \sin \theta)^2 d\theta = \int (1 + 2 \sin \theta + \sin^2 \theta) d\theta = \int \left(1 + 2 \sin \theta + \frac{1}{2} - \frac{1}{2} \cos 2\theta\right) d\theta$ $\int (1 + \cos 2\theta)^2 d\theta = \int (1 + 2 \cos 2\theta + \cos^2 2\theta) d\theta = \int \left(1 + 2 \cos 2\theta + \frac{1}{2} + \frac{1}{2} \cos 4\theta\right) d\theta$		
	$\int (1 + \sin \theta)^2 d\theta = \int (1 + 2 \sin \theta + \sin^2 \theta) d\theta$ and uses $\sin^2 \theta = \pm \frac{1}{2} \pm \frac{1}{2} \cos 2\theta$ $\int (1 + \cos 2\theta)^2 d\theta = \int (1 + 2 \cos 2\theta + \cos^2 2\theta) d\theta$ and uses $\cos^2 2\theta = \pm \frac{1}{2} \pm \frac{1}{2} \cos 4\theta$		M1(one) dM1(both)
	Allows the Ms for $r_1^2 \pm r_2^2$ but $(r_1 \pm r_2)^2$ is M0dM0		
	$\int \left(1 + 2 \sin \theta + \frac{1}{2} - \frac{1}{2} \cos 2\theta\right) d\theta = \frac{3}{2} \theta - 2 \cos \theta - \frac{1}{4} \sin 2\theta (+c)$ $\int \left(1 + 2 \cos 2\theta + \frac{1}{2} + \frac{1}{2} \cos 4\theta\right) d\theta = \frac{3}{2} \theta + \sin 2\theta + \frac{1}{8} \sin 4\theta (+c)$		A1(one) Requires 1 previous M mark A1(both)
	Area of R : $\frac{1}{2} \left[\frac{3}{2} \theta - 2 \cos \theta - \frac{1}{4} \sin 2\theta \right]_{-\frac{\pi}{2}}^{\frac{\pi}{6}} + \frac{1}{2} \left[\frac{3}{2} \theta + \sin 2\theta + \frac{1}{8} \sin 4\theta \right]_{\frac{\pi}{6}}^{\frac{\pi}{2}}$ $= \frac{1}{2} \left(\frac{\pi}{4} - \sqrt{3} - \frac{\sqrt{3}}{8} - \left(-\frac{3\pi}{4} \right) \right) + \frac{1}{2} \left(\frac{3\pi}{4} - \left(\frac{\pi}{4} + \frac{\sqrt{3}}{2} + \frac{\sqrt{3}}{16} \right) \right) \text{ or } \frac{1}{2} \left(\pi - \frac{9\sqrt{3}}{8} \right) + \frac{1}{2} \left(\frac{\pi}{2} - \frac{9\sqrt{3}}{16} \right)$ A completely valid method using the $\frac{1}{2}$ twice and the correct limits, obtaining a numerical expression with trig terms evaluated. May not be consistent - if the limits are seen correctly on the square brackets accept the sum of two substitutions. If just $a\pi + b\sqrt{3}$ results it must be $\frac{3\pi}{4} - \frac{27}{32}\sqrt{3}$		ddM1
	$= \frac{3\pi}{4} - \frac{27}{32}\sqrt{3}$ Correct expression in this form. Requires all previous marks.		A1
			(6)
			Total 9

Pearson Edexcel International Advanced Level

Friday 23 January 2026

Morning (Time: 1 hour 30 minutes)

**Paper
reference**

WFM03/01A

Mathematics

International Advanced Subsidiary/ Advanced Level

Further Pure Mathematics F3

Question paper

You must have:

Answer book (sent separately).

Do not return this question paper with the answer book.

Turn over ►

P87591A

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Pearson

1. **In this question you must show all stages of your working.**
Solutions relying entirely on calculator technology are not acceptable.

Determine the exact values of x for which

$$\cosh 2x - 7 \sinh x = 5$$

giving your answers as natural logarithms.

(7)

(Total for Question 1 is 7 marks)

2. **In this question you must show all stages of your working.**
Solutions relying entirely on calculator technology are not acceptable.

Determine

(a) $\int_{-2}^1 \frac{1}{x^2 + 4x + 13} dx$, giving your answer as a multiple of π (5)

(b) $\int_{-1}^4 \frac{1}{\sqrt{4x^2 - 12x + 34}} dx$, giving your answer in the form $p \ln(q + r\sqrt{2})$,
where p , q and r are rational numbers. (7)

(Total for Question 2 is 12 marks)

3. The hyperbola H has equation

$$\frac{x^2}{16} - \frac{y^2}{4} = 1$$

The line l is a tangent to H at the point $P(4 \cosh \alpha, 2 \sinh \alpha)$, where α is a constant, $\alpha \neq 0$

- (a) Using calculus, show that an equation for l is

$$2y \sinh \alpha - x \cosh \alpha + 4 = 0 \quad (4)$$

The line l cuts the y -axis at the point A .

- (b) Find the coordinates of A in terms of α (2)

The point B has coordinates $(0, 10 \sinh \alpha)$ and the point S is the focus of H for which $x > 0$

- (c) Show that the line segment AS is perpendicular to the line segment BS . (5)

(Total for Question 3 is 11 marks)



4.

$$I_n = \int \sec^n x \, dx \quad n \geq 0$$

(a) Prove that for $n \geq 2$

$$(n-1)I_n = \tan x \sec^{n-2} x + (n-2)I_{n-2} \quad (6)$$

(b) Hence, showing each step of your working, find the exact value of

$$\int_0^{\frac{\pi}{4}} \sec^6 x \, dx$$

(Solutions relying entirely on calculator technology are not acceptable.) (4)

(Total for Question 4 is 10 marks)

5.

$$\mathbf{M} = \begin{pmatrix} 4 & -5 & 0 \\ k & 2 & 0 \\ -3 & -5 & k \end{pmatrix}$$

where k is a real constant, $k \neq 0$, $k \neq -\frac{8}{5}$

(a) Find, in terms of k , the inverse of the matrix $\mathbf{M}$. (5)

A transformation $T: \mathbb{R}^3 \rightarrow \mathbb{R}^3$ is represented by the matrix

$$\begin{pmatrix} 4 & -5 & 0 \\ -1 & 2 & 0 \\ -3 & -5 & -1 \end{pmatrix}$$

The transformation T maps the plane Π_1 onto the plane Π_2

Given that the plane Π_2 has equation $2x - z = 4$

(b) find a Cartesian equation of the plane Π_1 (6)

(Total for Question 5 is 11 marks)

6. The curve C has parametric equations

$$x = \cosh t + t \quad y = \cosh t - t \quad 0 \leq t \leq \ln 3$$

- (a) Show that

$$\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2 = 2 \cosh^2 t \quad (3)$$

The curve C is rotated through 2π radians about the x -axis. The area of the curved surface generated is given by S .

- (b) Show that

$$S = 2\pi\sqrt{2} \int_0^{\ln 3} (\cosh^2 t - t \cosh t) dt \quad (2)$$

- (c) Hence find the value of S , giving your answer in the form

$$\frac{\pi\sqrt{2}}{9}(a + b \ln 3)$$

where a and b are constants to be determined.

(Solutions relying entirely on calculator technology are not acceptable.) (7)

(Total for Question 6 is 12 marks)

7. With respect to a fixed origin O , the points $A(-1, 5, 1)$, $B(1, 0, 3)$, $C(2, -1, 2)$ and $D(3, 6, -1)$ are the vertices of a tetrahedron.

- (a) Find the volume of the tetrahedron $ABCD$. (4)

The plane Π contains the points A , B , and C .

- (b) Find a Cartesian equation of Π . (4)

The point T lies on the plane Π .

The line DT is perpendicular to Π .

- (c) Find the exact coordinates of the point T . (4)

(Total for Question 7 is 12 marks)

TOTAL FOR PAPER IS 75 MARKS



Please check the examination details below before entering your candidate information

Candidate surname

Other names

Centre Number

Candidate Number

Pearson Edexcel International Advanced Level

Friday 23 January 2026

Morning (Time: 1 hour 30 minutes)

Paper
reference

WFM03/01A

Mathematics

**International Advanced Subsidiary/Advanced Level
Further Pure Mathematics F3
Answer Book**

You must have:

Question paper (sent separately).

Mathematical Formulae and Statistical Tables (Yellow), calculator.

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 7 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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Question 1

Write the answer to Question 1 on these 2 pages

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(Total for Question 1 is 7 marks)



Question 2

Write the answer to Question 2 on these 4 pages

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Question 2 continued

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Question 3

Write the answer to Question 3 on these 4 pages

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Question 3 continued

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(Total for Question 3 is 11 marks)



Question 4

Write the answer to Question 4 on these 4 pages

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Question 4 continued

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(Total for Question 4 is 10 marks)



Question 5

Write the answer to Question 5 on these 4 pages

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Question 5 continued

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(Total for Question 5 is 11 marks)



Question 6

Write the answer to Question 6 on these 4 pages

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Question 6 continued

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(Total for Question 6 is 12 marks)



Question 7

Write the answer to Question 7 on these 5 pages

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Question 7 continued

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Question 7 continued

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(Total for Question 7 is 12 marks)

TOTAL FOR PAPER IS 75 MARKS



Mark Scheme (Results)

January 2026

International Advanced Level in Further Pure

Mathematics WFM03/01A

Edexcel and BTEC Qualifications

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January 2026

Question paper Log Number P87591

Publication Code WFM03_01A_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: Method marks are awarded for 'knowing a method and completing an attempt to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)
 - Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

1. ft – follow through
 2. cao – correct answer only
 3. cso - correct solution only. There must be no clear errors in this part of the question to obtain this mark
 4. isw – ignore subsequent working
 5. awrt – answers which round to
 6. SC: special case
 7. oe – or equivalent
 8. dM – dependent method mark
 9. dp decimal places
 10. sf significant figures
 11. ✱ The answer is given on the paper – apply cso
 12. d... Dependent mark
-
4. All A marks are 'correct answer only' (cao), unless shown, for example, as A1ft to indicate that previous wrong working is to be followed through.
 5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
 - If all but one attempt is crossed out, mark the attempt which is NOT crossed out provided it is not cursory.
 - either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
7. Ignore wrong working or incorrect statements following a correct answer unless the mark scheme indicates otherwise.
8. Mark question parts separately unless the mark scheme indicates otherwise.

Method mark for solving a 3 term quadratic:

(Note: There may be other schemes where the below does not apply)

1. Factorisation

$$(x^2 + bx + c) = (x + p)(x + q), \text{ where } |pq| = |c|, \text{ leading to } x = \dots$$

$$(ax^2 + bx + c) = (mx + p)(nx + q), \text{ where } |pq| = |c| \text{ and } |mn| = |a|, \text{ leading to } x = \dots$$

2. Formula

Correct attempt to use the correct formula leading to
 $x = \dots$ (unsimplified). There is no credit just for quoting the correct
 formula if it is incorrectly used or if only a simplified calculator answer is
 seen.

**3. Completing the square (where $a = 1$; if $a \neq 1$ must divide by a first
 but allow equivalent work e.g., if a is a perfect square)**

$$\text{Solving } x^2 + bx + c = 0: \left(x \pm \frac{b}{2}\right)^2 \pm q \pm c = 0, \quad q \neq 0, \text{ leading to } x = \dots$$

Question Number	Scheme	Notes	Marks
1.	"...show all stages of your working. Solutions relying entirely on calculator technology are not acceptable."		
	Move to the alternative scheme if they use exponentials		
	$\cosh 2x - 7 \sinh x = 5 \Rightarrow 1 + 2 \sinh^2 x - 7 \sinh x = 5$ Replaces $\cosh 2x$ with $1 + 2 \sinh^2 x$. Or $\cosh 2x$ with $2 \cosh^2 x - 1$ or $\cosh^2 x + \sinh^2 x$ and then $\cosh^2 x$ with $1 + \sinh^2 x$. There must be no incorrect identities used.		M1
	$2 \sinh^2 x - 7 \sinh x - 4 = 0$	Correct 3TQ (implied by a correct solution for $\sinh x$)	A1
	$(2 \sinh x + 1)(\sinh x - 4) = 0 \Rightarrow \sinh x =$	Attempt to solve 3TQ in $\sinh x$ (usual rules) Solving method must be seen - note that e.g., 1100111 is a possible mark profile	M1
	$\sinh x = -\frac{1}{2}, 4$	Both correct values	A1
	$x = \ln \left(-\frac{1}{2} + \sqrt{\left(-\frac{1}{2}\right)^2 + 1} \right), \quad \ln \left(4 + \sqrt{(4)^2 + 1} \right)$ Obtains at least one correct exact log form of x for one of their real values of $\sinh x$. This mark may also be gained by using the correct exponential form of $\sinh x$ and solving appropriately (may be slips but must reach 3TQ in e^x - does not have to be written in $=0$ form). Then solved by usual rules but allow if consistent calculator answer - and must take lns)		M1
	$x = \ln \left(-\frac{1}{2} + \sqrt{\frac{5}{4}} \right) \text{ or e.g., } \ln \frac{-1 + \sqrt{5}}{2}, \quad \ln(4 + \sqrt{17})$ A1: One correct exact value of x . Allow equivalent processed exact answers. A1: Both values correct and exact and no additional incorrect answers. Allow equivalent processed exact answers. Condone missing brackets.		A1 A1 (7)
			Total 7

Alternative by exponential definitions (in most cases will score a max of 2/7)			
e.g., $\left(\frac{e^{2x} + e^{-2x}}{2}\right) - 7\left(\frac{e^x - e^{-x}}{2}\right) = 5$	Uses correct identities	M1 A1	
$e^{4x} - 7e^{3x} - 10e^{2x} + 7e^x + 1 = 0$	Correct quartic in e^x (any multiple - terms may not all be on one side but must be collected)		
$(e^{2x} + e^x - 1)(e^{2x} - 8e^x - 1) = 0 \Rightarrow e^x = \dots \quad \frac{-1 + \sqrt{5}}{2}, \quad 4 + \sqrt{17}$ M1: Solves their quartic as far as $e^x = \dots$ A1: Both correct exact values There must be a recognisable attempt to write a 5 term quartic as the product of two 3TQs in e^x (factorisation for the constant and for e^{4x} can have sign errors only) followed by an explicit method (usual rules) on at least one 3TQ.		M1 A1	
$\Rightarrow x = \dots$ Converts correctly to give at least one value for x as a valid exact natural logarithm. This mark requires a recognisable attempt to write a 5 term quartic as the product of two 3TQs in e^x as before but condone no explicit method on 3TQ		M1	
$x = \ln\left(-\frac{1}{2} + \sqrt{\frac{5}{4}}\right)$ or e.g., $\ln\frac{-1 + \sqrt{5}}{2}, \quad \ln(4 + \sqrt{17})$ A1: One correct exact value of x . Allow equivalent processed exact answers A1: Both values correct and exact and no additional incorrect answers. Allow equivalent exact answers. Condone missing brackets.		A1 A1 (7)	

Question Number	Scheme	Notes	Marks
2(a)	"...show all stages of your working. Solutions relying entirely on calculator technology are not acceptable."		
	$x^2 + 4x + 13 = (x + 2)^2 + 9$ or $(x + 2)^2 + 3^2$	Correctly completes the square	B1
	$\int \frac{1}{(x+2)^2 + 9} dx = \frac{1}{3} \arctan\left(\frac{x+2}{3}\right)$ M1: $k \arctan(\pm ax \pm b)$ $a, b \neq 0$, A1: Correct k can be 1. Condone e.g., "artan" if work confirms that "arctan" was intended		M1 A1
	$\left[\frac{1}{3} \arctan\left(\frac{x+2}{3}\right)\right]_{-2}^1 = \frac{1}{3}(\arctan 1 - \arctan 0)$	Correct use of correct limits but $\arctan 0$ or 0 need not be shown. Could go straight to a consistent value	dm1
	$\frac{\pi}{12}$	Correct value	A1
	May see "mini" substitutions here (& in (b)) such as $u = x + 2$: limits must change correctly		(5)
Example by Substitution	$x^2 + 4x + 13 = (x + 2)^2 + 9$ or $(x + 2)^2 + 3^2$	Correctly completes the square	B1
	$x + 2 = 3 \tan t \Rightarrow \frac{dx}{dt} = 3 \sec^2 t$ $x = -2, \tan t = 0, t = 0; x = 1, \tan t = 1, t = \frac{\pi}{4}$		
	$\int \frac{3 \sec^2 t}{9 \tan^2 t + 9} dt = \frac{1}{3} \int dt = \frac{1}{3} t$	M1: Substitutes $x + 2 = 3 \tan t$, uses $\tan^2 t + 1 = \sec^2 t$ and integrates to kt A1: Correct expression. Ignore limits	M1 A1
	$\left[\frac{1}{3} t\right]_0^{\frac{\pi}{4}} = \frac{1}{3} \times \frac{\pi}{4} - \frac{1}{3} \times 0, = \frac{\pi}{12}$	Either changes limits correctly and substitutes correctly or reverts to x correctly and uses original limits correctly. $\frac{1}{3} \times 0$ or 0 need not be seen - could go straight to a consistent value	dm1 A1
(b)	$4x^2 - 12x + 34 = 4\left(x - \frac{3}{2}\right)^2 + 25$ or $(2x - 3)^2 + 5^2$ oe May be seen within root M1: $4(x \pm p)^2 \pm q$ or $(2x \pm p)^2 \pm q$ oe ($p, q \neq 0$) A1: $4\left(x - \frac{3}{2}\right)^2 + 25$ oe e.g., $4\left(\left(x - \frac{3}{2}\right)^2 + \left(\frac{5}{2}\right)^2\right)$		M1 A1
	$\frac{1}{2} \int \frac{1}{\sqrt{\left(x - \frac{3}{2}\right)^2 + \frac{25}{4}}} dx = \frac{1}{2} \operatorname{arsinh}\left(\frac{x - \frac{3}{2}}{\frac{5}{2}}\right)$ or $\frac{1}{2} \operatorname{arsinh}\left(\frac{2x - 3}{5}\right)$ or e.g., $\frac{1}{2} \ln\left(x - \frac{3}{2} + \sqrt{\left(x - \frac{3}{2}\right)^2 + \left(\frac{5}{2}\right)^2}\right)$ M1: $k \operatorname{arsinh} f(x)$ or $p \ln\left(f(x) + \sqrt{(f(x))^2 + q}\right)$ oe $f(x) = \pm ax \pm b$ $a, b \neq 0$ A1: Correct (If log form ignore any embedded multiplying constant within the ln bracket). k can be 1. Condone e.g., "arsinh" if recovered. Above may be obtained via substitutions e.g., $x - \frac{3}{2} = \frac{5}{2} \sinh t (\rightarrow kt, = \frac{1}{2} t)$ or (unlikely) $x - \frac{3}{2} = \frac{5}{2} \tan t (\rightarrow k \{-\frac{1}{2}\} \ln(\sec t + \tan t))$		M1 A1
	$\left[\frac{1}{2} \operatorname{arsinh}\left(\frac{x - \frac{3}{2}}{\frac{5}{2}}\right)\right]_{-1}^4$ or $\frac{1}{2} [t]_{\operatorname{arsinh}(-1)}^{\operatorname{arsinh} 1} = \frac{1}{2} (\operatorname{arsinh}(1) - \operatorname{arsinh}(-1))$	Correct use of correct limits (changed correctly if necessary)	ddM1
	$= \frac{1}{2} (\ln(1 + \sqrt{2}) - \ln(-1 + \sqrt{2}))$ or $= \frac{1}{2} \times 2 \operatorname{arsinh}(1) = \ln(1 + \sqrt{2})$ Uses the correct logarithmic form of arsinh twice (or once if uses $\operatorname{arsinh}(1) - \operatorname{arsinh}(-1) = 2 \operatorname{arsinh}(1)$). This mark may also be gained by twice using the correct exponential form of $\sinh x$ and proceeding appropriately to a numerical expression. May be slips but must reach 3TQs in e^x (do not have to be written in =0 form). Then solved by usual rules but allow if consistent calculator answers		ddM1 Requires first 2 M marks
	Score ddM1 ddM1 together for correctly using correct limits on an appropriate log form, e.g., $\left[\frac{1}{2} \ln\left(\frac{2x-3}{5} + \sqrt{\left(\frac{2x-3}{5}\right)^2 + 1}\right)\right]_{-1}^4 = \dots$ or $\left[\frac{1}{2} \ln\left(2x-3 + \sqrt{(2x-3)^2 + 25}\right)\right]_{-1}^4 = \dots \left\{\frac{1}{2} (\ln(5+5\sqrt{2}) - \ln(-5+5\sqrt{2}))\right\}$		
	$= \frac{1}{2} \ln \frac{1+\sqrt{2}}{-1+\sqrt{2}} = \frac{1}{2} \ln\left(\frac{1+\sqrt{2}}{-1+\sqrt{2}} \times \frac{-1-\sqrt{2}}{-1-\sqrt{2}}\right) = \frac{1}{2} \ln(3+2\sqrt{2})$ [or $\ln(1+\sqrt{2})$] Not just values of constants unless form seen. Must include explicit surd work but it could be minimal and is not necessary with answer $\ln(1+\sqrt{2})$. Condone missing brackets.		A1 (7) Total 12

Question Number	Scheme	Notes	Marks
3(a)	$\left\{ \frac{dx}{d\alpha} = 4 \sinh \alpha, \frac{dy}{d\alpha} = 2 \cosh \alpha \Rightarrow \frac{dy}{dx} = \frac{2 \cosh \alpha}{4 \sinh \alpha} \text{ or } \frac{2x}{16} - \frac{2yy'}{4} = 0 \Rightarrow y' = \frac{x}{4y} \left\{ = \frac{4 \cosh \alpha}{8 \sinh \alpha} \right\} \right.$ $\text{or } \left\{ y = \frac{\sqrt{x^2 - 16}}{2} \Rightarrow y' = \frac{x}{2\sqrt{x^2 - 16}} \left\{ = \frac{4 \cosh \alpha}{2\sqrt{16 \cosh^2 \alpha - 16}} = \frac{4 \cosh \alpha}{8 \sinh \alpha} \right\} \right.$ M1: Differentiates x and y (correct forms) & divides correctly or differentiates implicitly to obtain $px - qyy' = 0$ oe and reaches $y' = \dots$ or explicitly to obtain $y' = \frac{kx}{\sqrt{x^2 - 16}}$ A1: Any correct derivative in terms of α e.g., $\frac{1}{2} \coth \alpha$		M1 A1
	$(y - 2 \sinh \alpha) = \frac{\cosh \alpha}{2 \sinh \alpha} (x - 4 \cosh \alpha) \text{ or}$ $2 \sinh \alpha = \frac{\cosh \alpha}{2 \sinh \alpha} (4 \cosh \alpha) + c \Rightarrow c = \dots \left\{ 2 \sinh \alpha - \frac{4 \cosh^2 \alpha}{2 \sinh \alpha} \right\} \Rightarrow y = \frac{\cosh \alpha}{2 \sinh \alpha} x + 2 \sinh \alpha - \frac{4 \cosh^2 \alpha}{2 \sinh \alpha}$ Correct straight line using their tangent gradient in terms of α		M1
	$2y \sinh \alpha - 4 \sinh^2 \alpha = x \cosh \alpha - 4 \cosh^2 \alpha \text{ or e.g., } y \sinh \alpha + 4(\cosh^2 \alpha - \sinh^2 \alpha) - x \cosh \alpha = 0$ or e.g., $y = \frac{\cosh \alpha}{2 \sinh \alpha} x - \frac{4}{2 \sinh \alpha} \Rightarrow 2y \sinh \alpha - x \cosh \alpha + 4 = 0^*$ Achieves the given answer (terms as printed in any order on one side) with an intermediate step. A0 if see e.g., sin for sinh.		A1*
			(4)
(b)	$A \left(0, \frac{-2}{\sinh \alpha} \right) \text{ oe}$	M1: $y = \pm \frac{p}{\sinh \alpha}$ or $y = \pm \frac{p}{q \sinh \alpha}$ A1: $y = \frac{-2}{\sinh \alpha}$ or $y = \frac{-4}{2 \sinh \alpha}$ oe For the A1 if x is given it must be 0. Could use exponentials. Allow M1A0 if just $\left(\pm \frac{p}{q \sinh \alpha}, 0 \right)$. "sin" is 00 unless above are seen	M1 A1
			(2)
(c)	For work in terms of a and/or e score the marks once appropriate values are seen or implied. May use e.g., F for S. May see use of $c^2 = (ae)^2 = a^2 + b^2$		
	e.g., $b^2 = a^2(e^2 - 1) \Rightarrow 4 = a^2 e^2 - 16$ or $4 = 16e^2 - 16 \Rightarrow e^2 = \frac{5}{4} \left(e = \frac{\sqrt{5}}{2} \right) \Rightarrow a^2 e^2 = 20$ Uses a correct eccentricity formula with $a = 4$ (or 16) & $b = 2$ (or 4) to obtain a value for $a^2 e^2$ or ae. Or finds a value for e and multiplies by a or a value for e^2 and $\times a^2$		M1
	$ae = \sqrt{20} \text{ or } 2\sqrt{5} \quad \left\{ \Rightarrow S(2\sqrt{5}, 0), B(0, 10 \sinh \alpha) \right\}$	Correct value for ae - could be implied	A1
	Grad $AS = \frac{\left(\frac{2}{\sinh \alpha} \right)}{2\sqrt{5}}$ or Grad $BS = -\frac{10 \sinh \alpha}{2\sqrt{5}}$ or $\overrightarrow{AS} = \begin{pmatrix} 2\sqrt{5} \\ \frac{2}{\sinh \alpha} \end{pmatrix}$ or $\overrightarrow{BS} = \begin{pmatrix} 2\sqrt{5} \\ -10 \sinh \alpha \end{pmatrix}$ At least 1 correct gradient or vector (allow as "coordinates" and could be 3D). If an ambiguous fraction within fraction given, look for recovery later. Not a ft mark.		B1
	$\frac{\frac{2}{\sinh \alpha}}{2\sqrt{5}} \times -\frac{10 \sinh \alpha}{2\sqrt{5}}$ or $\overrightarrow{AS} \cdot \overrightarrow{BS} = \begin{pmatrix} 2\sqrt{5} \\ \frac{2}{\sinh \alpha} \end{pmatrix} \cdot \begin{pmatrix} 2\sqrt{5} \\ -10 \sinh \alpha \end{pmatrix} = (2\sqrt{5})^2 + \frac{2}{\sinh \alpha} \times (-10 \sinh \alpha)$ (M1) $= -1$ or $= 0$ so AS and BS are perpendicular/"shown" etc. (A1) M1: Writes the product of their AS and BS gradients correctly (or writes $m_1 = -\frac{1}{m_2}$) or obtains a consistent scalar product expression e.g. $\overrightarrow{AS} \cdot \overrightarrow{BS}$. Must see more than just -1 or 0. May be using exponentials/cosech. A1: Product $= -1$ (or $m_1 = -\frac{1}{m_2}$) or scalar product $= 0$ with no errors and conclusion.		M1 A1 (last mark requires all previous marks)
	ALT: $AS^2 + BS^2 = \left(\frac{2}{\sinh \alpha} \right)^2 + (2\sqrt{5})^2 + (10 \sinh \alpha)^2 + (2\sqrt{5})^2$ $AB^2 = (10 \sinh \alpha + \frac{2}{\sinh \alpha})^2$ (B1 - either $AS^2 + BS^2$ (or AS^2 and BS^2) or AB^2 correct, M1 attempts both/all three, A1 shows equal e.g., $AB^2 = \left(\frac{2}{\sinh \alpha} \right)^2 + (10 \sinh \alpha)^2 + 2 \times \frac{2}{\sinh \alpha} \times 10 \sinh \alpha$ and conclusion) A0 if any sin for sinh seen. Allow work with SA and SB but A1 needs reference to AS and BS. Ignore $e = \pm \frac{\sqrt{5}}{2}$ and "$S(0, 2\sqrt{5})$" if recovered.		Alt by Pyth.
			(5)
			Total 11

Question Number	Scheme	Notes	Marks
4	$I_n = \int \sec^n x \, dx \quad n \geq 0$ If d(...) notation is used it must be resolved before the relevant marks are awarded		
4(a) Integrates first	$\int \sec^n x \, dx = \int \sec^{n-2} x \sec^2 x \, dx$	Splits $\sec^n x$ into $\sec^{n-2} x \sec^2 x$ at the start	M1
	$\int \sec^n x \, dx = \sec^{n-2} x \tan x - \int (n-2) \sec^{n-2} x \tan^2 x \, dx$	dM1: Uses integration by parts to obtain $\sec^{n-2} x \tan x \pm k \int \sec^{n-2} x \tan^2 x \, dx$ oe A1: Any correct expression	dM1 A1
	$\int \sec^n x \, dx = \sec^{n-2} x \tan x - \int (n-2) \sec^{n-2} x (\sec^2 x - 1) \, dx$	Replaces $\tan^2 x$ with $\sec^2 x - 1$ Requires 1st mark	B1
	$\int \sec^n x \, dx = \sec^{n-2} x \tan x - (n-2) \int \sec^n x \, dx + (n-2) \int \sec^{n-2} x \, dx$ or $I_n = \sec^{n-2} x \tan x - (n-2) I_n + (n-2) I_{n-2}$ Depends on all previous M and B marks. Obtains equation in I_n and I_{n-2} or integrals - not just the final answer		ddM1
	$(n-1) I_n = \tan x \sec^{n-2} x + (n-2) I_{n-2} *$	Fully correct proof. Allow e.g., $(n-2) I_{n-2} + \sec^{n-2} x \tan x = (n-1) I_n$	A1*
			(6)
ALT Identity first	$\int \sec^n x \, dx = \int \sec^{n-2} x \sec^2 x \, dx$	Splits $\sec^n x$ into $\sec^{n-2} x \sec^2 x$ at the start	M1
	$\int \sec^{n-2} x \sec^2 x \, dx = \int \sec^{n-2} x (\tan^2 x + 1) \, dx$ $\left\{ = \int \sec^{n-2} x \, dx + \int \tan^2 x \sec^{n-2} x \, dx \right\}$	Replaces $\sec^2 x$ with $\tan^2 x + 1$ Requires 1st mark	B1 (4th ePen mark)
	$\int \tan^2 x \sec^{n-2} x \, dx = \frac{1}{(n-2)} \tan x \sec^{n-2} x - \frac{1}{(n-2)} \int \sec^n x \, dx$ dM1: Uses int. by parts on $\int \tan^2 x \sec^{n-2} x \, dx$ to obtain $p \tan x \sec^{n-2} x \pm q \int \sec^n x \, dx$ oe A1: Any correct expression for $\int \tan^2 x \sec^{n-2} x \, dx$		dM1 A1
	$\int \sec^n x \, dx = \int \sec^{n-2} x \, dx + \frac{1}{(n-2)} \tan x \sec^{n-2} x - \frac{1}{(n-2)} \int \sec^n x \, dx$ or $I_n = I_{n-2} + \frac{1}{(n-2)} \tan x \sec^{n-2} x - \frac{1}{(n-2)} I_n$ Depends on all previous M and B marks. Obtains equation in I_n and I_{n-2} or integrals - not just the final answer.		ddM1
	$\Rightarrow \text{e.g., } (n-2+1) I_n = (n-2) I_{n-2} + \tan x \sec^{n-2} x$ $\Rightarrow (n-1) I_n = \tan x \sec^{n-2} x + (n-2) I_{n-2} *$	Fully correct proof. An intermediate step is required for this approach. Allow a final answer of e.g., $(n-2) I_{n-2} + \sec^{n-2} x \tan x = (n-1) I_n$	A1*
	For either method condone missing dx's, the odd missing variable, notational issues e.g., " $\sec x^{n-2}$ " and allow recovery of missing brackets if this is before the given answer. Since this question involves trigonometric and not hyperbolic functions we will condone the occasional e.g., tanh for tan but the final answer must be as shown.		

Question Number	Scheme	Notes	Marks
4(b)	"...showing each step of your working...Solutions relying entirely on calculator technology are not acceptable." $(n-1)I_n = \tan x \sec^{n-2} x + (n-2)I_{n-2}, \quad I_n = \frac{1}{n-1} \tan x \sec^{n-2} x + \frac{n-2}{n-1} I_{n-2}$		
I_6 first	$I_2 \left\{ = \left[\tan x \right]_0^{\frac{\pi}{4}} \right\} = 1$	Correct value for I_2 seen or implied Ignore "calculations" of I_0	B1
	$I_6 = \frac{1}{5} \left[\tan x \sec^4 x \right]_0^{\frac{\pi}{4}} + \frac{4}{5} I_4$ or e.g. $I_6 = \frac{1}{5} \tan \frac{\pi}{4} \sec^4 \frac{\pi}{4} + \frac{4}{5} I_4$ or e.g. $I_6 = \frac{1}{5} (1) (\sqrt{2})^4 + \frac{4}{5} I_4$ Applies the reduction formula once. No need to see or apply limits. Fine as $5I_6 = \dots$ and allow slips e.g., using an incorrect formula rearrangement e.g., $I_n = \tan x \sec^{n-2} x + (n-2)I_{n-2}$ or e.g., $I_n = \frac{1}{n-1} \tan x \sec^{n-2} x + (n-2)I_{n-2}$		M1
	$= \frac{1}{5} \tan x \sec^4 x + \frac{4}{5} \left(\frac{1}{3} \tan x \sec^2 x + \frac{2}{3} I_2 \right) = \frac{1}{5} (1) (\sqrt{2})^4 + \frac{4}{15} (1) (\sqrt{2})^2 + \frac{8}{15} (1)$ Applies the given reduction formula again (same slips as before) and uses the limits to reach a numerical expression for I_6 . If just a value is given it must be $\frac{28}{15}$		dM1
	$= \frac{28}{15}$	Correct value (or exact equivalent)	A1
			(4)
ALT I_4 first	$I_2 = \left\{ \left[\tan x \right]_0^{\frac{\pi}{4}} \right\} = 1$	Correct value for I_2 seen or implied Ignore "calculations" of I_0	B1
	$I_4 = \frac{1}{3} \left[\tan x \sec^2 x \right]_0^{\frac{\pi}{4}} + \frac{2}{3} I_2$ or e.g. $I_4 = \frac{1}{3} \tan \frac{\pi}{4} \sec^2 \frac{\pi}{4} + \frac{2}{3} I_2$ or e.g. $I_4 = \frac{1}{3} (1) (\sqrt{2})^2 + \frac{2}{3} I_2 \left\{ = \frac{4}{3} \right\}$ Applies the reduction formula once. No need to see or apply limits. Fine as $3I_4 = \dots$ and allow slips as main scheme		M1
	$I_6 = \frac{1}{5} \tan x \sec^4 x + \frac{4}{5} \left(\frac{1}{3} \tan x \sec^2 x + \frac{2}{3} I_2 \right) = \frac{1}{5} (1) (\sqrt{2})^4 + \frac{4}{15} (1) (\sqrt{2})^2 + \frac{8}{15}$ Applies the reduction formula again (same slips as before) and uses the limits to reach a numerical expression for I_6 . If just a value is given it must be $\frac{28}{15}$		dM1
	$= \frac{28}{15}$	Correct value (or exact equivalent)	A1
			Total 10

For either method in part (b), working must be shown and the given reduction formula must be used at least once. So do not allow e.g. I_6 to be attempted directly but I_4 can be evaluated directly without using the given reduction formula using an alternative explicit method e.g. by parts or by substitution. To score the dM1 in these cases they will need to have integrated correctly and reached a numerical expression for I_6 . The B mark can be awarded for a correct value for I_4 or I_6 ($\frac{4}{3}$ or $\frac{28}{15}$):

Parts:

$$\begin{aligned}
 I_4 &= \int \sec^4 x \, dx = \int \sec^2 x \sec^2 x \, dx = \sec^2 x \tan x - 2 \int \sec^2 x \tan^2 x \, dx \\
 &= \sec^2 x \tan x - 2 \int \sec^2 x (\sec^2 x - 1) \, dx = \sec^2 x \tan x - 2 \int \sec^4 x \, dx + 2 \int \sec^2 x \, dx \\
 &= \sec^2 x \tan x - 2I_4 + 2 \int \sec^2 x \, dx \Rightarrow 3I_4 = \sec^2 x \tan x + 2 \tan x \Rightarrow I_4 = \frac{1}{3} \sec^2 x \tan x + \frac{2}{3} \tan x
 \end{aligned}$$

Substitution:

$$\begin{aligned}
 I_4 &= \int \sec^4 x \, dx = \int \sec^2 x \sec^2 x \, dx = \int \sec^2 x (1 + \tan^2 x) \, dx \\
 u &= \tan x \Rightarrow \int \sec^2 x (1 + \tan^2 x) \, dx = \int \sec^2 x (1 + u^2) \frac{du}{\sec^2 x} = \frac{u^3}{3} + u = \frac{\tan^3 x}{3} + \tan x
 \end{aligned}$$

Question Number	Scheme	Notes	Marks
5.	$\mathbf{M} = \begin{pmatrix} 4 & -5 & 0 \\ k & 2 & 0 \\ -3 & -5 & k \end{pmatrix}$ Ignore labelling of matrices in (a) and allow any brackets/no brackets throughout		
(a)	$ \mathbf{M} = 4(2k) + 5(k^2)(+0)$	Correct determinant in any form (all 2 x 2 determinants processed). May use Sarrus e.g., $8k - (-5k^2)$	1st B1
	Minors: $\begin{pmatrix} 2k & k^2 & -5k+6 \\ -5k & 4k & -35 \\ 0 & 0 & 8+5k \end{pmatrix}$ or Cofactors: $\begin{pmatrix} 2k & -k^2 & 6-5k \\ 5k & 4k & 35 \\ 0 & 0 & 8+5k \end{pmatrix}$ A correct first step of minors or cofactors. May have transposed. Terms collected.		2nd B1
	$\mathbf{M}^{-1} = \frac{1}{5k^2 + 8k} \begin{pmatrix} 2k & 5k & 0 \\ -k^2 & 4k & 0 \\ 6-5k & 35 & 8+5k \end{pmatrix}$	M1: A full credible attempt at inverse: minors, cofactors, transpose and x 1/ their determinant B1: Any 2 correct rows or columns in Adj(M) - ignore any determinant A1: Any fully correct inverse with like terms collected	M1 3rd B1 A1
			(5)
(b)	e.g., $\mathbf{M}^{-1} = -\frac{1}{3} \begin{pmatrix} -2 & -5 & 0 \\ -1 & -4 & 0 \\ 11 & 35 & 3 \end{pmatrix}$	Any evidence of recognising $k = -1$	M1
	$\Pi_2 : 2x - z = 4 \Rightarrow x = s, y = t, z = 2s - 4$	Attempts parametric form. Could be slips but must be 2 parameters	M1
	$-\frac{1}{3} \begin{pmatrix} -2 & -5 & 0 \\ -1 & -4 & 0 \\ 11 & 35 & 3 \end{pmatrix} \begin{pmatrix} s \\ t \\ 2s-4 \end{pmatrix} = \begin{pmatrix} \dots \\ \dots \\ \dots \end{pmatrix}$ Completes an attempt at $\mathbf{M}^{-1} \times$ their parametric form. Allow losing the $-\frac{1}{3}$. May be achieved with separate vectors provided results brought together. Could be seen as $x = \dots, y = \dots, z = \dots$. Must complete processing e.g., on the $-(2s - 4) \Rightarrow \dots$		ddM1
	$-\frac{1}{3} \begin{pmatrix} -2s-5t \\ -s-4t \\ 17s+35t-12 \end{pmatrix}$ or e.g., $\begin{pmatrix} \frac{2}{3}s + \frac{5}{3}t \\ \frac{1}{3}s + \frac{4}{3}t \\ -\frac{11}{3}s - \frac{35}{3}t - 2s + 4 \end{pmatrix}$	Correct parametric form for Π_1 May be seen as $x = \dots, y = \dots, z = \dots$ Terms may not be collected	A1
	$3x = 2s + 5t, \quad 3y = s + 4t, \quad 3z = -11s - 35t - 6s + 12$ $\Rightarrow \dots \Rightarrow 11x - 5y + z = 4$ dddM1: Eliminates s and t to obtain a cartesian equation of correct form ("processed" with at least 4 terms but they may be uncollected). Requires all M marks. All of x, y and z must have been functions of both s and t and there must be some (minimal) algebra. May use e.g., a, b and c for x, y and z Allow for equivalent work e.g., $\begin{pmatrix} \frac{2}{3}s + \frac{5}{3}t \\ \frac{1}{3}s + \frac{4}{3}t \\ -\frac{17}{3}s - \frac{35}{3}t + 4 \end{pmatrix} \Rightarrow \begin{pmatrix} 0 \\ 0 \\ 4 \end{pmatrix} + \begin{pmatrix} \frac{2}{3} \\ \frac{1}{3} \\ -\frac{17}{3} \end{pmatrix} s + \begin{pmatrix} \frac{5}{3} \\ \frac{4}{3} \\ -\frac{35}{3} \end{pmatrix} t \Rightarrow \mathbf{n} = \begin{pmatrix} \frac{2}{3} \\ \frac{1}{3} \\ -\frac{17}{3} \end{pmatrix} \times \begin{pmatrix} \frac{5}{3} \\ \frac{4}{3} \\ -\frac{35}{3} \end{pmatrix} = \begin{pmatrix} \frac{11}{3} \\ -\frac{5}{3} \\ \frac{1}{3} \end{pmatrix} \text{ and } \begin{pmatrix} 0 \\ 0 \\ 4 \end{pmatrix} \cdot \begin{pmatrix} \frac{11}{3} \\ -\frac{5}{3} \\ \frac{1}{3} \end{pmatrix} = \frac{4}{3}$ $\Rightarrow \frac{11}{3}x - \frac{5}{3}y + \frac{1}{3}z = \frac{4}{3}$ A1: Any correct equation (terms collected) and in x, y and z e.g., $2z - 10y + 22x - 8 = 0$ A0 if given in e.g., x_1, y_1, z_1 or a, b & c etc.		dddM1 A1
			(6)
	Some guidance for alternatives overleaf		Total 11

Q5(b) alternatives:

$$\mathbf{M}^{-1} = \frac{1}{5k^2 + 8k} \begin{pmatrix} 2k & 5k & 0 \\ -k^2 & 4k & 0 \\ 6-5k & 35 & 8+5k \end{pmatrix} = -\frac{1}{3} \begin{pmatrix} -2 & -5 & 0 \\ -1 & -4 & 0 \\ 11 & 35 & 3 \end{pmatrix}, \quad \mathbf{M} = \begin{pmatrix} 4 & -5 & 0 \\ k & 2 & 0 \\ -3 & -5 & k \end{pmatrix} = \begin{pmatrix} 4 & -5 & 0 \\ -1 & 2 & 0 \\ -3 & -5 & -1 \end{pmatrix}$$

There are obviously a lot of possible alternatives here. The mark dependency applies as before. If the learner would score more by the main scheme then apply that but otherwise try and match the overall approach to one of the following examples.

Allow the first M mark for any recognition that $k = -1$ (which may be seen in $\mathbf{M}$ or $\mathbf{M}^{-1}$)

Score the next two M marks (M1dM1) together for a full method where enough work has been done so that a cartesian equation can be produced by a straightforward calculation or algebraic manipulation. If this is not the case, only the first mark will be available (unless using the main scheme scores more marks e.g., an acceptable attempt at the parametric form of Π_2 is also seen).

Then award the first A if everything is correct so far.

Examples:

Using $\mathbf{MP} = \mathbf{Q}$ with $P(x, y, z)$ & $Q(a, b, c) \Rightarrow a = 4x - 5y, c = -3x - 5y - z$ (4 marks)

$$2a - c = 4 \Rightarrow 8x - 10y + 3x + 5y + z = 4 \text{ (dddM1)} \Rightarrow 11x - 5y + z = 4 \text{ (A1)}$$

May work with $P(a, b, c)$ & $Q(x, y, z)$ and swap letters at the end

OR $\Pi_2 : 2x - z = 4$ so 3 points on Π_2 are e.g., $Q_1(2, 0, 0)$, $Q_2(3, 0, 2)$ & $Q_3(2, 1, 0)$

You may have to check to ensure these points are not collinear e.g., the vectors $\mathbf{Q}_1\mathbf{Q}_2$ and $\mathbf{Q}_1\mathbf{Q}_3$ are not multiples of each other otherwise this method is not viable. This will also be apparent if the three y-coordinates are all zero.

Could apply inverse to these points i.e., $\mathbf{P} = \mathbf{M}^{-1}\mathbf{Q}$ or could solve $\mathbf{MP} = \mathbf{Q}$

$$\Rightarrow P_1\left(\frac{4}{3}, \frac{2}{3}, -\frac{22}{3}\right), P_2(2, 1, -13) \text{ & } P_3(3, 2, -19)$$

$$P_2 - P_1 \Rightarrow \frac{1}{3} \begin{pmatrix} 2 \\ 1 \\ -17 \end{pmatrix}, \quad P_3 - P_1 \Rightarrow \frac{1}{3} \begin{pmatrix} 5 \\ 4 \\ -35 \end{pmatrix} \Rightarrow \text{normal by vector product: } \begin{pmatrix} 11 \\ -5 \\ 1 \end{pmatrix} \text{ (first four marks scored)}$$

$$\Pi_1 : 11x - 5y + z = 11\left(\frac{4}{3}\right) - 5\left(\frac{2}{3}\right) - \frac{22}{3} = \dots 4 \text{ (dddM1A1)}$$

OR A point on Π_2 is $(2, 0, 0)$ and 2 vectors (must have different directions) in Π_2 are $\begin{pmatrix} 1 \\ 0 \\ 2 \end{pmatrix}$ and $\begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$

Point becomes $\left(\frac{4}{3}, \frac{2}{3}, -\frac{22}{3}\right)$ and vectors become $\begin{pmatrix} \frac{2}{3} \\ \frac{1}{3} \\ -\frac{17}{3} \end{pmatrix}$ and $\begin{pmatrix} \frac{5}{3} \\ \frac{4}{3} \\ -\frac{35}{3} \end{pmatrix} \Rightarrow \text{normal: } \begin{pmatrix} 11 \\ -5 \\ 1 \end{pmatrix}$ as before

OR: The following approach using row vectors for the normal using $\mathbf{M}$ is also valid:

$$\Pi_2 : 2x - z = 4 \text{ has normal } \begin{pmatrix} 2 \\ 0 \\ -1 \end{pmatrix} \text{ and so } \Pi_1 \text{ normal is } \begin{pmatrix} 2 & 0 & -1 \end{pmatrix} \begin{pmatrix} 4 & -5 & 0 \\ -1 & 2 & 0 \\ -3 & -5 & -1 \end{pmatrix} = \begin{pmatrix} 11 & -5 & 1 \end{pmatrix}$$

and e.g., $Q_1(2, 0, 0) \Rightarrow P_1\left(\frac{4}{3}, \frac{2}{3}, -\frac{22}{3}\right)$ (4 marks)

$$\Pi_1 : 11x - 5y + z = 11\left(\frac{4}{3}\right) - 5\left(\frac{2}{3}\right) - \frac{22}{3} = \dots 4 \text{ (dddM1A1)}$$

$$\text{Could obtain the normal using the transpose of } \mathbf{M}: \begin{pmatrix} 4 & -1 & -3 \\ -5 & 2 & -5 \\ 0 & 0 & -1 \end{pmatrix} \begin{pmatrix} 2 \\ 0 \\ -1 \end{pmatrix} = \begin{pmatrix} 11 \\ -5 \\ 1 \end{pmatrix}$$

But note that this approach needs a point on Π_1 - i.e., there must be work to achieve the "4" (which just happens to be common to both planes).

Question Number	Scheme	Notes	Marks
6.	$x = \cosh t + t, \quad y = \cosh t - t$		
(a)	$\frac{dx}{dt} = \sinh t + 1, \quad \frac{dy}{dt} = \sinh t - 1$	Correct derivatives. Move to guidance overleaf at the point at which they move to exponentials if applicable and may see a combination of approaches. Could be implied	B1
	$(\sinh t + 1)^2 + (\sinh t - 1)^2$ $\{= \sinh^2 t + 2 \sinh t + 1 + \sinh^2 t - 2 \sinh t + 1\}$ $\{= 2 \sinh^2 t + 2\}$	Uses $\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2$ Correct for their derivatives. No need to expand but if it is only seen expanded the form must be correct (sign/coefficient errors only)	M1
	$\left\{ \left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2 \right\} = 2(1 + \sinh^2 t) \text{ or } = 2 + 2 \sinh^2 t = 2 \cosh^2 t^*$ Uses either intermediate step shown to complete the proof with no errors. A0 if e.g., sin accidentally used for sinh, x used for t, but condone $\sinh t^2$ used instead of $\sinh^2 t$ or $(\sinh t)^2$ & condone the occasional missing variable. "Meet in the middle" approaches need a conclusion.		A1*
			(3)
(b)	$\{S = 2\pi \int y \, ds =\} \quad 2\pi \int (\cosh t - t) \sqrt{2 \cosh^2 t} \, \{dt\}$ Uses $S = 2\pi \int y \, ds$ with the given y (not x) & the result from (a). Allow if x used anywhere for t, condone missing brackets and limits and dt not required		M1
	$S = 2\pi \sqrt{2} \int_0^{\ln 3} (\cosh^2 t - t \cosh t) \, dt^*$ Reaches given answer with no errors (condone missing brackets) with "S =" seen at some point in this part. Limits can appear at end. Allow e.g., $S = 2\sqrt{2} \pi \int_0^{\ln 3} -t \cosh t + \cosh^2 t \, dt^*$		A1*
			(2)
(c)	"Solutions relying entirely on calculator technology are not acceptable."		
	$\int \cosh^2 t \, dt = \int \left(\frac{1}{2} + \frac{1}{2} \cosh 2t \right) dt$	Uses/states $\cosh^2 t = \pm \frac{1}{2} \pm \frac{1}{2} \cosh 2t$ Does not need to be seen as integrand	M1
	$\int t \cosh t \, dt = t \sinh t - \int \sinh t \, dt$ M1: Applies integration by parts the right way round on $kt \cosh t$ and obtains the correct form (could have +). If only seen fully integrated must be $kt \cosh t \rightarrow k(t \sinh t - \cosh t)$ A1: Correct expression. Could be implied		M1 A1
	$\Rightarrow 2\sqrt{2}\pi \int (\cosh^2 t - t \cosh t) \, dt = 2\sqrt{2}\pi \left[\frac{1}{2}t + \frac{1}{4} \sinh 2t - t \sinh t + \cosh t \right]_{\text{oe}}$ A1: Correct form (sign/coeff. slips only inc. e.g. missing/wrong $2\sqrt{2}\pi$) A1: All correct. May use e.g., $\sinh 2t \rightarrow 2 \sinh t \cosh t$ and may be unsimplified (Note that both M marks required for these marks). Must be combined but this could be implied later.		A1 A1
	$= 2\sqrt{2}\pi \left\{ \left(\frac{1}{2} \ln 3 + \frac{10}{9} - \frac{4}{3} \ln 3 + \frac{5}{3} \right) - (1) \right\}$	Uses limits 0 and ln3 with an expression of the correct form. Hyperbolics credibly evaluated (and no "e"s). Allow any recognisable attempt at substitution here but look for subtraction of $f(0) \neq 0$	ddM1
	$\{S = 2\sqrt{2} \pi (\frac{16}{9} - \frac{5}{6} \ln 3)\}$ $\Rightarrow \{S =\} \frac{\pi \sqrt{2}}{9} (32 - 15 \ln 3)$	This answer but allow e.g., $\sqrt{2}\pi \left(\frac{32 - 15 \ln 3}{9} \right)$ Not just values for the constants unless form seen	A1
	Condone confusion with "t" and "x"		(7)
	See overleaf for examples using exponential definitions and some general guidance for other approaches to the integration in (c).		Total 12

Q6(a): Using exponential definitions:

$$x = \cosh t + t = \frac{e^t + e^{-t}}{2} + t, \quad y = \cosh t - t = \frac{e^t + e^{-t}}{2} - t$$

$$\frac{dx}{dt} = \frac{e^t - e^{-t}}{2} + 1, \quad \frac{dy}{dt} = \frac{e^t - e^{-t}}{2} - 1 \quad (\text{B1})$$

$$\left(\frac{e^t - e^{-t}}{2} + 1 \right)^2 + \left(\frac{e^t - e^{-t}}{2} - 1 \right)^2 \quad (\text{M1})$$

$$= \frac{1}{2} (e^t - e^{-t})^2 + 2 \quad \text{or e.g.,} = \frac{1}{2} (e^{2t} + 2 + e^{-2t})$$

$$= 2 \left(\frac{e^t + e^{-t}}{2} \right)^2 = 2 \cosh^2 t^*$$

(A1*: Must see $k(e^t + e^{-t})^2$ **and** at least one additional line after substitution)

Q6(c) example using exponential definitions:

$$\int \cosh^2 t \, dt = \int \left(\frac{e^t + e^{-t}}{2} \right)^2 dt = \frac{1}{4} \int (e^{2t} + 2 + e^{-2t}) dt \quad (\text{M1: integrable form - sign errors only})$$

$$\int t \cosh t \, dt = \frac{1}{2} \int (te^t + te^{-t}) dt = \frac{1}{2} \left(te^t - \int e^t dt - te^{-t} + \int e^{-t} dt \right)$$

(M1: applies parts, twice if necessary, correct form A1: All correct for the integral of $t \cosh t$)

$$\Rightarrow (2\sqrt{2}\pi) \left(\left(\frac{1}{8}e^{2t} + \frac{1}{2}t - \frac{1}{8}e^{-2t} \right) - \left(\frac{1}{2}te^t - \frac{1}{2}e^t - \frac{1}{2}te^{-t} - \frac{1}{2}e^{-t} \right) \right)$$

A1: Correct form (sign/coefficient slips only) A1: All correct. May be unsimplified

$$\Rightarrow 2\sqrt{2}\pi \left[\frac{1}{8}e^{2t} + \frac{1}{2}t - \frac{1}{8}e^{-2t} - \frac{1}{2}te^t + \frac{1}{2}e^t + \frac{1}{2}te^{-t} + \frac{1}{2}e^{-t} \right]_0^{\ln 3}$$

$$= 2\sqrt{2}\pi \left(\left(\frac{9}{8} + \frac{1}{2}\ln 3 - \frac{1}{72} - \frac{3}{2}\ln 3 + \frac{3}{2} + \frac{1}{6}\ln 3 + \frac{1}{6} \right) - \left(\frac{1}{8} + 0 - \frac{1}{8} - 0 + \frac{1}{2} + 0 + \frac{1}{2} \right) \right)$$

ddM1: Uses limits 0 and $\ln 3$. No exponentials.

Allow any credible attempt at substitution here but look for subtraction of $f(0) \neq 0$

$$\left\{ S = 2\sqrt{2}\pi \left(\frac{16}{9} - \frac{5}{6}\ln 3 \right) \right\} = \frac{\pi\sqrt{2}}{9} (32 - 15\ln 3) \quad \text{A1 as before}$$

Q6(c): For other potentially creditworthy attempts at the integration that work on the two terms separately, the following guidance applies:

M1: Reaches an integrable form for $\cosh^2 t$ (sign/coefficient errors only)

M1: Correct form for $\int t \cosh t \, dt$ A1: Fully correct integration of $\int t \cosh t \, dt$

A1: Correct form for S A1: Fully correct S

ddM1A1: As main scheme

Using parts on $\cosh t(\cosh t - t)$:

$$= \sinh t(\cosh t - t) - \int (\sinh^2 t - \sinh t) dt \quad (\text{2nd M1: correct form, A1: fully correct})$$

$$= \sinh t(\cosh t - t) - \int \left(-\frac{1}{2} + \cosh 2t - \sinh t \right) dt \quad (\text{1st M1: } \sinh^2 t = \pm \frac{1}{2} \pm \frac{1}{2} \cosh 2t)$$

$$\Rightarrow 2\sqrt{2}\pi \left[\sinh t \cosh t - t \sinh t + \frac{1}{2}t - \frac{1}{4}\sinh 2t + \cosh t \right] \quad (\text{A1: correct form, A1: fully correct})$$

Then ddM1A1 as main scheme

Question Number	Scheme	Notes	Marks
7.	$A(-1, 5, 1), B(1, 0, 3), C(2, -1, 2), D(3, 6, -1)$		
(a)	e.g., $\mathbf{AB} = \begin{pmatrix} 1 \\ 0 \\ 3 \end{pmatrix} - \begin{pmatrix} -1 \\ 5 \\ 1 \end{pmatrix} = \begin{pmatrix} 2 \\ -5 \\ 2 \end{pmatrix}, \mathbf{AC} = \begin{pmatrix} 3 \\ -6 \\ 1 \end{pmatrix}, \mathbf{AD} = \begin{pmatrix} 4 \\ 1 \\ -2 \end{pmatrix} \mathbf{BC} = \begin{pmatrix} 1 \\ -1 \\ -1 \end{pmatrix}, \mathbf{BD} = \begin{pmatrix} 2 \\ 6 \\ -4 \end{pmatrix}, \mathbf{CD} = \begin{pmatrix} -1 \\ -7 \\ 3 \end{pmatrix}$ Attempts any 3 edges (must attempt to subtract) which have a common vertex. Using position vectors OA etc is M0		M1
	e.g., $\begin{vmatrix} 2 & -5 & 2 \\ 3 & -6 & 1 \\ 4 & 1 & -2 \end{vmatrix}$ or $\begin{vmatrix} 2 \\ -5 \\ 2 \end{vmatrix} \cdot \begin{vmatrix} 3 \\ -6 & 1 \\ 4 & 1 & -2 \end{vmatrix}$ or $\begin{vmatrix} 2 \\ -5 \\ 2 \end{vmatrix} \cdot \left(\begin{vmatrix} 3 \\ -6 \\ 1 \end{vmatrix} \times \begin{vmatrix} 4 \\ 1 \\ -2 \end{vmatrix} \right)$ Completes an attempt to form an appropriate scalar triple product with their edges with a common vertex. Condone incorrect $\frac{1}{6}$ e.g., $\frac{1}{3}$ or $\frac{1}{2}$ but M0 if triple product is part of a calculation e.g., all square rooted		dM1
	$= \frac{1}{6} 2 \times 11 - 5 \times 10 + 2 \times 27 = \dots \left\{ \frac{1}{6} \times 26 = \right\} \frac{13}{3}$ ddM1: Finds value appropriately (may be negative if omission of modulus). Must include the $\frac{1}{6}$. M0 if a clear systematic error in processing and must have 2 consistent products (or values) in a sum of 3 if method unclear. If just a value is given it must be consistent, but accept a determinant form followed by a value unless clear evidence of an invalid method (e.g., determinant interpreted as a "modulus") A1: Correct (positive) volume (allow exact equivalents)		ddM1 A1
	Protracted methods may score the 1st mark as above but need to be complete attempts that find a value for the volume to receive credit.		(4)
	(b) $\mathbf{AB} \times \mathbf{AC} = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 2 & -5 & 2 \\ 3 & -6 & 1 \end{vmatrix} = \begin{pmatrix} 7 \\ 4 \\ 3 \end{pmatrix}$ Result must be seen/used in (b) if done in (a). M1: Completes cross product using attempts at two sides of ABC (Must have subtracted for the vectors & obtain 2 correct components for their product if method unclear). Allow determinant $\rightarrow$ vector unless clear evidence of invalid method. No position vectors A1: Correct normal vector (any multiple).		M1 A1
(c)	OR $-a + 5b + c = d, a + 3c = d, 2a - b + 2c = d \Rightarrow a = \dots\{7\}, b = \dots\{4\}, c = \dots\{3\}$ M1: Uses A, B & C to form 3 equations & solves to find all values A1: Correct. OR e.g., $(x, y, z) = (1, 5, 1) + s(2, -5, 2) + t(3, -6, 1) \rightarrow x = -1 + 2s + 3t, y = 5 - 5s - 6t, z = 1 + 2s + t$ (M1A1) and then eliminates parameters to an unsimplified plane equation of correct form dM1A1		
	$\begin{pmatrix} 7 \\ 4 \\ 3 \end{pmatrix} \cdot \begin{pmatrix} -1 \\ 5 \\ 1 \end{pmatrix} = \dots\{16\}$	Finds value for scalar product with appropriate vectors (normal & a point). Allow slips if valid method indicated but if value only given it must be consistent. Could sub. point into $7x + 4y + 3z + d = 0 \Rightarrow d = \dots$	dM1
	$7x + 4y + 3z = 16$	Correct 4 term equation (any multiple)	A1
			(4)
	$\{\mathbf{OT}\} = \begin{pmatrix} 3 \\ 6 \\ -1 \end{pmatrix} + \lambda \begin{pmatrix} 7 \\ 4 \\ 3 \end{pmatrix}$ oe	Attempts consistent parametric form of OT May see e.g., $\frac{x-3}{7} = \frac{y-6}{4} = \frac{z+1}{3}$ (I)	M1
(c)	$7(3 + 7\lambda) + 4(6 + 4\lambda) + 3(-1 + 3\lambda) = 16 \Rightarrow \lambda = \dots$ Substitutes parametric form of OT into their plane equation (at least 3 terms, allow slips e.g., $16 \rightarrow 0$) and solves for λ . Could solve (I) with their plane eqn. and score dM1ddM1 together		dM1
	$\lambda = -\frac{13}{37} \Rightarrow T$ is $\left(\frac{20}{37}, \frac{170}{37}, -\frac{76}{37} \right)$ Allow $x = \dots, y = \dots, z = \dots$	ddM1: Uses their value of λ in their OT equation to obtain coordinates/vector. Give BOD if no working unless a clearly trivial/invented answer is seen A1: Correct exact coordinates (or vector)	ddM1 A1
	Alternative methods need to reach a point/vector via a valid strategy for any marks.		(4)
			Total 12

Please check the examination details below before entering your candidate information

Candidate surname		Other names	
Centre Number		Candidate Number	

Pearson Edexcel International Advanced Level

Friday 23 January 2026

Morning (Time: 1 hour 30 minutes) **Paper reference** **WFM03/01**

Mathematics

International Advanced Subsidiary/Advanced Level

Further Pure Mathematics F3

You must have:
Mathematical Formulae and Statistical Tables (Yellow), calculator

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear.
Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 9 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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1. The hyperbola H is defined by the equation

$$\frac{x^2}{48} - \frac{y^2}{b^2} = 1$$

where b is a positive constant.

Given that H has a focus at the point $(8, 0)$, determine

- (i) the value of b ,
(ii) the exact value of the eccentricity of H .

(5)



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Question 1 continued

Handwriting practice area with horizontal lines.

(Total for Question 1 is 5 marks)



2.

In this question you must show all stages of your working.
Solutions relying entirely on calculator technology are not acceptable.

$$\mathbf{A} = \begin{pmatrix} k & 0 & 0 \\ 4 & 2 & 3 \\ 1 & 3 & 4 \end{pmatrix}$$

where k is a constant.

(a) Find, in terms of k , the determinant of $\mathbf{A}$ (1)

(b) Hence determine, in terms of k , the matrix $\mathbf{A}^{-1}$ (3)

Given that

- $k = 1$
- the matrix $\mathbf{B}$ satisfies $\mathbf{AB} = \mathbf{A}^T$

(c) determine the matrix $\mathbf{B}$ (3)



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Question 2 continued

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Question 2 continued

Handwriting practice area with horizontal lines.

(Total for Question 2 is 7 marks)



3. (a) Using the appropriate definitions of hyperbolic functions in terms of exponentials, show that

$$\sinh x + \operatorname{sech} x = \frac{e^{4x} + 4e^{2x} - 1}{2e^{3x} + 2e^x} \quad (4)$$

- (b) Hence solve the equation

$$\sinh x + \operatorname{sech} x = \frac{1}{2}e^x$$

Give the answer in the form $a \ln b$ where a is a rational number and b is an integer.

(Solutions relying on calculator technology are not acceptable.)

(4)



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Question 3 continued

Handwriting practice area with horizontal lines.

(Total for Question 3 is 8 marks)



4.

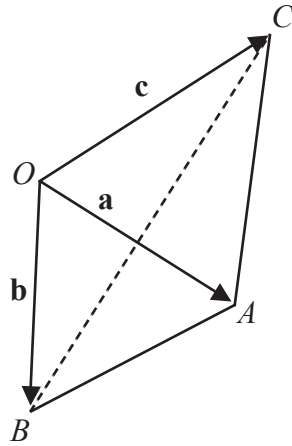


Figure 1

The points A , B and C have position vectors $\mathbf{a}$, $\mathbf{b}$ and $\mathbf{c}$ respectively, relative to a fixed origin O , as shown in Figure 1, where

$$\mathbf{a} = 2\mathbf{i} - \mathbf{k} \qquad \mathbf{b} = \mathbf{i} + 2\mathbf{j} - 2\mathbf{k} \qquad \text{and} \qquad \mathbf{c} = 3\mathbf{i} + \mathbf{j} + \mathbf{k}$$

Determine

- (a) $\mathbf{b} \times \mathbf{c}$ (2)
- (b) $\mathbf{a} \bullet (\mathbf{b} \times \mathbf{c})$ (2)
- (c) the volume of the tetrahedron $OABC$ (1)
- (d) the shortest distance from A to the plane containing O , B and C , giving the answer as a simplified surd. (3)



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Question 4 continued

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Question 4 continued

(Total for Question 4 is 8 marks)



5.

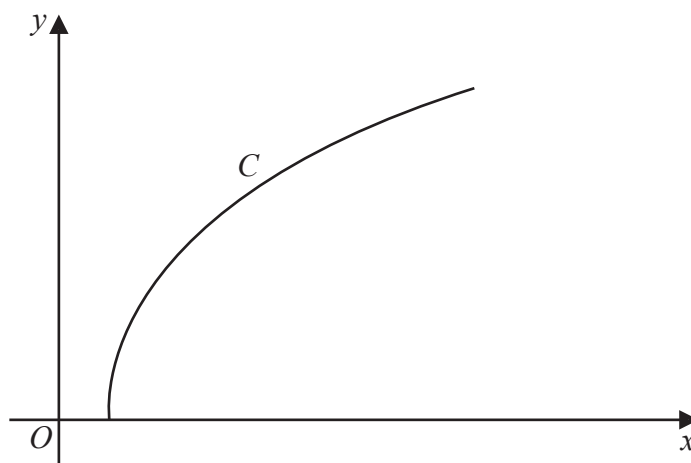


Figure 2

**In this question you must show all stages of your working.
Solutions relying on calculator technology are not acceptable.**

Figure 2 shows a sketch of the curve C defined by the parametric equations

$$x = \cosh 2t \quad y = 4 \sinh t \quad 0 \leq t \leq \frac{3}{2}$$

(a) Show that

$$\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2 = m \cosh^n t$$

where m and n are integers to be determined.

(5)

(b) Use algebraic integration to determine the exact length of C .

Give the answer in the form $a + \sinh b$ where a and b are integers to be found.

(3)

(c) Use algebraic integration to determine the exact area of the surface formed when C is rotated through 360° about the x -axis.

Give the answer in simplest form in terms of hyperbolic functions.

(4)



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Question 5 continued

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Question 5 continued

(Total for Question 5 is 12 marks)



6.

In this question you must show all stages of your working. Solutions relying on calculator technology are not acceptable.

The matrix $\mathbf{M}$ is given by

$$\begin{pmatrix} -2 & 2 & 2 \\ -3 & -7 & -3 \\ 1 & 1 & -3 \end{pmatrix}$$

- (a) Show that $\begin{pmatrix} 1 \\ 0 \\ -1 \end{pmatrix}$ is an eigenvector of $\mathbf{M}$, stating the corresponding eigenvalue. (3)
- (b) Show that the eigenvalue from part (a) is the only eigenvalue of $\mathbf{M}$. (4)

The transformation $M: \mathbb{R}^3 \rightarrow \mathbb{R}^3$ is represented by the matrix $\mathbf{M}$.

- (c) Determine a Cartesian equation for the image under M of the line with equation

$$x-1=\frac{y+1}{2}=\frac{z}{-3} \tag{4}$$

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Question 6 continued

Lined area for writing the answer to Question 6.



Question 6 continued

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Question 6 continued

(Total for Question 6 is 11 marks)



7.

In this question you must show all stages of your working.
Solutions relying entirely on calculator technology are not acceptable.

$$I_n = \int_0^{\frac{\pi}{4}} e^{4x} \tan^n x \, dx$$

- (a) Use integration to prove that, for $n \geq 1$

$$I_{n+1} = \frac{e^{\pi}}{n} - \frac{k}{n} I_n - I_{n-1}$$

where k is a constant to be determined.

(4)

- (b) Determine the exact value of I_0

(2)

Given that $I_1 = 3.7002$ to 5 significant figures,

- (c) use the answer to part (a) to determine the value of I_4 to 3 significant figures.

(3)



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Question 7 continued

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Question 7 continued

Handwriting practice area with horizontal lines.

(Total for Question 7 is 9 marks)



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Question 8 continued

Lined area for writing the answer to Question 8.



Question 8 continued

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Question 8 continued

(Total for Question 8 is 9 marks)



9.

$$y = \operatorname{artanh}\left(\frac{x}{\sqrt{1+x^2}}\right)$$

(a) Show that

$$\frac{dy}{dx} = \frac{1}{\sqrt{1+x^2}} \quad (4)$$

(b) Hence, by integrating the result in part (a), prove that

$$\operatorname{artanh}\left(\frac{x}{\sqrt{1+x^2}}\right) = \operatorname{arsinh} x \quad (2)$$



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Question 9 continued

Lined area for writing the answer to Question 9.



Question 9 continued

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(Total for Question 9 is 6 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (Results)

January 2026

Pearson Edexcel International Advanced Level in
Further Pure Mathematics F3
WFM03/01

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January 2026

Question Paper Log Number P78989A

Publication Code WFM03_01_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN:

- bod – benefit of doubt
- ft – follow through
 - the symbol $\surd$ will be used for correct ft
- cao – correct answer only
- cso – correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC – special case
- oe – or equivalent (and appropriate)
- d... or dep – dependent
- indep – independent
- dp – decimal places
- sf – significant figures
- * – The answer is printed on the paper or ag- answer given

- $\square$ or d... – The second mark is dependent on gaining the first mark
4. All A marks are 'correct answer only' (cao), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.
 5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. If you are using the annotation facility on ePEN, indicate this action by 'MR' in the body of the script.
 6. If a candidate makes more than one attempt at any question:
 - a) If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - b) If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

Ignore wrong working or incorrect statements following a correct answer

Question	Scheme	Marks
1 (i)+(ii)	$a^2 = 48$ or $ae = 8$ (oe)	B1
	E.g. $b^2 = (ae)^2 - a^2 = "8"^2 - "48" = \dots$ or $(ae)^2 = 64 \Rightarrow e^2 = \frac{"64"}{a^2} = \frac{"64"}{"48"} = \dots$ or $e = \frac{8}{a} = \dots$	M1
	$b = 4$ or $e = \frac{2\sqrt{3}}{3}$	A1
	e.g. $b^2 = a^2(e^2 - 1) \Rightarrow e^2 = \frac{"16"}{48} + 1 \Rightarrow e = \dots$ or $b^2 = "64" \left(\frac{"64"}{48} - 1 \right) = \dots \Rightarrow b = \dots$	M1
	$b = 4$ and $e = \frac{2\sqrt{3}}{3}$	A1
		(5)
(5 marks)		
Notes:		
(i)+(ii) Mark as a whole B1: States or implies $ae = 8$ or $a^2 = 48$ (oe) M1: Complete method to find either b or e or their squares. E.g. uses $b^2 = a^2(e^2 - 1)$ and expands and uses their ae and a^2 (which may be incorrect) to find b^2. Alternatively, may use $(ae)^2 = 64 \Rightarrow e^2 = \frac{64}{a^2} = \frac{64}{48}$ to get to e^2 first. A1: For either $b = 4$ or $e = \frac{2\sqrt{3}}{3}$. M1: Complete method to find the other unknown. E.g. uses $b^2 = a^2(e^2 - 1)$ with their a and b to find e or with their a and e to find b. A1: cao. Both values correct. Accept $\frac{2}{\sqrt{3}}$ for e. Must reject the negative values.		

Question	Scheme	Marks
2(a)	$\det \mathbf{A} = k \times (2 \times 4 - 3 \times 3) - 0 - 0 (= -k)$	B1
		(1)
(b)	Matrix of minors: $(\mathbf{M}) = \begin{pmatrix} 8-9 & 16-3 & 12-2 \\ 0 & 4k & 3k \\ 0 & 3k & 2k \end{pmatrix}$	M1
	Adj: $(\mathbf{C}^T) = \begin{pmatrix} -1 & 0 & 0 \\ -13 & 4k & -3k \\ 10 & -3k & 2k \end{pmatrix}$	M1
	$\mathbf{A}^{-1} = \frac{1}{-k} \begin{pmatrix} -1 & 0 & 0 \\ -13 & 4k & -3k \\ 10 & -3k & 2k \end{pmatrix} = \frac{1}{k} \begin{pmatrix} 1 & 0 & 0 \\ 13 & -4k & 3k \\ -10 & 3k & -2k \end{pmatrix} = \begin{pmatrix} \frac{1}{k} & 0 & 0 \\ \frac{13}{k} & -4 & 3 \\ \frac{-10}{k} & 3 & -2 \end{pmatrix}$	A1
		(3)
(c)	$\mathbf{AB} = \mathbf{A}^T \Rightarrow \mathbf{B} = \mathbf{A}^{-1} \mathbf{A}^T = \begin{pmatrix} 1 & 0 & 0 \\ 13 & -4 & 3 \\ -10 & 3 & -2 \end{pmatrix} \begin{pmatrix} 1 & 4 & 1 \\ 0 & 2 & 3 \\ 0 & 3 & 4 \end{pmatrix} = \dots$	M1
	$= \begin{pmatrix} 1 & 4 & 1 \\ 13 & 53 & 13 \\ -10 & -40 & -9 \end{pmatrix}$	A1A1
		(3)
(7 marks)		

Notes:

(a)

B1: Correct expression for the determinant. It does not need to be simplified for this mark.

(b)

M1: Attempts the matrix of minors with at least 4 correct.

M1: Applies the cofactors and takes the transpose (the determinant need not be introduced yet).

A1: Correct inverse, accept with the determinant outside or inside. (Any expression in the scheme is acceptable.)

(c)

M1: Correctly multiplies across by $\mathbf{A}^{-1}$, applies the transpose and multiplies.

A1: At least 5 correct entries

A1: Fully correct answer.

Alt

M1: Attempts $\mathbf{AB} = \mathbf{A}^T$ after applying the transpose, multiplies the LHS and equates elements

A1: At least 5 correct elements

A1: All elements correct

Question	Scheme	Marks
3a	$\sinh x + \operatorname{sech} x = \frac{e^x - e^{-x}}{2} + \frac{2}{e^x + e^{-x}}$	B1
	$= \frac{(e^x - e^{-x})(e^x + e^{-x}) + 4}{2(e^x + e^{-x})}$	M1
	$= \frac{e^{2x} - e^{-2x} + 4}{2e^x + 2e^{-x}} \times \frac{e^{2x}}{e^{2x}} = \dots$	M1
	$= \frac{e^{4x} + 4e^{2x} - 1}{2e^{3x} + 2e^x} *$	A1*
		(4)
3b	$\sinh x + \operatorname{sech} x = \frac{1}{2}e^x \Rightarrow \frac{e^{4x} + 4e^{2x} - 1}{2e^{3x} + 2e^x} = \frac{1}{2}e^x \Rightarrow \cancel{e^{4x}} + 4e^{2x} - 1 = \cancel{e^{4x}} + e^{2x}$	M1
	$3e^{2x} = 1$	A1
	$\Rightarrow x = \frac{1}{2} \ln \frac{1}{3}$	M1
	$= -\frac{1}{2} \ln 3$	A1
		(4)
(8 marks)		
Notes:		
(a) B1: Correct expression in terms of exponentials given. M1: Combines the terms over a common denominator. M1: Expands and simplifies to a point where positive indices for the exponentials are evident. A1*: Achieves the given answer with no incorrect work seen, and a step with the brackets all expanded before the final answer. Allow e.g. $e^{2x} - e^{-2x}$ for the expanded brackets. Note: There may be variations using other identities, e.g. $\frac{\sinh x \cosh x + 1}{\cosh x} = \frac{\sinh 2x + 2}{2 \cosh x}$ before applying identities. In such case the scheme can be followed – B1 for use of correct exponential identities when they are applied, M1 for combining the fraction (scored before the B mark here), then M1 for simplifying to positive indices in the exponents, A1 if all correct. (b) M1: Applies the result of (a) and cross multiplies to achieve an equation in e^{2x} only. A1: Correct equation as shown or $e^{2x} = \frac{1}{3}$ M1: Solves the exponential equation of form $ae^{kx} = b$ to find a value for x A1: cao.		

Question	Scheme	Marks
4(a)	$\mathbf{b} \times \mathbf{c} = (\mathbf{i} + 2\mathbf{j} - 2\mathbf{k}) \times (3\mathbf{i} + \mathbf{j} + \mathbf{k}) = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 1 & 2 & -2 \\ 3 & 1 & 1 \end{vmatrix}$ $= (2 \times 1 - 1 \times -2)\mathbf{i} \pm (1 \times 1 - 3 \times -2)\mathbf{j} + (1 \times 1 - 3 \times 2)\mathbf{k}$	M1
	$\mathbf{b} \times \mathbf{c} = 4\mathbf{i} - 7\mathbf{j} - 5\mathbf{k}$	A1
		(2)
(b)	$\mathbf{a} \bullet (\mathbf{b} \times \mathbf{c}) = (2\mathbf{i} - \mathbf{k}) \bullet (4\mathbf{i} - 7\mathbf{j} - 5\mathbf{k}) = 2 \times 4 + 0 \times -7 + (-1) \times (-5) = \dots$	M1
	$= 13$	A1
		(2)
(c)	$\text{Volume } OABC = \frac{1}{6} \mathbf{a} \bullet (\mathbf{b} \times \mathbf{c}) = \frac{13}{6}$	B1ft
		(1)
(d) Way 1	$\text{Area triangle } OBC = \frac{1}{2} \mathbf{b} \times \mathbf{c} = \frac{1}{2} \sqrt{4^2 + 7^2 + 5^2} = \dots$	M1
	$\text{Vol } OABC = \frac{1}{3} h \times \text{Area } OBC \Rightarrow \frac{1}{3} h \times \frac{1}{2} \sqrt{90} = \frac{13}{6} \Rightarrow h = \dots$	M1
	$= \frac{13}{3\sqrt{10}} \text{ or } \frac{13\sqrt{10}}{30}$	A1
		(3)
Way 2	Plane OBC is $\mathbf{r} \bullet 4\mathbf{i} - 7\mathbf{j} - 5\mathbf{k} = 0$ (using the origin as a point on the plane)	M1
	$d = \frac{ 4 \times 2 - 7 \times 0 - 5 \times -1 + 0 }{\sqrt{4^2 + 7^2 + 5^2}} = \dots \text{ oe}$	M1
	$= \frac{13}{3\sqrt{10}} \text{ or } \frac{13\sqrt{10}}{30}$	A1
		(3)
Way 3	Finding e.g. $\pm(\mathbf{c} - \mathbf{a})$ or $\pm(\mathbf{b} - \mathbf{a})$	M1
	Resolving along the direction of the normal e.g. $d = \frac{\left \pm(\mathbf{c} - \mathbf{a}) \bullet \begin{pmatrix} 4 \\ -7 \\ -5 \end{pmatrix} \right }{\sqrt{4^2 + 7^2 + 5^2}} \quad \text{or} \quad d = \frac{\left \pm(\mathbf{b} - \mathbf{a}) \bullet \begin{pmatrix} 4 \\ -7 \\ -5 \end{pmatrix} \right }{\sqrt{4^2 + 7^2 + 5^2}}$	M1
	$= \frac{13}{3\sqrt{10}} \text{ or } \frac{13\sqrt{10}}{30}$	A1

		(3)
(8 marks)		
Notes:		
Accept equivalent vector notation, e.g. column vectors, throughout. (a) M1: Attempts the vector product with at least two components correct (simplified or unsimplified). A1: Correct vector (b) M1: Takes the scalar product of a with their answer to (a). Obtaining a vector is M0. A1: Correct value. (c) B1ft: For $\frac{1}{6} \times \text{their answer to (b)}$ (d) Way 1 M1: Correct method for the area of the triangle <i>OBC</i>. M1: Sets up and solves a correct equation for the shortest distance using the formula $V = \frac{1}{3} A_b h$ with their area and their volume from (c). A1: Correct answer. Accept equivalents such as $\frac{13}{\sqrt{90}}$ or $\frac{13\sqrt{90}}{90}$ Way 2 M1: Identifies or implies the equation of the plane containing <i>OBC</i> (following their (a)). M1: Uses the perpendicular distance formula with their plane and point <i>A</i>. A1: Correct answer. Accept equivalents such as $\frac{13}{\sqrt{90}}$ or $\frac{13\sqrt{90}}{90}$ Way 3 M1: Finds the directional vector $\pm(\mathbf{c} - \mathbf{a})$ or $\pm(\mathbf{b} - \mathbf{a})$ M1: Resolves along the direction of the normal vector to the plane A1: Correct answer. Accept equivalents such as $\frac{13}{\sqrt{90}}$ or $\frac{13\sqrt{90}}{90}$		

Question	Scheme	Marks
5(a)	$\frac{dx}{dt} = 2 \sinh 2t$ and $\frac{dy}{dt} = 4 \cosh t$	B1
	$\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2 = 4 \sinh^2 2t + 16 \cosh^2 t$	M1
	$= 4(2 \sinh t \cosh t)^2 + 16 \cosh^2 t$	M1
	$= 16 \cosh^2 t (\sinh^2 t + 1)$	M1
	$= 16 \cosh^4 t$	A1
		(5)
(b)	$s = \int_0^{\frac{3}{2}} \sqrt{\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2} dt = \int_0^{\frac{3}{2}} 4 \cosh^2 t dt = \int_0^{\frac{3}{2}} 2(1 + \cosh 2t) dt$	M1
	$= [2t + \sinh 2t]_0^{\frac{3}{2}} = (3 + \sinh 3) - (0 + 0)$	dM1
	$= 3 + \sinh 3$	A1
		(3)
(c)	$S_x = 2\pi \int_0^{\frac{3}{2}} y \sqrt{\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2} dt = 2\pi \int_0^{\frac{3}{2}} 4 \sinh t \times 4 \cosh^2 t dt$	B1
	$= 32\pi \left[\frac{1}{3} \cosh^3 t \right]_0^{\frac{3}{2}}$	M1
	$= \frac{32\pi}{3} \left[\left(\cosh^3 \frac{3}{2} \right) - \left(\cosh^3 0 \right) \right]$	dM1
	$= \frac{32\pi}{3} \left(\cosh^3 \frac{3}{2} - 1 \right)$	A1
		(4)

(12 marks)

Notes:

(a)

B1: Correct derivatives.

M1: Square and adds their two derivatives (allow if coefficients not squared correctly).

M1: Applies the double argument formula for hyperbolics.

M1: Factors out the $\cosh t$ terms and applies Pythagorean identity for hyperbolics.

A1: Correct answer from correct work.

(b)

M1: Applies the arc length formula with the square root of their (a) and applies the double argument formula $\cosh^2 t = \pm \frac{1}{2} \pm \frac{1}{2} \cosh 2t$ to reach integrable form.

dM1: Integrates and substitutes the limits (allow bottom limit 0 implied). **Dependent on the previous method mark.**

A1: Correct answer.

Mixing up variables e.g. x and t etc loses final A mark if not recovered.

(c)

B1: States or applies the surface area formula with the square root of their (a) and y substituted, including the 2π but limits not needed for this mark.

M1: Integrates to the correct form (limits not needed for this mark). Alternatives may be possible here.

dM1: Substitutes the limits into their integral. **Dependent on the previous method mark.**

A1: Correct exact answer, accepting equivalents. Numerical equivalent 402.72... is A0.

Alt 1 for (c):

$$\begin{aligned} S_x &= 2\pi \int_0^{\frac{3}{2}} y \sqrt{\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2} dt = 32\pi \int_0^{\frac{3}{2}} \sinh t + \sinh^3 t dt = 32\pi \int_0^{\frac{3}{2}} \sinh t + \frac{1}{4}(\sinh 3t - 3\sinh t) dt \\ &= 32\pi \left[\cosh t + \frac{1}{4} \left(\frac{1}{3} \cosh 3t - 3 \cosh t \right) \right]_0^{\frac{3}{2}} = 32\pi \left(\frac{1}{4} \cosh \frac{3}{2} + \frac{1}{12} \cosh \frac{9}{2} - \frac{1}{4} - \frac{1}{12} \right) \\ &= \frac{8\pi}{3} \left(3 \cosh \frac{3}{2} + \cosh \frac{9}{2} - 4 \right) \end{aligned}$$

Alt 2 for (c)

$$\begin{aligned} S_x &= 2\pi \int_0^{\frac{3}{2}} y \sqrt{\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2} dt = 32\pi \int_0^{\frac{3}{2}} \sinh t + \sinh^3 t dt = 32\pi \int_0^{\frac{3}{2}} \sinh t + \sinh^2 t \sinh t dt \\ &= 32\pi \left[\int_0^{\frac{3}{2}} \sinh t + \int_0^{\frac{3}{2}} \cosh^2 t \sinh t dt - \int_0^{\frac{3}{2}} \sinh t \right] = 32\pi \left[\frac{1}{3} \cosh^3 t \right]_0^{\frac{3}{2}} \\ &= \frac{32\pi}{3} \left(\cosh^3 \frac{3}{2} - 1 \right) \end{aligned}$$

Question	Scheme	Marks
6(a)	$\begin{pmatrix} -2 & 2 & 2 \\ -3 & -7 & -3 \\ 1 & 1 & -3 \end{pmatrix} \begin{pmatrix} 1 \\ 0 \\ -1 \end{pmatrix} = \begin{pmatrix} -2-2 \\ -3+3 \\ 1+3 \end{pmatrix} = \dots$	M1
	$= \begin{pmatrix} -4 \\ 0 \\ 4 \end{pmatrix} = -4 \times \begin{pmatrix} 1 \\ 0 \\ -1 \end{pmatrix} \text{ has an eigenvector}$	A1
	Eigenvalue is -4	B1
		(3)
(b)	$\begin{vmatrix} -2-\lambda & 2 & 2 \\ -3 & -7-\lambda & -3 \\ 1 & 1 & -3-\lambda \end{vmatrix} = (-2-\lambda) \begin{vmatrix} -7-\lambda & -3 \\ 1 & -3-\lambda \end{vmatrix} - 2 \begin{vmatrix} -3 & -3 \\ 1 & -3-\lambda \end{vmatrix} + 2 \begin{vmatrix} -3 & -7-\lambda \\ 1 & 1 \end{vmatrix} =$ $= (-2-\lambda)((-7-\lambda)(-3-\lambda)+3) - 2(-3(-3-\lambda)+3) + 2(-3-(-7-\lambda))$	M1A1
	$0 = (-2-\lambda)(24+10\lambda+\lambda^2) - 2(2\lambda+8)$ $= -\lambda^3 - 12\lambda^2 - 48\lambda - 64$	M1
	$\Rightarrow -(\lambda+4)(\lambda^2+8\lambda+16) = -(\lambda+4)^3 = 0 \Rightarrow \lambda = -4 \text{ only}$	A1
		(4)
(c)	$\begin{pmatrix} -2 & 2 & 2 \\ -3 & -7 & -3 \\ 1 & 1 & -3 \end{pmatrix} \begin{pmatrix} 1+t \\ 2t-1 \\ -3t \end{pmatrix} = \dots$	M1
	$= \begin{pmatrix} -2-2t+4t-2-6t \\ -3-3t-14t+7+9t \\ 1+t+2t-1+9t \end{pmatrix} = \begin{pmatrix} -4-4t \\ 4-8t \\ 12t \end{pmatrix}$	A1
	Image line is $\frac{x+4}{-4} = \frac{y-4}{-8} = \frac{z}{12}$	M1A1
		(4)
(11 marks)		
Notes:		
(a) M1: Multiplies the matrix by the given vector, at least two correct entries. A1: Correct resulting vector and shows it is a multiple of the original vector. B1: Correct eigenvalue identified. Allow simply $\lambda = -4$ (b) Note: allow the marks for (b) to score if seen in part (a) M1: Expands $\det(\mathbf{M} - \lambda\mathbf{I})$ fully to a cubic (need not be expanded). A1: Fully correct expansion (need not be simplified).		

M1: Sets $\det(\mathbf{M} - \lambda \mathbf{I}) = 0$ and simplifies to the cubic. May identify a factor of $\lambda + 4$ in each term – allow the M for identifying this. $0 = (-2 - \lambda)(\lambda + 4)(\lambda + 6) - 4(\lambda + 4) = (\lambda + 4)(-\lambda^2 - 8\lambda - 16)$

A1: Reaches the cubed form and deduces only one eigenvalue. Must show the result by either fully factorising the correct cubic, or factorising the correct quadratic after the correct cubic is seen.

(c)

M1: Attempts the parametric form of the line and multiplies by the matrix $\mathbf{M}$.

A1: Correct result of the multiplication.

M1: Forms the Cartesian equation for their resulting vector.

A1: Correct answer (oe - e.g. $6x + 24 = 3y - 12 = -2z$).

Question	Scheme	Marks
7(a)	$I_n = \left[\frac{1}{4} e^{4x} \tan^n x \right]_0^{\frac{\pi}{4}} - \int_0^{\frac{\pi}{4}} \frac{n}{4} e^{4x} \tan^{n-1} x \sec^2 x \, dx$	B1
	$= \left[\frac{1}{4} e^{4x} \tan^n x \right]_0^{\frac{\pi}{4}} - \frac{n}{4} \int_0^{\frac{\pi}{4}} e^{4x} \tan^{n-1} x (1 + \tan^2 x) \, dx$	M1
	$= \left(\frac{1}{4} e^\pi \right) - (0) - \frac{n}{4} (I_{n-2} + I_{n+1})$	M1
	$\Rightarrow \frac{n}{4} I_{n+1} = \frac{1}{4} e^\pi - \frac{n}{4} I_{n-1} - I_n \Rightarrow I_{n+1} = \frac{e^\pi}{n} - \frac{4}{n} I_n - I_{n-1}$	A1
		(4)
Alt 1:	$I_{n+1} = \int_0^{\frac{\pi}{4}} e^{4x} \tan^{n-1} x \tan^2 x \, dx = \int_0^{\frac{\pi}{4}} e^{4x} \tan^{n-1} x (\sec^2 x - 1) \, dx$ $= \left[e^{4x} \frac{\tan^n x}{n} \right]_0^{\frac{\pi}{4}} - \int_0^{\frac{\pi}{4}} 4e^{4x} \frac{\tan^n x}{n} \, dx - I_{n-1}$	M1 B1 M1
	$= \left(\frac{e^\pi}{n} \right) - (0) - \frac{4}{n} I_n - I_{n-1}$	M1
	$\Rightarrow I_{n+1} = \frac{e^\pi}{n} - \frac{4}{n} I_n - I_{n-1}$	A1
		(4)
Alt 2:	$I_{n+1} = \int_0^{\frac{\pi}{4}} e^{4x} \tan^{n+1} x \, dx$ $= \left[\frac{1}{4} e^{4x} \tan^{n+1} x \right]_0^{\frac{\pi}{4}} - \int_0^{\frac{\pi}{4}} \frac{1}{4} e^{4x} (n+1) \tan^n x \sec^2 x \, dx$	B1
	$= \left[\frac{1}{4} e^{4x} \tan^{n+1} x \right]_0^{\frac{\pi}{4}} - \frac{n+1}{4} \int_0^{\frac{\pi}{4}} e^{4x} \tan^n x (1 + \tan^2 x) \, dx$	M1
	$= \left(\frac{1}{4} e^\pi \right) - (0) - \frac{n+1}{4} (I_n + I_{n+2})$	M1
	$\Rightarrow I_{n+2} = \frac{e^\pi}{n+1} - \frac{4}{n+1} I_{n+1} - I_n$ Replacing e.g. 'n = n - 1' $\Rightarrow I_{n+1} = \frac{e^\pi}{n} - \frac{4}{n} I_n - I_{n-1}$	A1

Alt 3	$I_n = \int_0^{\frac{\pi}{4}} e^{4x} \tan^{n-2} x \tan^2 x \, dx = \int_0^{\frac{\pi}{4}} e^{4x} \tan^{n-2} x (\sec^2 x - 1) \, dx \quad \text{M1}$ $= \left[e^{4x} \frac{\tan^{n-1} x}{n-1} \right]_0^{\frac{\pi}{4}} - \int_0^{\frac{\pi}{4}} 4e^{4x} \frac{\tan^{n-1} x}{n-1} \, dx - I_{n-2} \quad \text{B1}$	B1 M1
	$I_n = \left(\frac{e^\pi}{n-1} \right) - (0) - \frac{4}{n-1} I_{n-1} - I_{n-2}$	M1
	$\Rightarrow I_{n+1} = \frac{e^\pi}{n} - \frac{4}{n} I_n - I_{n-1}$	A1
(b)	$I_0 = \int_0^{\frac{\pi}{4}} e^{4x} \, dx = \left[\frac{1}{4} e^{4x} \right]_0^{\frac{\pi}{4}} = \dots$	M1
	$= \frac{1}{4} e^\pi - \frac{1}{4}$	A1
		(2)
(c)	$I_2 = \frac{e^\pi}{1} - \frac{4}{1} \times 3.7002 - \frac{1}{4} [e^\pi - 1] \quad (= 2.8047\dots)$	M1
	$I_3 = \frac{e^\pi}{2} - \frac{4}{2} \times 2.8047 - 3.7002 \quad (= 2.2607\dots)$	M1
	$I_4 = \frac{e^\pi}{3} - \frac{4}{3} \times 2.2607 - 2.8047 = \dots$	
	$= 1.8945\dots = 1.89$	A1
		(3)
(9 marks)		
Notes:		
(a) B1: Correct application of integration by parts on the given integral (need not be simplified). M1: Applies $\sec^2 x = \pm 1 \pm \tan^2 x$ to the integral. M1: Evaluates the definite part of the integral and replaces appropriately by I_{n-1} and I_{n+1} in the integral. A1: Achieves the correct answer from completely correct work with no errors seen and the I_{n-1} and I_{n+1} correctly established and substituted. Condone missing arguments etc if recovered, but if not recovered then final A0. <u>Alt 1:</u> B1: Correct application of integration by parts on a suitably adapted integral (need not be simplified). Awarded after the M1 in this approach but score as the first mark. M1: Applies $\sec^2 x = \pm 1 \pm \tan^2 x$ to the original integral. (First mark awarded in this approach but score as the second mark.) M1: Evaluates the definite part of the integral and replaces appropriately by I_{n-1} and I_{n+1} in the integral.		

A1: Achieves the correct answer from completely correct work with no errors seen and the I_{n-1} and I_{n+1} correctly established and substituted.

Variations on these methods may be seen but can be scored via this scheme, but the final A will need indices correctly adjusted if they work from different index at the start of the appropriate method.

Alt 2:

B1: Correct application of integration by parts on the given integral (need not be simplified).

M1: Applies $\sec^2 x = \pm 1 \pm \tan^2 x$ to the integral.

M1: Evaluates the definite part of the integral and replaces appropriately by I_n and I_{n+2} in the integral.

A1: Achieves the correct answer from completely correct work with no errors seen and the I_{n-1} and I_{n+1} correctly established and substituted. If I_{n+2} is correctly found, then accept a change of variable to obtain the correct reduction formula e.g. letting ' $n = n - 1$ '

(b)

M1: Integrates to ke^{4x} , $k = \pm 4$ or $\pm \frac{1}{4}$ and substitutes the limits.

A1: Correct answer.

(c)

M1: Applies the reduction formula at least once with their I_0 and the given value for I_1 and $n = 1$.

M1: Proceeds to apply twice more to reach a value for I_4 . Evidence of the use of (a) must be clear.

A1: Correct answer.

Question	Scheme	Marks
8(a)	$\frac{2x}{16} + \frac{2y}{9} \frac{dy}{dx} = 0$ or $\frac{dy}{dx} = \frac{dy}{d\theta} \frac{d\theta}{dx} = \frac{3\cos\theta}{-4\sin\theta}$ or $\frac{dy}{dx} = \frac{9}{2} \left(1 - \frac{x^2}{16}\right)^{-\frac{1}{2}} \times -\frac{2x}{16}$	B1
	$m_N = -\frac{dx}{dy} = \frac{4\sin\theta}{3\cos\theta} \left(= \left(\frac{-2(4\cos\theta) \times 9}{16 \times 2(3\sin\theta)} \right)^{-1} \right)$	M1
	$y - 3\sin\theta = \frac{4\sin\theta}{3\cos\theta} (x - 4\cos\theta)$	M1
	$3y\cos\theta - 9\sin\theta\cos\theta = 4x\sin\theta - 16\sin\theta\cos\theta$ $\Rightarrow 4x\sin\theta - 3y\cos\theta = 7\sin\theta\cos\theta$	A1*
		(4)
(b)	$x_A = \frac{7\cos\theta}{4}$	B1
	$\text{Area } OAP = \frac{1}{2} x_A \times y_P = \frac{1}{2} \times \frac{7}{4} \cos\theta \times 3\sin\theta$	M1
	$= \frac{21}{8} \sin\theta\cos\theta = \frac{21}{8} \times \frac{1}{2} \sin 2\theta$	M1
	$= \frac{21}{16} \sin 2\theta$	A1
		(4)
(c)	$\frac{21}{16}$	B1ft
		(1)

(9 marks)

Notes:

(a)

B1: Any correct differential statement for the ellipse given.

M1: Substitutes P and applies the negative reciprocal to find the gradient of the normal in terms of θ

M1: Attempts the equation of the normal using their attempt at the normal gradient – any adapted $\frac{dy}{dx}$ or equivalent method. If using the ' $y = mx + c$ ' method then they must make progress to finding the ' c '.

A1*: Multiplies by the " $4\cos\theta$ " to get rid of the fractions in the equation and correctly reaches the given equation with derivative having been seen and no errors in the working.

(b)

B1: States or uses the correct x coordinate at point A .

M1: Correct method for the area of triangle OAP .

M1: Applies the double angle identity for sin to reach the required form.

A1: Correct answer.

(c)

B1ft: Identifies their value of k as the maximum value for the area.

Question	Scheme	Marks
9(a)	$\frac{dy}{dx} = \frac{1}{1 - \left(\frac{x}{\sqrt{1+x^2}} \right)^2} \times \dots$	M1
	$\frac{dy}{dx} = \dots \times \frac{1 \times \sqrt{1+x^2} - x \times \frac{1}{2}(1+x^2)^{-\frac{1}{2}} \times 2x}{\left(\sqrt{1+x^2} \right)^2} \left(= \frac{1}{(1+x^2)^{\frac{3}{2}}} \right)$	M1
	$\frac{dy}{dx} = \frac{1}{1 - \left(\frac{x}{\sqrt{1+x^2}} \right)^2} \times \frac{1 \times \sqrt{1+x^2} - x \times \frac{1}{2}(1+x^2)^{-\frac{1}{2}} \times 2x}{\left(\sqrt{1+x^2} \right)^2}$	A1
	$= \frac{1}{1 - \frac{x^2}{1+x^2}} \times \frac{\sqrt{1+x^2} - x^2(1+x^2)^{-\frac{1}{2}}}{1+x^2} = \frac{1+x^2 - x^2}{(1+x^2 - x^2)\sqrt{1+x^2}} = \frac{1}{\sqrt{1+x^2}}^*$	A1*
		(4)
(b)	$\frac{dy}{dx} = \frac{1}{\sqrt{1+x^2}} \Rightarrow y = \int \frac{1}{\sqrt{1+x^2}} dx = \operatorname{arsinh} x + c$ $\Rightarrow \operatorname{artanh} \left(\frac{x}{\sqrt{1+x^2}} \right) = \operatorname{arsinh} x + c$	M1
	$x = 0 \Rightarrow \operatorname{artanh}(0) = \operatorname{arsinh}(0) + c \Rightarrow c = 0$ Therefore $\operatorname{artanh} \left(\frac{x}{\sqrt{1+x^2}} \right) = \operatorname{arsinh} x$	A1
		(2)
(6 marks)		
Notes:		
(a) M1: Attempts $\frac{dy}{dx}$, with correct form for the artanh, ie the $\frac{1}{1 - \left(\frac{x}{\sqrt{1+x^2}} \right)^2}$ (and this may be all) Need not be simplified and allow if the squaring is not fully correct (e.g. numerator or denominator squared is sufficient to imply the attempt at squaring). M1: Attempts $\frac{dy}{dx}$ with a correct attempt at the chain rule (or product rule) used (the artanh derivative need not be correct for this mark). A1: A correct unsimplified expression for the derivative. A1*: Simplifies to the give answer with suitable intermediate step and no errors seen (e.g. either of those shown in the scheme). (b)		

M1: Integrates the answer to part (a) to achieve the arsinh answer with constant included and equates to the initial function. A1: Shows the constant of integration is zero to complete the proof with conclusion, no errors.		
9(a) Alt	$\tanh y = \frac{x}{\sqrt{1+x^2}} \Rightarrow \operatorname{sech}^2 y \frac{dy}{dx} = \frac{A\sqrt{1+x^2} - Bx(1+x^2)^{\frac{1}{2}} \times x}{(\sqrt{1+x^2})^2}$	M1
	$\Rightarrow (1 - \tanh^2 y) \frac{dy}{dx} = \left(1 - \frac{x^2}{1+x^2}\right) \frac{dy}{dx} = \dots$	M1
	$\left(1 - \frac{x^2}{1+x^2}\right) \frac{dy}{dx} = \frac{\sqrt{1+x^2} - x^2(1+x^2)^{-\frac{1}{2}}}{1+x^2}$	A1
	$\Rightarrow \left(\frac{1+x^2-x^2}{1+x^2}\right) \frac{dy}{dx} = \frac{1+x^2-x^2}{(1+x^2)\sqrt{1+x^2}} \Rightarrow \frac{dy}{dx} = \frac{1}{\sqrt{1+x^2}}^*$	A1*
		(4)
Notes:		
(a) M1: Takes tanh of both sides and differentiates using the product or quotient rule on the RHS, achieving the form shown. M1: Applies $\operatorname{sech}^2 y = 1 \pm \tanh^2 y$ and replaces tanh y to get a derivative statement in terms of x only. A1: A correct unsimplified expression in terms of x in the derivative. A1*: Simplifies to the give answer with suitable intermediate step and no errors seen.		

Pearson Edexcel International Advanced Level

Friday 9 January 2026

Morning (Time: 1 hour 30 minutes)

**Paper
reference**

WME01/01A

Mathematics

International Advanced Subsidiary/Advanced Level

Mechanics M1

Question Paper

You must have:

Answer book (sent separately).

Do not return this question paper with the answer book.

Turn over ►

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1. Two particles, P and Q , have masses $2m$ and $3m$ respectively. They are moving towards each other, in opposite directions, along the same straight line, on a smooth horizontal plane. The particles collide.

Immediately before they collide the speed of P is $2u$ and the speed of Q is u .

In the collision the magnitude of the impulse exerted on P by Q is $5mu$.

- (a) Find the speed of P immediately after the collision. (3)
- (b) State whether the direction of motion of P has been reversed by the collision. (1)
- (c) Find the speed of Q immediately after the collision. (3)

(Total for Question 1 is 7 marks)



2. A suitcase of mass 40 kg is being dragged in a straight line along a rough horizontal floor at constant speed using a thin strap.

The strap is inclined at 20° above the horizontal.

The coefficient of friction between the suitcase and the floor is $\frac{3}{4}$

The strap is modelled as a light inextensible string and the suitcase is modelled as a particle.

Find the tension in the strap.

(7)

(Total for Question 2 is 7 marks)

3. A ball is thrown vertically upwards with speed 20 m s^{-1} from a point A , which is h metres above the ground.

The ball moves freely under gravity until it hits the ground 5 s later.

- (a) Find the value of h .

(3)

A second ball is thrown vertically downwards with speed $w \text{ m s}^{-1}$ from A and moves freely under gravity until it hits the ground.

The first ball hits the ground with speed $V \text{ m s}^{-1}$ and the second ball hits the ground with speed $\frac{3}{4} V \text{ m s}^{-1}$

- (b) Find the value of w .

(5)

(Total for Question 3 is 8 marks)



4. [In this question $\mathbf{i}$ and $\mathbf{j}$ are unit vectors directed due east and due north respectively.]

A particle P is moving with constant velocity $(-6\mathbf{i} + 2\mathbf{j})\text{ m s}^{-1}$

At time $t = 0$, P passes through the point with position vector $(21\mathbf{i} + 5\mathbf{j})\text{ m}$, relative to a fixed origin O .

- (a) Find the direction of motion of P , giving your answer as a bearing to the nearest degree. (3)
- (b) Write down the position vector of P at time t seconds. (1)
- (c) Find the time at which P is north-west of O . (3)

(Total for Question 4 is 7 marks)

5.

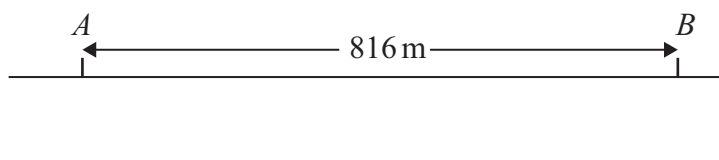


Figure 1

Two posts, A and B , are fixed at the side of a straight horizontal road and are 816 m apart, as shown in Figure 1.

A car and a van are at rest side by side on the road and level with A .

At time $t = 0$, the car and the van start to move in the direction AB .

The car accelerates from rest with constant acceleration for T seconds until it reaches a speed of 24 m s^{-1}

The car then moves at a constant speed of 24 m s^{-1}

The van accelerates from rest with constant acceleration for 12 s until it reaches a speed of $V \text{ m s}^{-1}$

The van then moves at a constant speed of $V \text{ m s}^{-1}$

When the car has been moving at 24 m s^{-1} for 30 s, the van draws level with the car at B , and each vehicle has then travelled a distance of 816 m.

- (a) Sketch, on the same diagram, a speed-time graph for the motion of each vehicle from A to B . (3)
- (b) Find the value of T . (3)
- (c) Find the value of V . (3)

(Total for Question 5 is 9 marks)

6. A car pulls a trailer along a straight horizontal road using a light inextensible towbar. The mass of the car is M kg, the mass of the trailer is 600 kg and the towbar is horizontal and parallel to the direction of motion.

There is a resistance to motion of magnitude 200 N acting on the car and a resistance to motion of magnitude 100 N acting on the trailer.

The driver of the car spots a hazard ahead. Instantly he reduces the force produced by the engine of the car to zero and applies the brakes of the car.

The brakes produce a braking force on the car of magnitude 6500 N and the car and the trailer have a constant deceleration of magnitude 4 m s^{-2}

Given that the resistances to motion on the car and trailer are unchanged and that the car comes to rest after travelling 40.5 m from the point where the brakes were applied,

find

- (a) the thrust in the towbar while the car is braking, (3)
- (b) the value of M , (3)
- (c) the time it takes for the car to stop after the brakes are applied. (3)

(Total for Question 6 is 9 marks)

7.

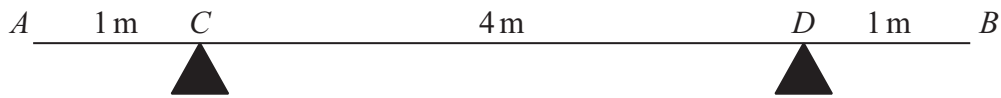


Figure 2

A non-uniform rod AB has length 6 m and mass 8 kg. The rod rests in equilibrium, in a horizontal position, on two smooth supports at C and at D , where $AC = 1$ m and $DB = 1$ m, as shown in Figure 2.

The magnitude of the reaction between the rod and the support at D is twice the magnitude of the reaction between the rod and the support at C .

The centre of mass of the rod is at G , where $AG = x$ m.

- (a) Show that $x = \frac{11}{3}$ (6)

The support at C is moved to the point F on the rod, where $AF = 2$ m.

A particle of mass 3 kg is placed on the rod at A . The rod remains horizontal and in equilibrium.

The magnitude of the reaction between the rod and the support at D is k times the magnitude of the reaction between the rod and the support at F .

- (b) Find the value of k . (6)

(Total for Question 7 is 12 marks)



8.

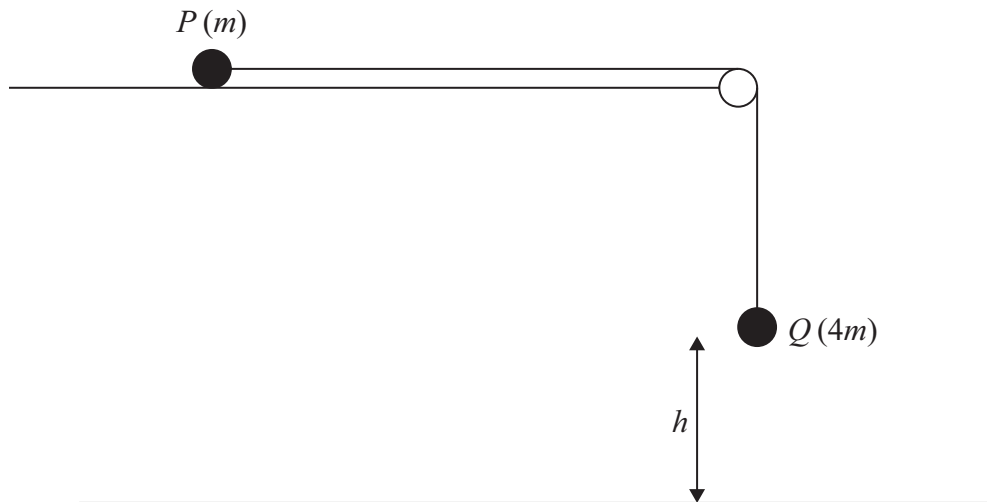


Figure 3

Two particles P and Q have masses m and $4m$ respectively.
Particle P is attached to one end of a light inextensible string and particle Q is attached to the other end.

Particle P is held at rest on a rough horizontal table. The string lies along the table and passes over a small smooth light pulley which is fixed at the edge of the table.
Particle Q hangs at rest vertically below the pulley, at a height h above a horizontal plane, as shown in Figure 3.

The coefficient of friction between P and the table is 0.5

Particle P is released from rest with the string taut and slides along the table.

- (a) Find, in terms of mg , the tension in the string when both particles are moving. (8)

The particle P does not reach the pulley before Q hits the plane.

- (b) Show that the speed of Q immediately before it hits the plane is $\sqrt{1.4gh}$ (2)

When Q hits the plane, Q does not rebound and P continues to slide along the table.
Given that P comes to rest before it reaches the pulley,

- (c) show that the total length of the string must be greater than $2.4h$ (6)

(Total for Question 8 is 16 marks)

TOTAL FOR PAPER IS 75 MARKS

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Please check the examination details below before entering your candidate information

Candidate surname

Other names

Centre Number

Candidate Number

Pearson Edexcel International Advanced Level

Friday 9 January 2026

Morning (Time: 1 hour 30 minutes)

Paper
reference

WME01/01A

Mathematics

**International Advanced Subsidiary/Advanced Level
Mechanics M1
Answer Book**

You must have:

Question paper (sent separately),
Mathematical Formulae and Statistical Tables (Yellow), calculator.

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Whenever a numerical value of g is required, take $g = 9.8 \text{ m s}^{-2}$ and give your answer to either 2 significant figures or 3 significant figures.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 8 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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Question 1

Write the answer to Question 1 on these 2 pages

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(Total for Question 1 is 7 marks)



Question 2

Write the answer to Question 2 on these 2 pages

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Question 3

Write the answer to Question 3 on these 2 pages

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Question 4

Write the answer to Question 4 on these 4 pages

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Question 4 continued

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(Total for Question 4 is 7 marks)



Question 5

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Question 5 continued

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(Total for Question 5 is 9 marks)



Question 6

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Question 6 continued

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(Total for Question 6 is 9 marks)



Question 7

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Question 7 continued

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(Total for Question 7 is 12 marks)



Question 8

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Question 8 continued

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Question 8 continued

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(Total for Question 8 is 16 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (Final)

January 2026

International Advanced Level in Mechanics M1
WME01A

Edexcel and BTEC Qualifications

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January 2026

Question Paper Log Number P87596A

Publication Code WME01_01A_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)

Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN:

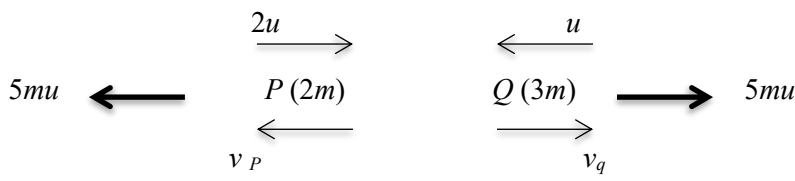
- bod – benefit of doubt
- ft – follow through
 - the symbol $\checkmark$ will be used for correct ft
- cao – correct answer only
- cso – correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC – special case
- oe – or equivalent (and appropriate)
- d... or dep – dependent
- indep – independent
- dp – decimal places
- sf – significant figures
- * – The answer is printed on the paper or ag- answer given
- $\square$ or d... – The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.
5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. If you are using the annotation facility on ePEN, indicate this action by 'MR' in the body of the script.
6. If a candidate makes more than one attempt at any question:
 - a) If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - b) If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
7. Ignore wrong working or incorrect statements following a correct answer.

General Principles for Mechanics Marking

(N.B. specific mark schemes may sometimes override these general principles)

- Rules for M marks:
 - correct number of terms
 - dimensionally correct
 - all terms that need resolving (i.e. *multiplied* by cos or sin) are resolved
 - only terms that need resolving are resolved
 - +/– errors are condoned
 - sin/cos confusion is condoned
- Omission or extra g in a resolution is an accuracy error not method error.
- Omission of mass from a resolution is a method error.
- Omission of a length from a moments equation is a method error.
- Omission of units or incorrect units is not (usually) counted as an accuracy error.
- DM indicates a dependent method mark, i.e. one that can only be awarded if a previous specified method mark(s) has been awarded.
- Any numerical answer which comes from use of $g = 9.8$ should be given as a decimal to 2 or 3 SF.
- Use of $g = 9.81$ should be penalised once per (complete) question.
 - N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *once* per complete question. However, premature approximation should be penalised every time it occurs.
- Marks must be entered in the same order as they appear on the mark scheme.
- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c)...then that working can only score marks for that part of the question.
- Accept column vectors in all cases.
- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft

Question Number	Scheme	Marks
1(a)		
	$5mu = 2m(v_P - -2u)$ or $5mu = 2m(-v_P - -2u)$	M1 A1
	Speed of P is $\frac{1}{2}u$	A1
		(3)
(b)	Reversed	B1
		(1)
(c)	$5mu = 3m(v_Q - -u)$ or $5mu = 3m(-v_Q - -u)$	M1 A1
	Speed of Q is $\frac{2}{3}u$	A1
		(3)
	OR	
	$2m2u - 3mu = -2m\frac{1}{2}u + 3mv_Q$ or $2m2u - 3mu = -2m\frac{1}{2}u - 3mv_Q$	M1 A1
	Speed of Q is $\frac{2}{3}u$	A1
		(3)
		7
	Notes	
(a)		
M1	Complete method to find an equation in v_P , m and u only: Use of $5mu =$ change in momentum of P (must have $2m$ in both terms so allow with $2m$ outside the bracket even if it changes after the brackets are removed) (M0 if <i>clearly</i> adding momenta) but condone sign errors. N.B. they could find v_Q first and then use CLM	
A1	Correct equation for <i>their</i> v_P	
A1	$\frac{1}{2}u$ oe (A0 if -ve)	
(b)		
B1	cao; only allow if $\frac{1}{2}u$ or $-\frac{1}{2}u$ has been correctly obtained in (a). Allow: '(Yes) it has' but NOT just 'Yes' nor 'has been changed' nor just "opposite"	

(c)		
M1	Complete method to find an equation in v_Q , m and u only: Use of $5mu =$ change in momentum of Q (must have $3m$ in both terms so allow with $3m$ outside the bracket even if it changes after the brackets are removed) but condone sign errors.	
A1	Correct equation	
A1	$\frac{2}{3}u$; Accept $0.67u$ or better. (A0 if –ve)	
	OR	
M1	Complete method to find an equation in v_Q , m and u only: Use of CLM with correct no. of terms and correct pairings and their v_p (M0 for CLM with 2 unknowns) but condone sign errors.	
A1	Correct equation for their v_Q	
A1	$\frac{2}{3}u$; Accept $0.67u$ or better. (A0 if –ve)	

Question Number	Scheme	Marks
2.	$T \cos 70^\circ + R = 40g$	M1 A1
	$T \cos 20^\circ = F$	M1 A1
	$F = \frac{3}{4}R$	B1
	Eliminate R and solve for T	dM1
	$T = 250 \text{ (N) or } 246 \text{ (N)}$	A1
		7
	Notes	
M1	Resolving vertically with usual rules i.e. correct no. of terms, condone sin/cos confusion, condone sign errors.	
A1	Correct equation.	
M1	Resolving horizontally with usual rules i.e. correct no. of terms, condone sin/cos confusion, condone sign errors.	
A1	Correct equation.	
B1	For $F = \frac{3}{4}R$ seen (could be on a diagram). N.B. R does not need to be substituted.	
dM1	Dependent on previous two M marks	
A1	246 (N) or 250 (N).	
	N.B. For a clear misread where they have the suitcase being dragged up an inclined plane, leading to: $R = 40g \cos 20^\circ$ $T - F - 40g \sin 20^\circ = 0$ $F = \frac{3}{4}R$ (leads to $T = 410.3 \text{ (N)}$ if done correctly) Can score MAX: M1A0M1A0B1dM0A0 (apply usual rules for M marks)	

Question Number	Scheme	Marks
3(a)		
	$22.5 = 5V - \frac{1}{2} \times g \times 5^2$	M1A1
	($h =$) 22.5 or 23	A1
		(3)
(b)	$v^2 = u^2 + 2as$ (or cons. of energy)	
	First ball: $V^2 = 20^2 + 2 \times g \times 22.5$ OR $V = -20 + (5 \times g)$ OR $22.5 = 5V - \frac{1}{2} \times g \times 5^2$	M1A1
	($V^2 = 841$) $V = 29$	
	Second ball: $\left(\frac{3}{4} \times '29'\right)^2 = w^2 + 2 \times g \times '22.5'$	M1A1ft (their V and their h)
	$w^2 = \frac{9}{16} \times 841 - 2 \times 9.8 \times 22.5$	
	$w = 5.66$ or 5.7	A1
		(5)
		8
	Notes	
(a)		
M1	Complete method to find an equation in h only: $s = ut + \frac{1}{2}at^2$: Must be using 5 and 20 but condone slips in substitution, condone sign errors. Alternatives will use time and distance to top (2.0408.. s and 20.408.. m) or speed at ground (29 m s ⁻¹)	
A1	Correct equation in h or s only N.B. Allow premature approximation	
A1	22.5 or 23 only. Ignore units. Must be positive. N.B. $\frac{45}{2}$ is A0	
(b)		
M1	First ball: Use of <i>suvat</i> to find an equation in V or V^2 , using their h . (this may have been done in (a)), condone sign errors.	
A1	Correct unsimplified equation.	
M1	Second ball: Use of <i>suvat</i> to find an equation in w only, using $\frac{3}{4} \times$ their V , condone sign errors	
A1ft	Correct equation in w only using their V and their h	
A1	5.66 or 5.7 only. Ignore units. Alternatives will use the time (1.64519 s)	

Question Number	Scheme	Marks
	Allow use of column vectors throughout.	
4(a)	$\tan \alpha = 1/3 \Rightarrow \alpha = 18.4^\circ$	M1 A1
	Bearing is 288° (nearest degree)	A1
		(3)
(b)	$(21\mathbf{i} + 5\mathbf{j}) + t(-6\mathbf{i} + 2\mathbf{j})$	B1
		(1)
(c)	$21 - 6t = -(5 + 2t)$	M1 A1
	$t = 6.5$	A1
		(3)
		7
	Notes	
(a)		
M1	An equation in a relevant angle. e.g. $\tan \theta = \pm \frac{2}{6}$ or $\pm \frac{6}{2}$ or $\sin \theta = \pm \frac{2}{\sqrt{2^2 + 6^2}}$	
A1	A correct angle from their equation e.g. $\pm 18.4^\circ$, $\pm 71.6^\circ$, $\pm 108.4^\circ$, ...	
A1	288° (nearest degree)	
(b)		
B1	$(21\mathbf{i} + 5\mathbf{j}) + t(-6\mathbf{i} + 2\mathbf{j})$ oe	
(c)		
M1	M1 for $21 - 6t = \pm(5 + 2t)$ or equivalent if they have a wrong answer to (b). Must be in t only.	
A1	A correct equation in t only.	
A1	6.5 oe	

Question Number	Scheme	Marks
5(a)		B1 shape of either B1 shape of second (must cross first and end at the same time) B1 V, 24, 12, T, $30+T$ Allow with their values of V and T. N.B. if they don't end at the same time, allow the 3rd B1, if they have $30+T$ at the end of one of them.
		(3)
(b)	CAR: Using Areas: $\frac{1}{2}(T + 30 + 30) \times 24 = 816$ or $\frac{1}{2} \times T \times 24 + (24 \times 30) = 816$ Using <i>suvat</i>: $816 - (24 \times 30) = 96$ $24^2 = 2a \times 96 \Rightarrow a = 3$ $24 = 3T \text{ or } 96 = \frac{1}{2} \times 3T^2$	M1A1
	$T = 8$	A1
		(3)

(c)	VAN: Using Areas: $\frac{1}{2}((8+30)+(8+18))V = 816$ or $\frac{1}{2} \times 12V + V(18+8) = 816$ Using <i>suvat</i>: $12 \times (8+18)a + \frac{1}{2}a \times 12^2 = 816 \Rightarrow a = 2.125$ $V = 12 \times 2.125$	M1A1ft
	$V = 25.5$	A1
		(3)
		9
	Notes	
(a)	N.B. If graphs are on separate axes, can score Max B1B0B0	
B1	Correct shape of either graph. N.B. B0 ONCE if there is a continuous vertical line at the end.	
B1	Correct shape of second graph which must cross the first graph and end at the same time.	
B1	V , 12, 24, T and $T + 30$ placed correctly	
	N.B. All 3 marks can be earned if they have $V < 24$ and $T > 12$ on their graph.	
(b)		
M1	Complete method to find an equation in T only using 816 distance travelled by CAR, using either areas with <i>correct structure</i> (ignore what they have on their diagram) or <i>suvat</i> .	
A1	A correct unsimplified equation in T only.	
A1	8	
	N.B. M0 if they assume that the total time is 30 or 42 when setting up the equation.	
(c)		
M1	Complete method to find an equation in V only using 816 distance travelled by VAN, using either areas with <i>correct structure</i> (ignore what they have on their diagram) or <i>suvat</i> .	
A1ft	A correct unsimplified equation in V only, using their T	
A1	25.5 oe	
	N.B. M0 if they assume that the total time is 30 or 42 when setting up the equation.	

Question Number	Scheme	Marks
6(a)	Trailer: $-100 - T = 600 \times (-4)$	M1 A1
	2300 (N)	A1
		(3)
6(b)	System: $6500 + 100 + 200 = 4(M + 600)$	M1 A1
	$M = 1100$	A1
	OR	
	Car: $6500 + 200 - '2300' = 4M$	M1 A1
	$M = 1100$	A1
		(3)
6(c)	OR $s = vt - \frac{1}{2}at^2 : 40.5 = \frac{1}{2} \cdot 4 \cdot t^2$ $0 = u^2 - 2 \times 4 \times 40.5 \text{ (} u = 18 \text{) then}$ $0 = 18 - 4t \text{ or } 40.5 = 18t - \frac{1}{2} \times 4t^2$	M1 A1
	$t = 4.5 \text{ s}$	A1
		(3)
		9
	Notes	
	N.B. In (a) and (b), use the mass in the 'ma' term to decide which part of the system is being considered.	
(a)		
M1	Complete method to find an equation in T only. Correct terms but condone sign errors.	
A1	Correct equation in T only. (allow $-100 + T = 600 \times (-4)$ oe)	
A1	Correct answer (must be positive)	
(b)		
M1	Complete method to find an equation in M only using an equation of motion for: the Whole System, correct terms but condone sign errors. OR the Car, correct terms (including their T) but condone sign errors.	
A1	Correct equation in M only.	
A1	Correct answer.	
(c)		
M1	Complete method, using <i>suvat</i> , to find an equation in t only They may find $u(18)$ first. N.B. Clear use of $s = ut + \frac{1}{2}at^2$ with $u = 0$ and $a = 4$ is M0 e.g. $40.5 = -2t^2$ from no working is M0A0	
A1	Correct equation in t only.	
A1	Correct answer.	

Question Number	Scheme	Marks
	N.B. Consistent omission of g in both parts of this question can score all of the marks (as can consistent use of $g = 9.81$ as it cancels) but for inconsistent omission, mark as per the scheme.	
7(a)		
	Possible equations: Resolve vertically: $3R = 8g$ M(C): $8g(x-1) = 4 \times 2R$ M(D): $8g(5-x) = 4R$ M(A): $8gx = 5 \times 2R + 1 \times R$ M(B): $8g(6-x) = 1 \times 2R + 5 \times R$	M1A1 M1A1
	N.B. Their equations may not be in x , if they've clearly defined a different distance, and can score the A1 in each case.	
	$x = \frac{11}{3} *$	dM1A1*
	Special Case: M(G): $R(x-1) = 2R(5-x)$	M2A2
	$(x-1) = 2(5-x)$ $x = \frac{11}{3} *$	dM1 A1*
	N.B. If R and $2R$ are consistently reversed, can score max M1A1 (if vert res is used)M1A0 dM1A0* N.B. If a decimal approximation is used can score max 5/6	
		(6)

Question Number	Scheme	Marks
7(b)		
	Possible equations: Resolve vertically: $R_F + R_D = 11g$ M(A): $2R_F + 5R_D = 8g \times \frac{11}{3}$ M(B): $4R_F + R_D = 8g \times \frac{7}{3} + 3g \times 6$ M(D): $3R_F = 8g \times \frac{4}{3} + 3g \times 5$ M(F): $3R_D + 3g \times 2 = 8g \times \frac{5}{3}$ M(G): $\frac{5}{3}R_F = 3g \times \frac{11}{3} + \frac{4}{3}R_D$ M(C): $(R_F \times 1) + 4R_D + 3g \times 1 = 8g \times \frac{8}{3}$	M1A1 M1A1
	$k = \frac{R_D}{R_F} = \frac{22}{77} = \frac{2}{7}$	dM1A1
		(6)
		12
	Notes	
	N.B. For both (a) and (b), enter marks for the equations on ePEN in the order in which the equations appear.	
(a)		
M1	Resolve or take moments, correct no. of terms, condone R and $2R$ interchanged and sign errors to give first equation.	
A1	Correct equation	
M1	Resolve or take moments, correct no. of terms, condone R and $2R$ interchanged and sign errors to give second equation.	
A1	Correct equation	
dM1	Eliminate R to produce an equation in x only, dependent on both M's	
A1*	Given answer correctly obtained.	

	Special Case:	
M2	Moments about G , condone R and $2R$ interchanged.	
A2	Correct equation	
dM1	Eliminate R to produce an equation in x only, dependent on both M's	
A1*	Given answer correctly obtained.	
(b)	N.B. No marks if they use their answer(s) from (a).	
M1	Resolve or take moments with correct no. of terms, but condone sign errors to give first equation.	
A1	Correct equation	
M1	Resolve or take moments with correct no. of terms, but condone sign errors to give second equation.	
A1	Correct equation	
dM1	Eliminate R_D and R_F and solve to give a numerical value of k , dependent on both M's. N.B. Can be scored even if it leads to $k < 0$.	
A1	Accept 0.29 or better (0.285714....)	
	N.B. If R and kR are consistently reversed, can score max M1A1 (if vert res is used) M1A0dM1A0	

Question Number	Scheme	Marks
8(a)	$R = mg; F = 0.5R$	B1; B1
	For Q : $4mg - T = 4ma$	M1 A1
	For P : $T - F = ma$	M1 A1
	(whole system: $4mg - F = 5ma$)	
	Eliminate a and solve for T	dM1
	$T = 1.2mg$	A1
		(8)
8(b)	$v^2 = 2 \times 0.7gh \Rightarrow v = \sqrt{1.4gh}$ *	M1 A1*
		(2)
8(c)	$\pm 0.5mg = ma' \Rightarrow a' = \pm 0.5g$	M1 A1
	$0^2 = 1.4gh - 2 \times 0.5g \times d$	M1 A1
	$d = 1.4h$	A1
	Hence, length of string is greater than $1.4h + h = 2.4h$ *	A1 *
		(6)
		16
	Notes	
(a)		
B1	$R = mg$ seen (on a diagram possibly) seen or implied	
B1	$F = 0.5R$ seen (on a diagram possibly) seen or implied	
	N.B. Both B marks can be implied by $0.5mg$ appearing in an equation.	
M1	Equation of motion for Q , with all terms, condone sign errors.	
A1	Correct equation.	
M1	Equation of motion for P , with all terms, condone sign errors.	
A1	Correct equation.	
	N.B. Condone use of $4mg - F = 5ma$ for either equation Allow $-a$ instead of a in both equations	
dM1	Eliminate a and solve for T , dependent on both M marks.	
A1	Accept any equivalent	
	N.B. If they have different tensions, can score Max B1B1M1A1M1A0 dM0A0	
(b)		
M1	Complete method to obtain an equation in v and h using their a (not g) from part (a).	
A1*	Given answer correctly obtained. N.B. Must have ' $v =$ '	
(c)		
M1	Equation of motion with correct terms.	
A1	Correct equation	
M1	Complete method to obtain an equation in d and h ONLY , condone sign errors.	

	N.B. Must have found a new acceleration from a new equation of motion. N.B. M0 if using their a from part (a).	
A1	Correct equation	
A1	Correct d in terms of h	
A1*	Given answer correctly obtained – their answer must reflect the inequality	

Please check the examination details below before entering your candidate information

Candidate surname					Other names				
Centre Number					Candidate Number				

Pearson Edexcel International Advanced Level

Friday 9 January 2026

Morning (Time: 1 hour 30 minutes) **Paper reference** **WME01/01**

Mathematics

International Advanced Subsidiary/Advanced Level

Mechanics M1

You must have:
Mathematical Formulae and Statistical Tables (Yellow), calculator

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Whenever a numerical value of g is required, take $g = 9.8 \text{ m s}^{-2}$, and give your answer to either 2 significant figures or 3 significant figures.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 7 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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1. A particle P of mass $3m$ and a particle Q of mass $5m$ are on a smooth horizontal surface. The particles move towards each other in opposite directions along the same straight line and collide.

Immediately before the collision, the speed of P is $3u$ and the speed of Q is $4u$

The magnitude of the impulse exerted on P by Q in the collision is $\frac{33}{2}mu$

Find

- (i) the speed of P immediately after the collision,
(ii) the speed of Q immediately after the collision.

(6)



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Question 1 continued

Handwriting practice area with horizontal lines.

(Total for Question 1 is 6 marks)



2.

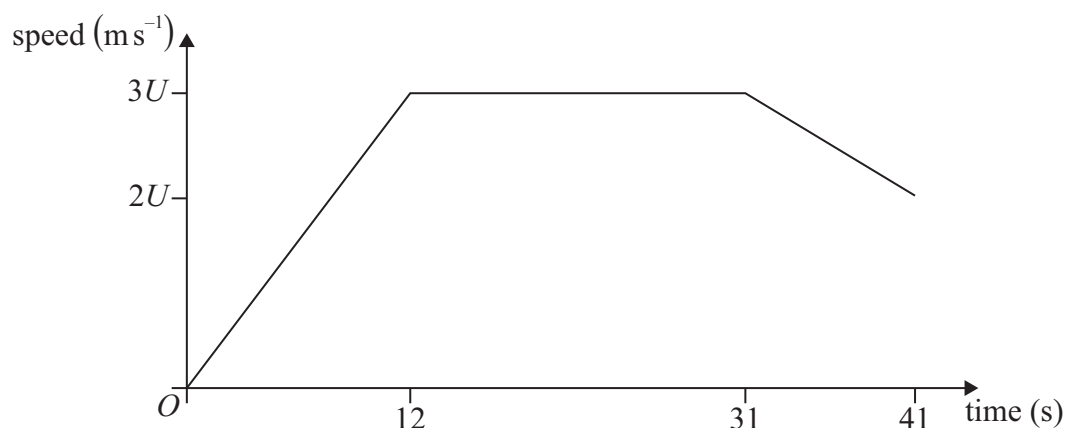


Figure 1

A particle P starts from rest at time $t = 0$ and moves in a straight line

- from $t = 0$ to $t = 12$ s, P accelerates uniformly until it reaches a speed of $3U \text{ m s}^{-1}$
- from $t = 12$ s to $t = 31$ s, P moves with constant speed $3U \text{ m s}^{-1}$
- from $t = 31$ s to $t = 41$ s, P decelerates uniformly until it has speed $2U \text{ m s}^{-1}$

as shown on the speed-time graph in Figure 1.

The distance travelled by P between $t = 0$ and $t = 41$ s is 600 m.

- (a) Show that $U = 6$ (3)
- (b) Find the distance travelled by P whilst moving from rest to a speed of 6 m s^{-1} (2)
- (c) Find the acceleration of P between $t = 0$ and $t = 12$ s. (1)
- (d) Find the deceleration of P between $t = 31$ s and $t = 41$ s. (2)
- (e) Sketch an acceleration-time graph to represent the motion of P from $t = 0$ to $t = 41$ s. (2)



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Question 2 continued

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Question 2 continued

Lined area for writing the answer to Question 2.

(Total for Question 2 is 10 marks)



3. A particle moves on a smooth horizontal plane under the action of three horizontal forces, $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$, where

$$\mathbf{F}_1 = (2p\mathbf{i} - 3p\mathbf{j})\text{N}$$

$$\mathbf{F}_\gamma = (q\mathbf{i} + \mathbf{j})\mathbf{N}$$

$$\mathbf{F}_3 = (3\mathbf{i} - q\mathbf{j})N$$

where p and q are constants.

The resultant force acts in the direction of the vector $(4\mathbf{i} - 5\mathbf{j})$

- (a) Show that

$$2p - q = 19 \tag{4}$$

The mass of the particle is 0.5 kg.

Given that $p = 7$

- (b) find the acceleration of the particle. (4)



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P 7 8 9 1 2 A 0 9 2 8

Question 3 continued

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Question 3 continued

(Total for Question 3 is 8 marks)



4.

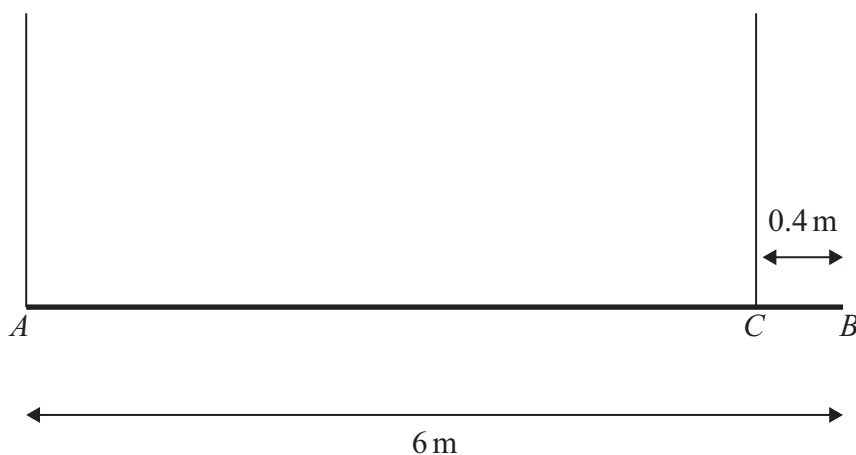


Figure 2

Figure 2 shows a uniform rod AB of length 6 m suspended by two light vertical ropes.

The first rope is attached to the rod at A .

The second rope is attached to the rod at the point C , where $CB = 0.4\text{ m}$.

The rod has mass 30 kg .

A particle of mass 20 kg is now attached to the rod at B .

The rod is in equilibrium in a horizontal position.

(a) Find

- (i) the tension in the rope attached to the rod at C ,
- (ii) the tension in the rope attached to the rod at A .

(6)

The particle of mass 20 kg at B is removed and replaced by a particle of mass $M\text{ kg}$.

The rod remains in equilibrium in a horizontal position.

(b) Find the exact maximum value of M .

(3)



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Question 4 continued

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Question 4 continued

(Total for Question 4 is 9 marks)



5. The points O, A, B and C are on a rough horizontal surface where $OABC$ is a straight line.

A particle is projected horizontally from O and slides across the surface, passing through A , B and C in that order.

The particle passes through

- A with speed $U \text{ m s}^{-1}$
- B with speed $\frac{U}{2} \text{ m s}^{-1}$

The coefficient of friction between the particle and the surface is $\frac{1}{7}$

It takes 0.75 s for the particle to move from A to B .

- (a) Show that $U = 2.1$ to 2 significant figures.

(6)

The particle passes through C with speed $\frac{U}{3} \text{ m s}^{-1}$

- (b) Find the time taken to move from B to C .

(3)

- (c) Find the distance AC .

(3)



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Question 5 continued

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Question 5 continued

(Total for Question 5 is 12 marks)



6. [In this question $\mathbf{i}$ and $\mathbf{j}$ are horizontal unit vectors directed due east and due north respectively and position vectors are given relative to a fixed origin O .]

At 9 am, a ship S leaves a harbour and moves with constant velocity $(10\mathbf{i} + 15\mathbf{j})\text{ km h}^{-1}$

- (a) Find the exact speed of S (2)

The harbour is at the origin O .

At 9 am, a boat B leaves the point with position vector $(50\mathbf{i} + 10\mathbf{j})\text{ km}$ and moves with constant velocity $(-8\mathbf{i} + 10\mathbf{j})\text{ km h}^{-1}$

- (b) Find the direction in which B is moving, giving your answer as a bearing to the nearest degree. (3)

- (c) Show that at time t hours after 9 am,

$$\overrightarrow{SB} = [(50 - 18t)\mathbf{i} + (10 - 5t)\mathbf{j}] \text{ km} \quad (4)$$

- (d) Show that B and S do not collide. (3)

When B is north-east of S , the distance between S and B is $d\text{ km}$.

- (e) Find the value of d . (4)



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Question 6 continued

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Question 6 continued

(Total for Question 6 is 16 marks)



7.

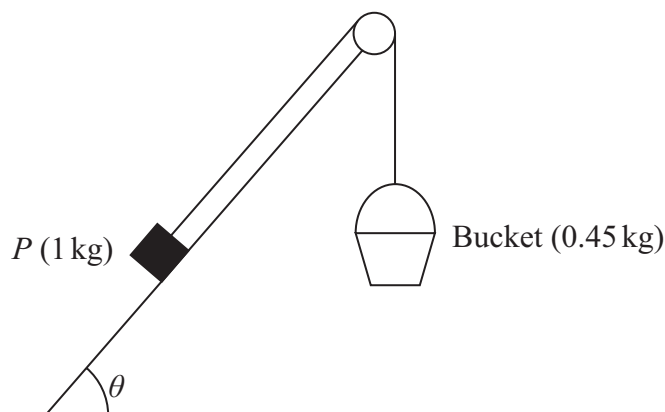


Figure 3

A rough plane is inclined at an angle θ to the horizontal, where $\tan \theta = \frac{4}{3}$

One end of a light inextensible string is attached to a package P .

The string passes over a smooth pulley that is fixed at the top of the plane.

The string from P to the pulley lies along a line of greatest slope of the plane.

The other end of the string is attached to a bucket.

The package P has mass 1 kg and is **held** at rest on the plane.

The bucket has mass 0.45 kg and hangs vertically below the pulley with the string taut, as shown in Figure 3.

The coefficient of friction between P and the plane is μ

When a small block of mass 0.2 kg is placed in the bucket, the system is released and remains at rest in **limiting equilibrium**, with P on the point of slipping down the plane.

- (a) Show that $\mu = \frac{1}{4}$ (7)

Additional identical blocks of mass 0.2 kg are added one at a time into the bucket until P starts to move **up** the plane.

At the instant when P starts to move up the plane, there are a **total** of n blocks in the bucket.

- (b) Find
- the value of n
 - the magnitude of the initial acceleration of P
- (7)



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Question 7 continued

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Question 7 continued

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(Total for Question 7 is 14 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (Final)

January 2026

International Advanced Level in Mechanics M1

WME01/01

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January 2026

Question Paper Log Number P78912A

Publication Code WME01_01_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)

Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN:

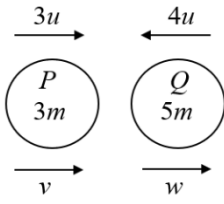
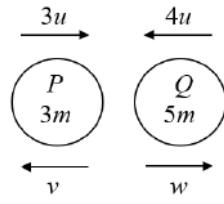
- bod – benefit of doubt
- ft – follow through
 - the symbol $\checkmark$ will be used for correct ft
- cao – correct answer only
- cso – correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC – special case
- oe – or equivalent (and appropriate)
- d... or dep – dependent
- indep – independent
- dp – decimal places

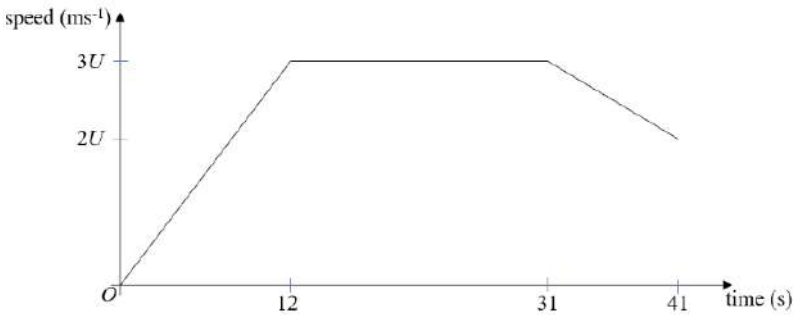
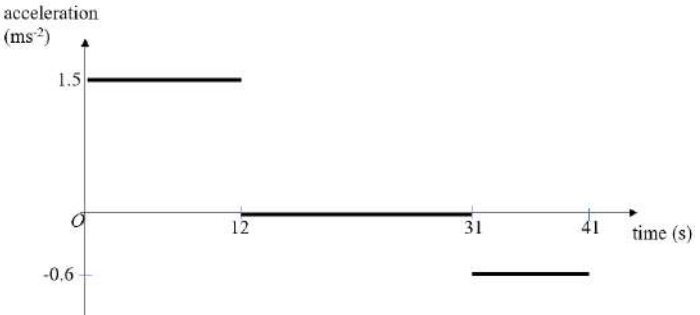
- sf – significant figures
 - * – The answer is printed on the paper or ag- answer given
 - □ or d... – The second mark is dependent on gaining the first mark
4. All A marks are 'correct answer only' (cao), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.
 5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. If you are using the annotation facility on ePEN, indicate this action by 'MR' in the body of the script.
 6. If a candidate makes more than one attempt at any question:
 - a) If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - b) If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
 7. Ignore wrong working or incorrect statements following a correct answer.

General Principles for Mechanics Marking

(**N.B.** specific mark schemes may sometimes override these general principles)

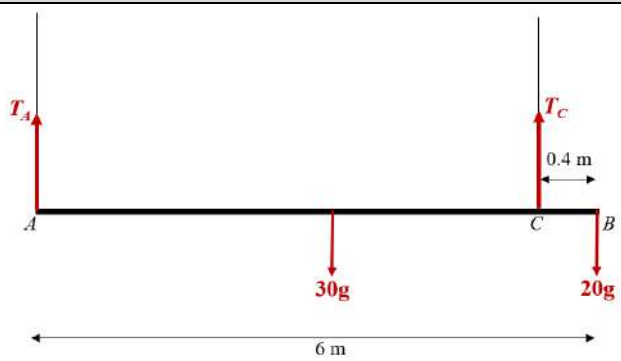
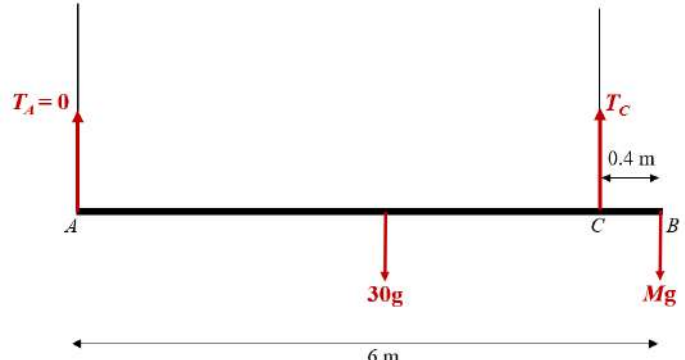
- Rules for M marks:
 - correct number of terms
 - dimensionally correct
 - all terms that need resolving (i.e. *multiplied* by cos or sin) are resolved
 - only terms that need resolving are resolved
 - +/- errors are condoned
 - sin/cos confusion is condoned
- Omission or extra g in a resolution is an accuracy error not method error.
- Omission of mass from a resolution is a method error.
- Omission of a length from a moments equation is a method error.
- Omission of units or incorrect units is not (usually) counted as an accuracy error.
- DM indicates a dependent method mark, i.e. one that can only be awarded if a previous specified method mark(s) has been awarded.
- Any numerical answer which comes from use of $g = 9.8$ should be given as a decimal to 2 or 3 SF.
- Use of $g = 9.81$ should be penalised once per (complete) question.
 - N.B. Over-accuracy or under-accuracy of correct answers should only be penalised once per complete question. However, premature approximation should be penalised every time it occurs.
- Marks must be entered in the same order as they appear on the mark scheme.
- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c)...then that working can only score marks for that part of the question.
- Accept column vectors in all cases.
- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft

Question Number	Scheme		Marks
1			
(i)	Impulse equation for P		M1
	$-\frac{33}{2}mu = 3m(v - 3u)$	$-\frac{33}{2}mu = 3m(-v - 3u)$	A1
	Speed of $P = \frac{5}{2}u$		A1
(ii)	Impulse equation for Q or CLM		M1
	Impulse: $\frac{33}{2}mu = 5m(w - -4u)$ or CLM: $3m(3u) + 5m(-4u) = 3m\left(-\frac{5}{2}u\right) + 5mw$		A1
	Speed of $Q = \frac{7}{10}u$		A1
			(6)
	Notes for Question 1		
	Allow parts (i) and (ii) to be answered in either order.		
1(i)			
M1	Relevant equation to find the speed of P . Impulse-momentum equation using $\frac{33}{2}mu$, $3m$ and $3u$. Dimensionally correct, correct no. of terms, condone sign errors. If speed of Q is found first, may use CLM with their velocity of Q and correct mass-velocity pairs. M0 if g is used in Impulse equation but condone consistent g in CLM.		
A1	Correct equation for P . If speed of Q is found first, CLM equation is: $3m(3u) + 5m(-4u) = 3m(\pm v) + 5m\left(-\frac{7}{10}u\right)$		
A1	Correct speed of P , must be positive.		
1(ii)			
M1	Relevant equation to find the speed of Q . Impulse-momentum equation using $\frac{33}{2}mu$, $5m$ and $4u$ or CLM with v replaced and mass-velocity paired correctly. Dimensionally correct, correct no. of terms, condone sign errors. M0 if g is used in Impulse equation but condone consistent g in CLM.		
A1	Correct unsimplified equation. CLM note: there is no follow through for incorrect velocity of P		
A1	Correct speed of Q , must be positive.		

Question Number	Scheme	Marks
2		
(a)	Method to find U	M1
	$600 = \frac{12 \times 3U}{2} + (19 \times 3U) + \left(\frac{3U + 2U}{2} \right) 10$	A1
	$U = 6 *$	A1*
		(3)
(b)	Method to find required distance: $\frac{4 \times 6}{2}$	M1
	12 (m)	A1
		(2)
(c)	$1.5 \text{ (ms}^{-2}\text{)}$	B1
		(1)
(d)	Method to find deceleration, $\pm \frac{6}{10}$	M1
	$0.6 \text{ (ms}^{-2}\text{)}$	A1
		(2)
(e)		B1 (shape) B1ft (vertical labels)
		(2)
		(10)
Notes for Question 2		
2(a)		
M1	Complete method using distance of 600 to form an equation in U only. Correct structure of areas. Accept verification approach (i.e. numerical areas sum to 600)	
A1	Correct unsimplified equation.	

A1*	Obtain given answer from complete and correct working. Must be at least one line of working in addition to an equation and the given answer. Must reach " $U = 6$ " or " $6 = U$ ". If using verification, must conclude $U = 6$.	
2(b)		
M1	Complete method to find the distance travelled in the first 4 seconds. May find acceleration and use <i>suvat</i> . Eg $18 = 0 + 12a \quad (\Rightarrow a = 1.5) \quad \text{then} \quad 6^2 = 0^2 + 2 "a" s$ - Area in 12s is 108m, $SF = \frac{1}{9} \Rightarrow Dist = "108" \div 9$	
A1	Correct answer.	
2(c)		
B1	Correct answer.	
2(d)		
M1	Correct method to find the deceleration.	
A1	Correct answer, must be positive.	
2(e)		
B1	Correct shape of acceleration-time graph. Three solid horizontal lines correctly positioned relative to an axis representing positive, negative and zero acceleration. BOD if section 12,, t ,, 31 is difficult to see. B0 if there is a solid vertical line.	
B1ft	Both values present on the vertical axis. Follow through their constant acceleration but must have one above the time axis and one below the time axis (representing a positive and negative acceleration). However, B0 if any graph sections are not horizontal.	

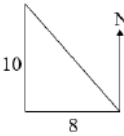
Question Number	Scheme	Marks
3		
(a)	$(2p\mathbf{i} - 3p\mathbf{j}) + (q\mathbf{i} + \mathbf{j}) + (3\mathbf{i} - q\mathbf{j}) = (2p + q + 3)\mathbf{i} + (-3p + 1 - q)\mathbf{j}$	M1
	Correct method using the direction vector $4\mathbf{i} - 5\mathbf{j}$ to form an equation in p and q only	M1
	$\frac{2p + q + 3}{-3p + 1 - q} = \frac{4}{-5}$	A1
	Working that leads to $2p - q = 19 \quad *$	A1 *
		(4)
(b)	$q = -5$	B1
	N2L in vector form	M1
	$(14 - 5 + 3)\mathbf{i} + (-21 + 1 + 5)\mathbf{j} = 0.5\mathbf{a}$	A1
	$\mathbf{a} = (24\mathbf{i} - 30\mathbf{j}) \quad (\text{ms}^{-2})$	A1
		(4)
		(8)
	Notes for Question 3 Accept column vectors throughout	
3(a)		
M1	Find the sum of the three forces and collect $\mathbf{i}$'s and $\mathbf{j}$'s	
M1	Use the direction vector $4\mathbf{i} - 5\mathbf{j}$ correctly with their $\mathbf{i}$ and $\mathbf{j}$ components to form an equation in p and q only. Accept equivalent forms. May use $(2p + q + 3)\mathbf{i} + (-3p + 1 - q)\mathbf{j} = \lambda(4\mathbf{i} - 5\mathbf{j})$ and equate components to form an equation in p and q . M0 if equation is formed from simultaneous equations.	
A1	Correct unsimplified equation in p and q	
A1*	Obtain the given answer from complete and correct working. Must see at least one line of working between the initial equation in p and q and the given answer. Accept $19 = 2p - q$	
3(b)		
B1	Correct value for q	
M1	Use of $\mathbf{F} = m\mathbf{a}$ (vector form) with $p = 7$ and their q substituted. Must use the resultant force (vector sum of $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$) correctly with $m\mathbf{a}$. M0 for using $ \mathbf{F} = m \mathbf{a} $. M0 if weight is included as a force.	
A1	Correct unsimplified vector equation	
A1	Correct acceleration vector. ISW if Pythagoras is used to find $ \mathbf{a} $ after finding acceleration vector.	

Question Number	Scheme	Marks
4 (a)		
	First relevant equation in T_A and/or T_C	M1
	Correct unsimplified equation Relevant equations:	A1
	• M(B) $(T_A \times 6) + (T_C \times 0.4) = (30g \times 3)$ • M(A) $(T_C \times 5.6) = (30g \times 3) + (20g \times 6)$ • M(C) $(T_A \times 5.6) + (20g \times 0.4) = (30g \times 2.6)$ • M(G) $(T_A \times 3) + (20g \times 3) = (T_C \times 2.6)$ • Vert $T_A + T_C = 20g + 30g$	
	Second equation in T_A and/or T_C	M1
	Correct unsimplified equation	A1
	$T_C = 368$ or 370 (N)	A1
	$T_A = 123$ or 120 (N)	A1
		(6)
(b)		
	Form an equation in M only	M1
	M(C) : $(Mg \times 0.4) = (30g \times 2.6)$	A1
	$M = 195$	A1
		(3)
		(9)
	Notes for Question 4	

	Mark parts (i) and (ii) together if required. Penalise use of $g = 9.81$ on first occasion only. Penalise over/under accuracy of final answer on first occasion only.	
4(a)	If more than two equations seen, mark the two that are used in the order they appear.	
M1	First relevant equation in T_C and/or T_A . Correct number of terms. Dimensionally correct (force $\times$ length in a moments equation).	
A1	Correct unsimplified equation	
M1	Form a second relevant equation in T_C and/or T_A . Correct number of terms. Dimensionally correct (force $\times$ length in a moments equation). Condone re-using T in $M(A)$ and $M(C)$ as long as clearly separate tensions.	
A1	Correct unsimplified equation	
A1	Correct answer for tension in C , 2/3sf. Accept $\frac{75}{2}g$, $37.5g$ ISW	
A1	Correct answer for tension in A , 2/3sf. Accept $\frac{25}{2}g$, $12.5g$ ISW	
4(b)		
M1	Uses moments to form an equation in M only. Correct terms included and dimensionally correct. May use two equations and eliminate T_C . Vert : $T_C = 30g + Mg$ $M(A) : (T_C \times 5.6) = (30g \times 3) + (Mg \times 6)$ $M(G) : (T_C \times 2.6) = (Mg \times 3)$ $M(B) : (T_C \times 0.4) = (30g \times 3)$ M0 if tension at A is never 0. M0 if a tension from part (a) is used.	
A1	Correct unsimplified equation in M only	
A1	Correct answer only.	

Question Number	Scheme	Marks
5	$ \begin{array}{ccccccc} U = 2.1 & & \frac{U}{2} = 1.05 & & \frac{U}{3} = 0.7 & & a = -1.4 \\ \rightarrow & & \rightarrow & & \rightarrow & & \rightarrow \\ \hline A & & B & & C & & \\ t = 0 & & t = 0.75 & & t = 0.75 + 0.25 & & \end{array} $	
(a)	Vert $R = mg$	B1
	$F = \frac{1}{7}R$	B1
	N2L $-F = ma$	M1
	$a = \pm \frac{g}{7}$ or ± 1.4	A1
	<i>suvat</i> from A to B $\frac{U}{2} = U + a(0.75)$	M1
	Obtain given answer $U = 2.1 *$	A1*
		(6)
(b)	<i>suvat</i> from B to C	M1
	For example, $\bullet \frac{2.1}{3} = \frac{2.1}{2} + \left(\frac{-g}{7}\right)t$ $\bullet \frac{U - \frac{U}{2}}{0.75} = \frac{\frac{U}{2} - \frac{U}{3}}{t}$	A1
	$t = 0.25$ (s)	A1
		(3)
(c)	<i>suvat</i> from A to C	M1
	For example, $\bullet s = \left(\frac{2.1 + \frac{2.1}{3}}{2}\right)(0.75 + "0.25")$ $\bullet \left(\frac{2.1}{3}\right)^2 = 2.1^2 + 2\left(-\frac{g}{7}\right)s$	A1ft
	1.4 (m)	A1
		(3)
		(12)
	Notes for Question 5	
	Penalise use of $g = 9.81$ on first occasion only. Penalise over/under accuracy of final answer on first occasion only.	
5(a)		
B1	Vertical equilibrium $R = mg$ seen or implied.	

B1	$F = \frac{1}{7}R$ seen or implied.	
M1	Use of N2L. Correct number of terms and dimensionally correct. Note: $-\frac{1}{7}mg = ma$ implies first 3 marks. M0 if $a = \pm 1.4$ with no evidence of $F = ma$ or $\pm \frac{g}{7}$	
A1	Correct acceleration, accept $\pm \frac{g}{7}$	
M1	Correct method using relevant <i>suvat</i> equation(s) from <i>A</i> to <i>B</i> to form an equation in <i>U</i> and <i>a</i> only. M0 for use of $a = \pm g$	
A1*	Obtain given answer from complete and correct working. Must use $g = 9.8$. Allow use of $a = 0.67U$ or better. Must reach $U = 2.1$ or $2.1 = U$.	
5(b)		
M1	Correct method using relevant <i>suvat</i> equation(s) from <i>B</i> to <i>C</i> to form an equation in <i>t</i> (and <i>U</i>). Must use $\frac{U}{2}$ and $\frac{U}{3}$ or numerical equivalent. Use of their acceleration for the method mark ($a \neq \pm g$)	
A1	Correct unsimplified equation in <i>t</i> only	
A1	Correct answer, 2sf following use of $g = 9.8 \text{ ms}^{-2}$	
5(c)		
M1	Complete method to find the distance from <i>A</i> to <i>C</i> . Relevant <i>suvat</i> equation(s) for the full time period. Accept in terms of <i>U</i> for the method mark. Use of their acceleration for the method mark ($a \neq \pm g$)	
A1ft	Correct unsimplified equation. Follow through their “0.25”.	
A1	Correct answer	

Question Number	Scheme	Marks
6 (a)	$\sqrt{10^2 + 15^2}$	M1
	$\sqrt{325}$ or $5\sqrt{13}$ (km h^{-1})	A1
		(2)
(b)	$\tan \theta = \pm \frac{10}{8}$ or $\tan \theta = \pm \frac{8}{10}$ o.e.	M1
	A correct relevant angle 51.340... or 38.659...	A1
	 Bearing = 321 ($^{\circ}$)	A1
		(3)
(c)	Method to find $\overrightarrow{SB}$ using difference of general position vectors.	M1
	Correct expression for S at time t $t(10\mathbf{i} + 15\mathbf{j})$	A1
	Correct expression for B at time t $(50\mathbf{i} + 10\mathbf{j}) + t(-8\mathbf{i} + 10\mathbf{j})$	A1
	$\overrightarrow{SB} = [(50\mathbf{i} + 10\mathbf{j}) + t(-8\mathbf{i} + 10\mathbf{j})] - [t(10\mathbf{i} + 15\mathbf{j})]$ Leading to $\overrightarrow{SB} = [(50 - 18t)\mathbf{i} + (10 - 5t)\mathbf{j}] *$	A1*
		(4)
(d)	Equate each component of $\overrightarrow{SB}$ to zero	M1
	$50 - 18t = 0 \Rightarrow t = \frac{25}{9}$ $10 - 5t = 0 \Rightarrow t = 2$	A1
	Times are not the same $\Rightarrow B$ and S do not collide	A1*
		(3)
(e)	Equate $\mathbf{i}$ and $\mathbf{j}$ components of $\overrightarrow{SB}$ $50 - 18t = 10 - 5t$	M1
	$t = \frac{40}{13}$	A1
	Method to find distance, $ \overrightarrow{SB} $ $d = \sqrt{\left(50 - 18 \times \frac{40}{13}\right)^2 + \left(10 - 5 \times \frac{40}{13}\right)^2}$	dM1
	Correct answer $= 7.6$ (km) or better	A1
		(4)
		(16)
	Notes for Question 6	
6(a)		

M1	Correct use of Pythagoras. May be implied by a correct answer.	
A1	Must be exact.	
6(b)		
M1	Correct use of trigonometry to find a relevant angle.	
A1	Correct relevant angle seen eg 51.350... , 38.659..., Accept $\tan^{-1}\left(\frac{8}{10}\right), \tan^{-1}\left(\frac{10}{8}\right)$	
A1	Correct answer, must be to the nearest degree.	
6(c)		
M1	Method to find $\overrightarrow{SB}$. Must subtract two general position vectors of the form $\mathbf{r}_0 + t\mathbf{v}$ (accept collected i and j).	
A1	Correct expression for position of the ship at time t .	
A1	Correct expression for the position of the boat at time t .	
A1*	Obtain given answer from complete and correct working. Accept working in column vectors. Final answer must have correct i-j notation. Accept $\overrightarrow{SB}$ or SB . Allow missing units.	
(d)		
M1	Equate both i and j components to zero	
A1	Correct values for t	
A1*	Obtain given answer from fully correct working with conclusion. E.g. Following correct t values: 'do not collide'	
(d) ALT 1		
M1	Method to find the minimum value of d or d^2 ($349t^2 - 1900t + 2600$) Eg - Completes the square: $349\left(t - \frac{950}{349}\right)^2 + \frac{4900}{349}$ - Differentiates and setting equal to 0: $698t - 1900 = 0 \Rightarrow t = \frac{950}{349}$ - Calculator: $\min d^2 = 14.04...$ or $\min d = 3.747...$ when $t = \frac{950}{349}$	
A1	Correct value for $\min d$ or d^2 identified: $\frac{4900}{349}$ or $\sqrt{\frac{4900}{349}}$	
A1*	Conclusion following correct working.	
(d) ALT 2		
M1	Method to find there are no real roots of the quadratic $349t^2 - 1900t + 2600$. May use the quadratic formula or discriminant or calculator but there must be evidence of finding 'no real roots', not just a statement.	
A1	$d = \frac{1900 \pm \sqrt{1900^2 - 4(349)(2600)}}{2(349)} \Rightarrow \text{roots } \frac{950 \pm 70i}{349}$ - Discriminant $= 1900^2 - 4(349)(2600) = -19600 < 0$	

A1*	No real roots or so never collide. N.B. Must see justification for ‘no real roots’ to score either of the A marks. Correct conclusion from correct working	
(e)	N.B. For the last 2 marks, send the item to Review if a candidate appears to be affected by the SW/NE error.	
M1	Equate i and j components to find an equation in t	
A1	Correct value for t . Accept 3.1 or better.	
dM1	Dependent on previous M. Method to find distance using Pythagoras (square and add terms of $\overrightarrow{SB}$).	
A1	$\frac{70\sqrt{2}}{13}$ or 7.6 (km) or better (calculator display 7.614996105) Award at the point of a correct numerical expression then ISW	

Question Number	Scheme	Marks
(a) On point of slipping down plane (b) Starts to move up the plane		
7(a)	Method to form an equation in F only.	M1
	Either whole system: $F + 0.45g + 0.2g = g \sin \theta$	A1
	Or two equations and eliminate T	A1
	For P : $T + F = g \sin \theta$	
	For bucket and block: $T = 0.45g + 0.2g$	A1
	Perpendicular equilibrium for P	M1
	$R = g \cos \theta \left(= \frac{3}{5}g \right)$	A1
	Use of $F = \mu R$ and correct trig ratios	M1
	$\mu = \frac{1}{4}^*$	A1*
		(7)
(b)(i)	Method to form an inequality or equation in n only	M1
	Either whole system: $0.45g + 0.2ng > g \sin \theta + F$	A1
	Or two inequalities and eliminate T	
	For P : $T > F + g \sin \theta$	
	For bucket and blocks: $0.45g + 0.2ng > T$	A1
	Leads to $n > 2.5$ (or $n = 2.5$)	
(ii)	so $n = 3$	
	Method using N2L to form an equation in a only	M1
	Either whole system:	A1
	$0.45g + 0.2(3)g - g \sin \theta - F = (1 + 0.45 + 0.2(3))a$	
	$0.45g + 0.6g - \frac{4}{5}g - \frac{3}{20}g = 2.05a$	A1
	Or two equations and eliminate T	
	For P : $T - g \sin \theta - F = a$	A1
	For bucket and blocks: $0.45g + 0.2(3)g - T = (0.45 + 0.2(3))a$	
	$a = 0.48$ or $0.478 \text{ (m s}^{-2}\text{)}$	A1
		(7)

		(14)
	Notes for Question 7	
7(a)		
M1	Complete method to form an equation in F (or μR) only. May use equilibrium or N2L with $a = 0$ (whole system or two equations and eliminate T). Dimensionally correct, correct no of terms, condone sin/cos confusion, condone sign errors. M0 if a is never equal to zero.	
A1	Correct unsimplified equation in F with at most one error (or μR)	
A1	Correct unsimplified equation in F (or μR)	
M1	Perpendicular equilibrium to find an expression for R , condone sin/cos confusion.	
A1	Correct unsimplified expression for R	
M1	Use of $F = \mu R$ and correct trig ratios. Must use μR with their R in an attempt at N2L ($a = 0$ or $a \neq 0$)	
A1*	Obtain given answer from complete and correct working. Must see sufficient working with the equilibrium equation and the given answer. Must have clear use of $a = 0$ if using N2L. A0* for $\mu = 0.25$	
7(b) (i)	Marks parts (i) and (ii) together if required	
M1	Complete method to form an equation/inequality in n only. May use equilibrium or N2L (whole system to two equations and eliminate T). Dimensionally correct, correct no of terms, condone sin/cos confusion, condone sign errors. Accept method using $(0.45g + 0.2ng)$ or $(0.65g + 0.2ng)$ Accept a systematic method adding blocks ($n = 2$ and 3). In each trial, must make a comparison. $\left(\text{useful values: } g \sin \theta + F = \frac{19}{20}g \text{ and } F = \frac{3}{20}g = 1.47 \right)$	
A1	Correct unsimplified equation or inequality.	
A1	Correct value of n	
7(b)(ii)		
M1	Use of N2L to form an equation in a only (whole system or two equations and eliminate T). Dimensionally correct, correct no of terms, condone sin/cos confusion, condone sign errors. Allow with their calculated n if used consistently on both sides.	
A1	Correct unsimplified equation with at most one error. Note: repeated use of incorrect n is one error eg $n = 2, 2.5, 4$ and use of $n = 3$ from an incorrect method is one error (fortuitous)	
A1	Correct unsimplified equation.	
A1	Accept $\frac{2g}{41}$	

Pearson Edexcel International Advanced Level

Thursday 15 January 2026

Morning (Time: 1 hour 30 minutes)

**Paper
reference**

WME02/01A

Mathematics

International Advanced Subsidiary/Advanced Level

Mechanics M2

Question Paper

You must have:

Answer book (sent separately).

Do not return this question paper with the answer book.

Turn over ►

P87597A

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C:1/1/




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1. A particle P of mass 2 kg is moving with velocity $(3\mathbf{i} + 4\mathbf{j})\text{ m s}^{-1}$ when it receives an impulse.

Immediately after the impulse is applied, P has velocity $(2\mathbf{i} - 3\mathbf{j})\text{ m s}^{-1}$.

- (a) Find the magnitude of the impulse.

(5)

- (b) Find the angle between the direction of the impulse and the direction of motion of P immediately before the impulse is applied.

(3)

(Total for Question 1 is 8 marks)

2. A cyclist and his bicycle have a total mass of 75 kg . The cyclist is moving **up** a straight road inclined at an angle θ to the horizontal, where $\sin\theta = \frac{1}{21}$.

The non-gravitational resistance to motion is modelled as a constant force of magnitude R newtons.

The cyclist is working at a constant rate of 280 W and moving at a constant speed of 2 m s^{-1} .

- (a) Find the value of R .

(4)

Later the cyclist cycles **down** the same road on the same bicycle.

He is again working at a constant rate of 280 W and the resistance to motion is now modelled as a constant force of magnitude 60 N .

- (b) Find the acceleration of the cyclist at the instant when his speed is 3.5 m s^{-1} .

(4)

(Total for Question 2 is 8 marks)



3.

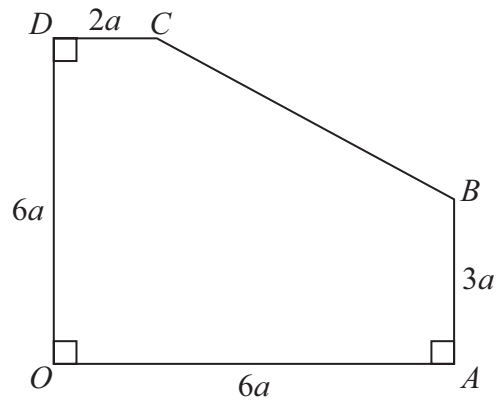


Figure 1

The uniform lamina $OABCD$ is shown in Figure 1, with $OA = 6a$, $AB = 3a$, $CD = 2a$ and $DO = 6a$ and with right angles at O , A and D .

(a) Find the distance of the centre of mass of the lamina

(i) from OD ,

(ii) from OA .

(6)

The lamina is suspended from C and hangs freely in equilibrium with CB inclined at an angle α to the vertical.

(b) Find, to the nearest degree, the size of the angle α .

(4)

(Total for Question 3 is 10 marks)

4.

**In this question you must show all stages of your working.
Solutions relying on calculator technology are not acceptable.**

At time t seconds ($t \geq 0$), a particle P has position vector $\mathbf{r}$ metres with respect to a fixed origin O , where

$$\mathbf{r} = \left(t^3 - \frac{9}{2}t^2 - 24t \right) \mathbf{i} + \left(-t^3 + 3t^2 + 12t \right) \mathbf{j}$$

At time T seconds, P is moving in a direction parallel to the vector $-\mathbf{i} - \mathbf{j}$

Find

(a) the value of T ,

(5)

(b) the magnitude of the acceleration of P at the instant when $t = T$.

(5)

(Total for Question 4 is 10 marks)

5.

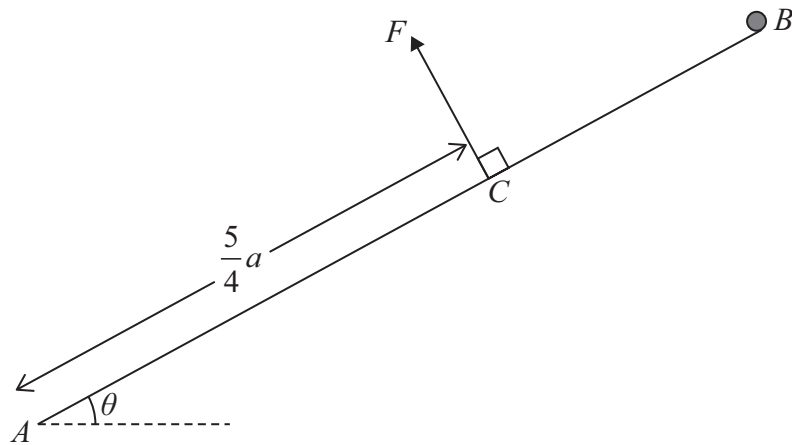


Figure 2

A uniform rod AB , of mass m and length $2a$, is freely hinged to a fixed point A .

A particle of mass km is fixed to the rod at B .

The rod is held in equilibrium, at an angle θ to the horizontal, by a force of magnitude F acting at the point C on the rod, where $AC = \frac{5}{4}a$, as shown in Figure 2.

The line of action of the force at C is at right angles to AB and is in the vertical plane containing AB .

Given that $\tan \theta = \frac{3}{4}$

(a) show that $F = \frac{16}{25}mg(1 + 2k)$ (4)

(b) find, in terms of m , g and k ,

(i) the horizontal component of the force exerted by the hinge on the rod at A ,

(ii) the vertical component of the force exerted by the hinge on the rod at A . (5)

Given also that the force acting on the rod at A acts at 45° above the horizontal,

(c) find the value of k . (3)

(Total for Question 5 is 12 marks)



6. Two particles A and B , of mass m and $2m$ respectively, are moving in the same direction along the same straight line on a smooth horizontal surface, with B in front of A .

Particle A has speed 3 m s^{-1} and particle B has speed 2 m s^{-1} .

Particle A collides directly with particle B .

The coefficient of restitution between A and B is $\frac{2}{3}$.

The direction of motion of both particles is **not** changed by the collision.

Immediately after the collision, A has speed $v \text{ m s}^{-1}$ and B has speed $w \text{ m s}^{-1}$.

(a) (i) Show that $w = \frac{23}{9}$

(ii) Find the value of v .

(7)

When A and B collide they are 3 m from a smooth vertical wall which is perpendicular to their direction of motion.

After the collision with A , particle B hits the wall and rebounds.

The coefficient of restitution between B and the wall is $\frac{1}{2}$

There is a second collision between A and B at a point d m from the wall.

(b) Find the value of d .

(7)

(Total for Question 6 is 14 marks)

7. [In this question, the unit vectors $\mathbf{i}$ and $\mathbf{j}$ are in a vertical plane, $\mathbf{i}$ being horizontal and $\mathbf{j}$ being vertically upwards.]

At time $t = 0$, a particle P is projected with velocity $(4\mathbf{i} + 9\mathbf{j})\text{ms}^{-1}$ from a fixed point O on horizontal ground.

The particle moves freely under gravity.

When P is at the point H on its path, P is at its greatest height above the ground.

- (a) Find the time taken by P to reach H . (2)

At the point A on its path, the position vector of P relative to O is $(k\mathbf{i} + k\mathbf{j})\text{m}$, where k is a positive constant.

- (b) Find the value of k . (4)

- (c) Find, in terms of k , the position vector of the other point on the path of P which is at the same vertical height above the ground as the point A . (3)

At time T seconds the particle is at the point B and is moving perpendicular to $(4\mathbf{i} + 9\mathbf{j})$

- (d) Find the value of T . (4)

(Total for Question 7 is 13 marks)

TOTAL FOR PAPER IS 75 MARKS



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Please check the examination details below before entering your candidate information

Candidate surname

Other names

Centre Number

Candidate Number

Pearson Edexcel International Advanced Level

Thursday 15 January 2026

Morning (Time: 1 hour 30 minutes)

Paper
reference

WME02/01A

Mathematics

**International Advanced Subsidiary/Advanced Level
Mechanics M2
Answer Book**

You must have:

Question paper (sent separately),
Mathematical Formulae and Statistical Tables (Yellow), calculator.

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Whenever a numerical value of g is required, take $g = 9.8 \text{ m s}^{-2}$ and give your answer to either 2 significant figures or 3 significant figures.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 7 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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Question 1

Write the answer to Question 1 on these 2 pages

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(Total for Question 1 is 8 marks)



Question 2

Write the answer to Question 2 on these 4 pages

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Question 2 continued

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(Total for Question 2 is 8 marks)



Question 3

Write the answer to Question 3 on these 4 pages

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Question 3 continued

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(Total for Question 3 is 10 marks)



Question 4

Write the answer to Question 4 on these 4 pages

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Question 4 continued

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(Total for Question 4 is 10 marks)



Question 5

Write the answer to Question 5 on these 4 pages

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Question 5 continued

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(Total for Question 5 is 12 marks)



Question 6

Write the answer to Question 6 on these 4 pages

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Question 6 continued

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(Total for Question 6 is 14 marks)



Question 7

Write the answer to Question 7 on these 5 pages

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Question 7 continued

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Question 7 continued

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(Total for Question 7 is 13 marks)

TOTAL FOR PAPER IS 75 MARKS



Please check the examination details below before entering your candidate information

Candidate surname		Other names	
Centre Number		Candidate Number	

Pearson Edexcel International Advanced Level

Thursday 15 January 2026

Morning (Time: 1 hour 30 minutes) Paper reference **WME02/01**

Mathematics

International Advanced Subsidiary/Advanced Level

Mechanics M2

You must have:
Mathematical Formulae and Statistical Tables (Yellow), calculator

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear.
- Answers without working may not gain full credit.
- Whenever a numerical value of g is required, take $g = 9.8 \text{ m s}^{-2}$, and give your answer to either 2 significant figures or 3 significant figures.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 7 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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1. A van of mass 1200 kg is moving **up** a straight road that is inclined at an angle θ to the horizontal, where $\sin \theta = \frac{1}{14}$

The engine of the van is working at a constant rate of 20 000 W.

The resistance to motion of the van from non-gravitational forces is modelled as a constant force of magnitude R newtons.

At the instant when the acceleration of the van is 0.75 m s^{-2} , the speed of the van is $\lambda \text{ m s}^{-1}$ and $R = 26\lambda$ where λ is a non-zero constant.

- (a) Show that $R = 260$

(4)

Later on, the van is moving **down** the same straight road. The model for the resistance to motion of the van still has magnitude 260 N.

The engine of the van is now working at a constant rate of P watts.

At the instant when the speed of the van is 12 m s^{-1} , the acceleration of the van is 1.8 m s^{-2}

- (b) Find the value of P

(4)



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Question 1 continued

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Question 1 continued

(Total for Question 1 is 8 marks)



2.

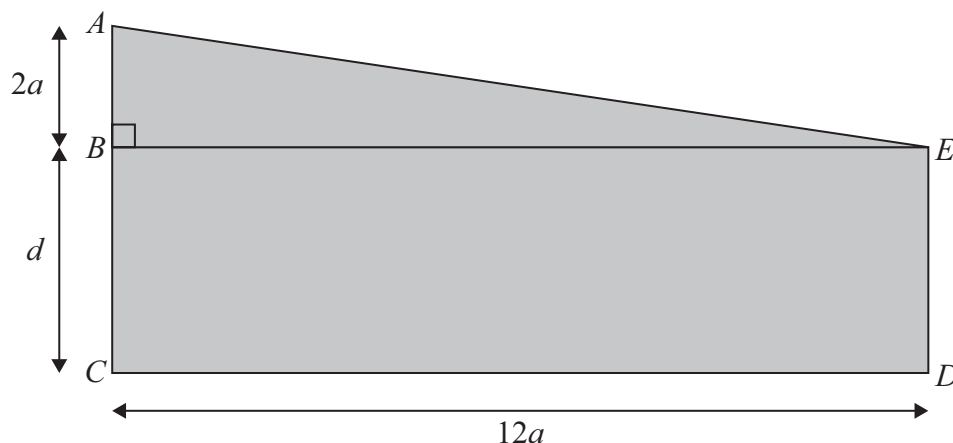


Figure 1

The uniform lamina $ABCDE$ shown shaded in Figure 1 is formed by joining a rectangle to a right-angled triangle.

The right-angled triangle ABE has $AB = 2a$ and $BE = 12a$

The rectangle $BCDE$ has $BE = CD = 12a$ and $BC = ED = d$

The distance of the centre of mass of the lamina from AC is $\bar{x}$

(a) Show that

$$\bar{x} = \frac{2a(2a + 3d)}{(a + d)} \quad (5)$$

The lamina has weight W .

A particle of weight $\frac{W}{2}$ is attached to the lamina at D .

The lamina is free to rotate in a vertical plane about a smooth horizontal axis through A . The axis is perpendicular to the plane of the lamina.

When a horizontal force of magnitude F is applied to the lamina at C towards D , the lamina rests in equilibrium with the line CD horizontal.

Given that $d = 4a$,

(b) find F in terms of W . (4)



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Question 2 continued

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Question 2 continued

Handwriting practice area with 20 horizontal lines.

(Total for Question 2 is 9 marks)



3.

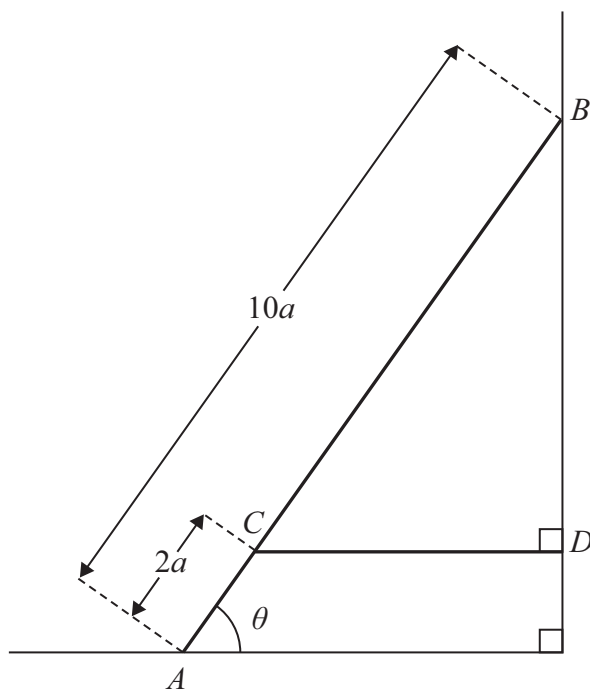


Figure 2

A uniform rod AB has mass m and length $10a$.

The end A is on smooth horizontal ground and the end B is against a smooth vertical wall.

To prevent the rod from slipping, one end of a light inextensible string is attached to the rod at the point C , where $AC = 2a$

The other end of the string is attached to the wall at the point D .

The string is parallel to the ground and in the same vertical plane as the rod.

The rod is in equilibrium in a vertical plane perpendicular to the wall.

The rod is inclined at an angle θ to the horizontal, as shown in Figure 2, where $0 < \theta < 90^\circ$

The tension in the string is T .

(a) Show that

$$\tan \theta = \frac{5mg}{8T}$$

(4)

A particle of mass $3m$ is now attached to a point E on the rod and the rod remains in equilibrium.

Given that the maximum tension in the string before breaking is $2mg$ and $\tan \theta = \frac{4}{3}$

(b) find the maximum distance AE .

(5)



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Question 3 continued

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Question 3 continued

Handwriting practice area with horizontal lines.

(Total for Question 3 is 9 marks)



4. [In this question $\mathbf{i}$ and $\mathbf{j}$ are perpendicular horizontal unit vectors and position vectors are given relative to a fixed point O .]

The velocity of a particle P at time t seconds, $t > 0$, is given by

$$\left[(6t - 25\sqrt{t} + 14)\mathbf{i} + (8t - 30\sqrt{t} + 7)\mathbf{j} \right] \text{ms}^{-1}$$

- (a) Find the value of t when P is at instantaneous rest. (3)

- (b) Find the value of t when the acceleration of P is perpendicular to $(2\mathbf{i} - \mathbf{j})$ (4)

When $t = 1$, P is at the point with position vector $\left(\frac{1}{3}\mathbf{i} - 7\mathbf{j}\right)\text{m}$.

- (c) Find the distance OP when $t = 4$ (6)



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Question 4 continued

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Question 4 continued

(Total for Question 4 is 13 marks)



5. At time $t = 0$, a stone S is projected from a point A on the top of a cliff.

The point A is 120 m above horizontal ground.

The stone S is projected with speed 25 m s^{-1} at an angle of 60° above the horizontal.

The stone S is modelled as a particle moving freely under gravity.

For the motion of S from A until it first hits the ground

- (a) find the maximum height above the ground reached by S , (4)
- (b) find the direction of motion of S when $t = 5$ seconds, (4)
- (c) find the length of time for which S is moving at a speed greater than 25 m s^{-1} (3)



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Question 5 continued

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Question 5 continued

(Total for Question 5 is 11 marks)



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Question 6 continued

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Question 6 continued

(Total for Question 6 is 12 marks)



7.

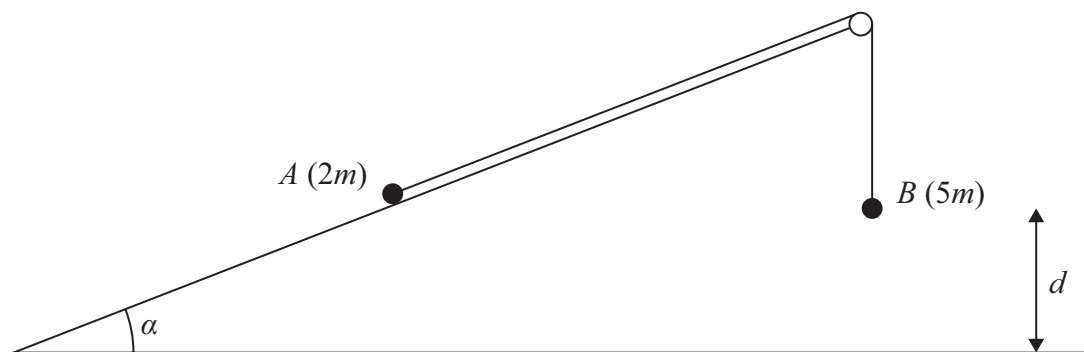


Figure 3

Figure 3 shows a rough plane inclined at an angle α to the horizontal, where $\tan \alpha = \frac{5}{12}$

The plane is fixed to horizontal ground.

A small smooth pulley is fixed at the top of the plane.

One end of a light inextensible string is attached to a particle A that is held at rest on the plane.

The string passes over the pulley and the other end of the string is attached to a particle B that hangs vertically below the pulley.

The string from A to the pulley lies along a line of greatest slope of the plane.

Particle A has mass $2m$ and particle B has mass $5m$.

The distance from B to the ground is d .

When the system is released from rest with the string taut, A begins to move up the plane and in the subsequent motion A never reaches the pulley.

The coefficient of friction between A and the plane is μ .

The work done against friction as A moves a distance d up the plane is $\frac{3mgd}{13}$

(a) Find the value of μ .

(4)

The speed of B as it hits the ground is V .

(b) Use the work-energy principle to find an expression for V^2 in terms of g and d .

(5)

(c) Find the speed of A when it has moved a **total** distance of $2d$ up the plane, giving your answer in terms of g and d .

(4)



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Question 7 continued

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Question 7 continued

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(Total for Question 7 is 13 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (Results)

January 2026

Pearson Edexcel International Advanced Level in
Mechanics M2
WME02/01

Edexcel and BTEC Qualifications

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January 2026

Question Paper Log Number P78913A

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN:

- bod – benefit of doubt
- ft – follow through
 - the symbol $\surd$ will be used for correct ft
- cao – correct answer only
- cso – correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC – special case
- oe – or equivalent (and appropriate)
- d... or dep – dependent
- indep – independent
- dp – decimal places
- sf – significant figures
- * – The answer is printed on the paper or ag- answer given

- $\square$ or d... – The second mark is dependent on gaining the first mark
4. All A marks are 'correct answer only' (cao), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.
 5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. If you are using the annotation facility on ePEN, indicate this action by 'MR' in the body of the script.
 6. If a candidate makes more than one attempt at any question:
 - a) If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - b) If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

Ignore wrong working or incorrect statements following a correct answer

General Principles for Mechanics Marking

(**N.B.** specific mark schemes may sometimes override these general principles)

- Rules for M marks:
 - correct number of terms
 - dimensionally correct
 - all terms that need resolving (i.e. *multiplied* by cos or sin) are resolved
 - only terms that need resolving are resolved
 - +/- errors are condoned
 - sin/cos confusion is condoned
- Omission or extra g in a resolution is an accuracy error not method error.
- Omission of mass from a resolution is a method error.
- Omission of a length from a moments equation is a method error.
- Omission of units or incorrect units is not (usually) counted as an accuracy error.
- DM indicates a dependent method mark, i.e. one that can only be awarded if a previous specified method mark(s) has been awarded.
- Any numerical answer which comes from use of $g = 9.8$ should be given as a decimal to 2 or 3 SF.
- Use of $g = 9.81$ should be penalised once per (complete) question.
 - N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *once* per complete question. However, premature approximation should be penalised every time it occurs.
- Marks must be entered in the same order as they appear on the mark scheme.
- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c)...then that working can only score marks for that part of the question.
- Accept column vectors in all cases.
- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft

Question number	Scheme	Marks
1		
1(a)	Use of $P = Fv$ $\left(D = \frac{20000}{\lambda} \right)$	M1
	Equation of motion $D - 1200g \sin \theta - 26\lambda = 1200a$	M1
	$\frac{20000}{\lambda} - 1200g \frac{1}{14} - 26\lambda = 1200(0.75)$ $(26\lambda^2 + 1740\lambda - 20000 = 0)$	A1
	$\lambda = 10 \Rightarrow R = 260^*$	A1*
		(4)
	ALTERNATIVE using R	
	Use of $P = Fv$ $\left(D = \frac{20000}{\lambda} \right)$ and $R = 26\lambda$ to give $D = \frac{20000}{\frac{R}{26}} = \frac{520000}{R}$	M1
	Equation of motion $D - 1200g \sin \theta - R = 1200a$	M1
	$\frac{520000}{R} - 1200g \times \frac{1}{14} - R = 1200a$ $(R^2 + 1740R - 520000 = 0)$	A1
	$R = 260^*$	A1*
1(b)	Equation of motion	M1
	$D' + 1200g \sin \theta - 260 = 1200(1.8)$	A1
	$\frac{P}{12} + \frac{1200g}{14} - 260 = 1200(1.8)$	A1
	$P = 19000$	A1
		(4)
		(8)

	Notes for question	
(a)		
M1	Use of $P = Fv$, $\left(D = \frac{20\,000}{\lambda} \right)$	
M1	Equation of motion. Dimensionally correct, correct number of terms, condone sin/cos confusion and sign errors. Trig and D do not need to be replaced. Allow R for 26λ	
A1	Correct unsimplified equation in λ only or λ and g .	
A1*	Given answer obtained from correct working. Must see $\lambda = 10$ A0 if $R = 260$ appears without seeing $\lambda = 10$	
	ALTERNATIVE	
M1	Use of $P = Fv$ and $R = 26\lambda$ to form expression for D .	
M1	Equation of motion. Dimensionally correct, correct number of terms, condone sin/cos confusion and sign errors. Trig and D do not need to be replaced	
A1	Correct unsimplified equation in R only or R and g .	
A1*	Correct answer obtained from correct working,	
(b)		
M1	Equation of motion. Dimensionally correct, correct number of terms, condone sin/cos confusion and sign errors.	
A1	A correct unsimplified equation of motion. Trig does not need to be replaced but does for final A mark.	
A1	Replace trig in equation of motion and use $\frac{P}{12}$ to produce a correct unsimplified equation in P only.	
A1	Correct answer, 2/3sf only. Accept $P = 19\,000$ only	

Question number	Scheme	Marks									
2											
2(a)	<table border="1"> <thead> <tr> <th></th><th>Mass ratio</th><th>Distance from AC</th></tr> </thead> <tbody> <tr> <td>Triangle</td><td>$12a^2$</td><td>$4a$</td></tr> <tr> <td>Rectangle</td><td>$12ad$</td><td>$6a$</td></tr> </tbody> </table>		Mass ratio	Distance from AC	Triangle	$12a^2$	$4a$	Rectangle	$12ad$	$6a$	B1 mass B1 dist
	Mass ratio	Distance from AC									
Triangle	$12a^2$	$4a$									
Rectangle	$12ad$	$6a$									
	Moments about AC or a parallel axis	M1									
	$(12a^2 \times 4a) + (12ad \times 6a) = (12a^2 + 12ad)\bar{x}$	A1									
	$\bar{x} = \frac{2a(2a + 3d)}{(a + d)} *$	A1*									
		(5)									
2(b)	$\bar{x} = \frac{28}{5}a$	B1									
	Moments equation about A	M1									
	$\left(W \times \frac{28}{5}a\right) + \left(\frac{W}{2} \times 12a\right) = F \times 6a$	A1									
	$F = \frac{29}{15}W$	A1									
		(4)									
		(9)									

	Notes for question	
(a)		
B1	Correct mass ratios	
B1	Correct distances from AC .	
M1	Moments taken about AC or a parallel axis. Dimensionally correct equation. All terms required.	
A1	Correct unsimplified equation. If mass ratios are simplified before taking moments: $4a^2 + 6ad = (a+d)\bar{x}$ Incorrect use of brackets will be penalised in final A mark.	
A1*	Correctly obtain given answer from completely correct working, including use of brackets. At least one stage of simplification must be seen in working. Final answer must be a correctly factorised fraction eg allow $(d+a)$ for $((a+d)$ etc	
(b)		
B1	$\bar{x} = \frac{28}{5}a$. This mark can be awarded for a correct substitution of $4a$ in to a $\bar{x} = \frac{2a(2a+3d)}{(a+d)}$. ISW subsequent working if incorrect result occurs.	
M1	Complete method to find an equation in F , W (and a) Dimensionally correct equation. All terms required. $d = 4a$ must be substituted.	
A1	Correct unsimplified equation.	
A1	Correct answer, accept $1.9W$ or better $1.9333..W$ accept $\frac{58}{30}W$	
	N.B. In part (b) If $d=4a$ is not used, then zero marks in this part.	

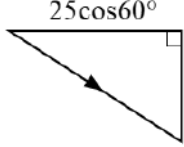
Question number	Scheme	Marks
3		
3(a)	$P = T$ or $R = mg$	B1
	Moments equation	M1
	E.g. $M(A) (P \times 10a \sin \theta) = (mg \times 5a \cos \theta) + (T \times 2a \sin \theta)$ with P and or R substituted	A1
	$\tan \theta = \frac{5mg}{8T} *$	A1*
		(4)
3(b)		
	$Q = 2mg$ or $R = 4mg$	B1
	Moments equation	M1
	e.g. $M(A) (Q \times 10a \sin \theta) = (3mg \times d \cos \theta) + (mg \times 5a \cos \theta) + (2mg \times 2a \sin \theta)$ Q and/or R do not need to be substituted for this mark but $T = 2mg$ does.	A1
	Q and/or R substituted to produce a correct equation in in d , a and (g) only	A1
	$d = 5.4a$ or $5.44a$ (m)	A1
		(5)
		(9)

	Notes for question NB for the moment equations in this question, ignore the stated centre of the moment and mark the equation.	
(a)		
B1	Resolves horizontally or vertically	
M1	A complete method to obtain an unsimplified equation in T , m , g and θ (allow a as well) Requires all terms and no extras. Dimensionally correct. Condone sign errors and sin/cos confusion. P and/or R must be substituted	
A1	Correct unsimplified equation in T , m , g and θ Other moments equations include: $[M(C)] \quad 2aR \cos \theta + 3amg \cos \theta = 8aP \sin \theta \Rightarrow 2mg + 3mg = 8aT \tan \theta$ $[M(G)] \quad 5aR \cos \theta = 5aP \sin \theta + 3aT \sin \theta$ $[M(B)] \quad 10aR \cos \theta = 5amg \cos \theta + 8aT \sin \theta$ $[M(D)] \quad 8aP \sin \theta + 5amg \cos \theta = 10R \cos \theta$ $[M(\text{corner})] \quad 10aR \cos \theta + 2aT \sin \theta = 5amg \cos \theta + 10aP \sin \theta$ $[M(PR \text{ intersect})] \quad 8aT \sin \theta = 5amg \cos \theta$	
A1*	Obtain given answer from correct working.	
(b)	N.B. In part (b), allow use of inequalities for first 4 marks but must have equality for final A mark	
B1	Resolves horizontally or vertically or parallel or perpendicular to rod. Parallel: $R \sin \theta + 2mg \sin \theta = mg \sin \theta + 3mg \sin \theta + Q \cos \theta$ Perp: $Q \sin \theta + R \cos \theta = 2mg \sin \theta + mg \cos \theta + 3mg \cos \theta$	
M1	Form a moments equation. Requires all terms and no extras. Dimensionally correct. Condone sign errors and sin/cos confusion. $T=2mg$ (and $W=mg$) must be used for M mark. May be seen later. Other relevant equations include: $[M(C)] \quad 2aR \cos \theta + 3amg \cos \theta + 3mg(d-2a) \cos \theta = 8aQ \sin \theta$ $[M(G)] \quad 5aR \cos \theta + 3mg(d-5a) \cos \theta = 2mg3a \sin \theta + 5Qa \sin \theta$ $[M(E)] \quad dR \cos \theta = 2mg(d-2a) \sin \theta + mg(d-5a) \cos \theta + Q(10a-d) \sin \theta$ $[M(B)] \quad 3mg \times (10a-d) \cos \theta + mg \times 5a \cos \theta + 2mg \times 8a \sin \theta = R \times 10a \cos \theta$ $[M(D)] \quad 10aR \cos \theta + 8Qa \sin \theta = 5amg \cos \theta + 3mg(10a-d) \cos \theta$ $[M(\text{corner})] \quad 10aR \cos \theta + 2mg2a \sin \theta = 5amg \cos \theta + 3mg(10a-d) \cos \theta + 10aQ \sin \theta$ $[M(PR \text{ intersect})] \quad 8a \times 2mg \sin \theta = 5amg \cos \theta + 3mgd \cos \theta$	
A1	Correct equation with at most one error, allow Q and R but T must be substituted.	
A1	Correct equation in d , a and (g) only ie Q and/or R must be substituted.	
A1	Correct answer. Accept $5.4a$ or better, exact answer is $\frac{49}{9}a$, $5.444\dots a$	

Question number	Scheme	Marks
4	Accept column vectors throughout the question	
4(a)	Solves at least one of $14 + 6t - 25\sqrt{t} = 0$ $7 + 8t - 30\sqrt{t} = 0$	M1
	Find $t = \frac{49}{4}$ from at least one equation	A1
	Both equations used to conclude $t = \frac{49}{4}$ only	A1
		(3)
4(b)	Differentiates both components	M1
	$\mathbf{a} = \left(6 - \frac{25}{2}t^{-\frac{1}{2}}\right)\mathbf{i} + \left(8 - 15t^{-\frac{1}{2}}\right)\mathbf{j}$	A1
	Use of components to form a relevant equation in t . Scalar product gives: $\begin{pmatrix} 6 - \frac{25}{2}t^{-\frac{1}{2}} \\ 8 - 15t^{-\frac{1}{2}} \end{pmatrix} \cdot \begin{pmatrix} 2 \\ -1 \end{pmatrix} = 0$ $\Rightarrow 2\left(6 - \frac{25}{2}t^{-\frac{1}{2}}\right) - \left(8 - 15t^{-\frac{1}{2}}\right) = 0$	M1
	$t = 6.25$	A1
		(4)
4(c)	Integrates both components	M1
	$\mathbf{s} = \left(14t + 3t^2 - \frac{50}{3}t^{\frac{3}{2}}\right)\mathbf{i} + \left(7t + 4t^2 - 20t^{\frac{3}{2}}\right)\mathbf{j} \quad (+ \text{ constant vector})$	A1
	Use $t = 1$ and $\mathbf{s} = \frac{1}{3}\mathbf{i} - 7\mathbf{j}$ to find	M1
	$\mathbf{s} = \left(14t + 3t^2 - \frac{50}{3}t^{\frac{3}{2}}\right)\mathbf{i} + \left(7t + 4t^2 - 20t^{\frac{3}{2}} + 2\right)\mathbf{j}$	A1
	Complete method to find OP $\sqrt{\left(14(4) + 3(4)^2 - \frac{50}{3}(4)^{\frac{3}{2}}\right)^2 + \left(7(4) + 4(4)^2 - 20(4)^{\frac{3}{2}} + 2\right)^2}$	M1
	$OP = 72$ or better	A1
		(6)

(c) ALT 1	Last 4 marks in (c) using definite integration	
	Use of correct limits in integrated expression to find displacement, $1 \leq t \leq 4$	M1
	$\left[\left(14t + 3t^2 - \frac{50}{3}t^{\frac{3}{2}} \right) \mathbf{i} + \left(7t + 4t^2 - 20t^{\frac{3}{2}} \right) \mathbf{j} \right]_1^4 = -\frac{89}{3} \mathbf{i} - 59 \mathbf{j}$	A1
	Complete method to find OP	M1
	$OP = \sqrt{\left(-\frac{88}{3}\right)^2 + (-66)^2}$	
	$OP = 72$ or better	A1
		(6)
		(13)
	Notes for question	
(a)		
M1	Solves for t or $\sqrt{t}$ in either i or j component equal to zero.	
A1	Find $t = \frac{49}{4}$ from at least one equation. Using i components: $t = \frac{49}{4}$ (and $\frac{4}{9}$) or Using j components, $t = \frac{49}{4}$ (and $\frac{1}{16}$) N.B. Equating components is M0 Adding components and equating to 0 is M0	
A1	Uses both equations to conclude $t = \frac{49}{4}$ (only). May solve both equations or solve one and using verification.	
	Special case	
	Find magnitude of vector and equate to zero and solve for t	M1
	Find $t = \frac{49}{4}$ as one possible solution	A1
	For final A mark must obtain correct value of t and dismiss other cases. Equation $100P^4 - 780P^3 + 1805P^2 - 1120P + 245 = 0$ Where $P = \sqrt{t} \Rightarrow P = \frac{7}{2}, t = \frac{49}{4}$	A1

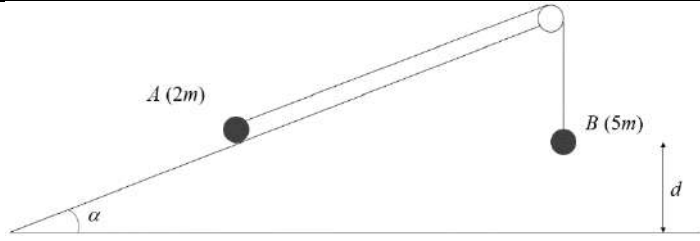
(b)		
M1	Differentiates both components of v . In each component, at least one power must decrease by 1.	
A1	Correct expression for acceleration, seen or implied.	
M1	Use the components of acceleration to form a relevant equation in t only. May use the parallel vector $\mathbf{i} + 2\mathbf{j}$ to form an equation in t $\frac{\left(6 - \frac{25}{2}t^{-\frac{1}{2}}\right)}{8 - 15t^{-\frac{1}{2}}} = \frac{1}{2} \text{ or }$ only. For example, $\left(6 - \frac{25}{2}t^{-\frac{1}{2}}\right)\mathbf{i} + \left(8 - 15t^{-\frac{1}{2}}\right)\mathbf{j} = \lambda(\mathbf{i} + 2\mathbf{j})$ to form simultaneous equations with λ eliminated. Must be correct ratio M0 if using $-\frac{1}{2}, \frac{2}{1}$ or $\lambda(\mathbf{i} - 2\mathbf{j})$	
A1	Correct answer, accept 6.3	
(c)		
M1	Integrates both components of v . In each component, at least one power must increase by 1.	
A1	Correct unsimplified expression. Allow with no constant(s) of integration.	
M1	Use $t = 1$ and $s = \frac{1}{3}\mathbf{i} - 7\mathbf{j}$, to find an expression for position.	
A1	Correct expression for position at time, t .	
M1	Use $t = 4$ and Pythagoras to find the distance OP. Must use an expression that has come from an attempt to integrate v M0 if they find $\sqrt{\left(-\frac{89}{3}\right)^2 + 59^2}$	
A1	Correct answer, accept 72 or better 72.2249..., Accept $\frac{22\sqrt{97}}{3}$	

Question number	Scheme	Marks
5		
5(a)	Method to find a relevant vertical displacement	M1
	Eg • Single <i>suvat</i> equation $0 = (25 \sin 60^\circ)^2 + 2(-g)h$ • Conservation of energy: $\frac{1}{2}m(25)^2 - \frac{1}{2}m(25 \cos 60^\circ)^2 = mgh$	A1
	$h = \frac{1875}{8g}$ (23. 9158..)	A1
	Max height = 144 or 140 (m)	A1
		(4)
5(b)	Horizontal component of velocity = $25 \cos 60^\circ$	B1
	Method to find vertical component of velocity when $t = 5$ s $v = 25 \sin 60^\circ - 5g$	M1
	Use of trig to find relevant angle Eg $\tan^{-1}\left(\frac{\text{their } v}{25 \cos 60^\circ}\right)$ or inverse	M1
	 65° below the horizontal or 25° to downward vertical. Direction can be implied from diagram	A1
		(4)
5(c)	Complete method to find the required length of time	M1
	$120 = (25 \sin 60^\circ)t + \frac{1}{2}gt^2$	A1
	3.2 or 3.21 (s)	A1
		(3)
		(11)

	Notes for question	
(a)		
M1	Complete method to find a relevant vertical displacement using <i>suvat</i> or conservation of energy. Requires all terms and no extras. Condone sign errors and sin/cos confusion.	
A1	Correct unsimplified equation(s) in relevant vertical displacement only.	
A1	Correct relevant vertical displacement.	
A1	Correct required height, 2/3sf.	
(b)		
B1	Correct horizontal component of speed. May be seen on a diagram.	
M1	Complete method to find the vertical component of speed $t = 5$. Requires all terms and no extras. Condone sign errors and sin/cos confusion.	
M1	Complete method to find the direction of motion when $t = 5$.	
A1	Correct direction. Accept 65° or 65.4° and below the horizontal oe, accept if clear from a diagram. Accept 65.4° to horizontal, 155° to vertical etc with diagram A0 for 155° or 15.4° without diagram A0 for -65.4° or 65.4° above horizontal	
(c)		
M1	Complete method to find the required length of time using <i>suvat</i> . Requires all terms and no extras. Condone sign errors and sin/cos confusion. Method may use more than one <i>suvat</i> equation. Eg Time to <i>B</i> – Time taken to be level with <i>A</i> FYI: Time from <i>A</i> to ground = 7.62871 s Time from <i>A</i> to top = 2.2092 s Time from <i>A</i> back to same level = $2(2.2092) = 4.41849$ s NB Candidates who only look at $ v > 25$ will get $t > 4.418$, but for full method need to consider total length of flight (7.62.) and then find difference.	
A1	Correct unsimplified equation(s) in required time only.	
A1	Correct answer and no others, 2/3sf	

Question number	Scheme	Marks
6		
6(a)	Equation for CLM	M1
	$5m(3u) = 5mv + 3mw$ or $5m(3u) = -5mv + 3mw$	A1
	Use of impact law	M1
	$3ue = w - v$ or $3ue = w + v$	A1
	$\frac{15u}{8}(1+e)$ *	A1*
		(5)
6(b)	Velocity of P after collision, (to the right.) $v = \frac{3u}{8}(5-3e)$	M1
	$(5-3e) > 0 \Rightarrow \frac{3u}{8}(5-3e) > 0$	A1
	Uses $(0 <) e \leq 1$ to determine direction of P , compares with direction of Q and concludes correctly*	A1*
NB: Possible max scores for last two A marks in (b) - If $(0 <) e \leq 1$ seen followed by both positive, then A1A1 - If $(0 <) e < 1$ seen followed by both positive, then A1A0 - If $e_{\max} = 1$ seen followed by $v = \frac{3}{4}u > 0$, then A1A1 - If $e = 1$ only seen followed by both positive then, A1A0 - If $e = 1$ and $e = 0$ used, then A1A0 - If $e = 1$ and $e = 0$ used and $(0 <) e \leq 1$ seen, then A1A1 - If v_P and v_Q found then states $v_P > 0$, $v_Q > 0$ with no reference to e values, then A0A0		
		(3)
6(c)	Rebound speed of Q $\frac{15u}{16}(1+e)$	B1
	Use of impulse - momentum	M1
	$\frac{45mu}{4} = 3m \left(\frac{15u}{16}(1+e) - -\frac{15u}{8}(1+e) \right)$	A1ft
	$e = \frac{1}{3}$	A1
		(4)
		(12)

	Notes for question	
(a)		
M1	Equation for CLM. Dimensionally correct, all terms required. Condone sign errors. Mass and velocity paired correctly.	
A1	Correct unsimplified equation, accept $\pm v$	
M1	Use of impact law. Condone sign errors but must be used the right way round.	
A1	Correct unsimplified equation, sign of v consistent with CLM.	
A1*	Obtain given answer from correct working. Must be in factorised fraction form, allow equivalent factorised forms. Must be at least one line of working after equations with preferably an equation in w only	
(b)		
M1	Method to find the velocity of P after the collision.	
A1	Correct deduction without justification. Allow $(3e-5) < 0$ followed by $e < \frac{5}{3}$ Use $e = 1$, or 'better' to show that $v_p > 0$	
A1*	Correct justification i.e. uses $(0 <) e \leq 1$, compares with direction of Q and concludes correctly. Fully correct answer using either $e_{\max} = 1$ or $e \leq 1$, to show that $v_p > 0$ [and $e > 0$ to show that $v_Q > 0$] A0 If uses $(0 <) e < 1$	
(c)		
B1	Correct rebound speed of Q after the collision with the wall, in terms of e and u allow $\pm$	
M1	Impulse-momentum equation using result from (a) and rebound speed of Q . May not replace w until later in working eg $\frac{45mu}{4} = 3m \left(w - -\frac{w}{2} \right)$ w must be substituted for this M mark. Candidates could solve for $w = \frac{5}{2}u$ and then equate this to w $\frac{5}{2}u = \frac{15u}{8}(1+e)$	
A1ft	Correct unsimplified equation in e (m and u). Follow their rebound speed of Q .	
A1	Correct answer. Allow 0.33 or better. Note that calculators can solve the equation so there may be little evidence of working out.	

Question number	Scheme	Marks
7		
7(a)	$F = \mu 2mg \cos \alpha$	M1
	Use of WD to give an equation in μ	M1
	$\frac{3mgd}{13} = \mu(2mg \cos \alpha) \times d$	A1
	$\mu = \frac{1}{8}$	A1
		(4)
7(b)	At least one correct KE term $\frac{1}{2}(2m)V^2 \quad \frac{1}{2}(5m)V^2$	B1
	At least one correct GPE term $5mgd \quad 2mgd \sin \alpha$	B1
	Work-energy equation	M1
	$\frac{3mgd}{13} = (5m)gd - (2m)gd \sin \alpha - \frac{1}{2}(2m)V^2 - \frac{1}{2}(5m)V^2$	A1
	$V^2 = \frac{8gd}{7}$	A1
		(5)
7(c)	Method 1: Work-energy equation for A to move the further distance, d to form an equation in w , d , g (with their V substituted).	M1
	$\left(\frac{3mgd}{13} = \frac{1}{2}(2m)V^2 - \frac{1}{2}(2m)w^2 - (2m)gd \sin \alpha \right)$ $\frac{3mgd}{13} = \frac{1}{2}(2m)\frac{8gd}{7} - \frac{1}{2}(2m)w^2 - (2m)gd \sin \alpha$ SC for these two A marks: uses work energy from start to end to give: $5mgd = 2\left(\frac{3mgd}{13}\right) + (2mg)2d \sin \alpha + \frac{1}{2}(2m)w^2 + \frac{1}{2}(5m)\frac{8gd}{7}$	A1 A1
	$w = \sqrt{\frac{gd}{7}}$	A1
		(4)

7(c)	Method 2: Use $F=ma$ up the plane to find new acceleration and then apply <i>suvat</i> for second part of motion to form an equation in w, d, g (with their V substituted). $-F - 2mg \sin \alpha = 2ma'$ leads to $a' = -\frac{g}{2}$ And then apply " $v^2 = u^2 + 2as$ " to get	M1
	$w^2 = V^2 - 2 \times \frac{g}{2} \times d \Rightarrow w^2 = \frac{8gd}{7} - 2 \times \frac{g}{2} \times d$	A1A1
	$w = \sqrt{\frac{gd}{7}}$	A1
		(13)
	Notes for question	
(a) M1	Use $F = \mu R$ with $R = 2mg \cos \alpha$ Condone sin/cos confusion.	
M1	Use work-done to form an equation in μ . R must be in the form $kmg \cos \alpha$ or $kmg \sin \alpha$ Dimensionally correct, all terms required and no extras. Condone sign errors and sin/cos confusion. d 's may have been cancelled	
A1	Correct unsimplified equation.	
A1	Correct μ . Accept 0.13, 0.125, $\frac{1}{8}$	
(b) B1	At least one correct KE term	
B1	At least one correct GPE term	
M1	Use work-energy to form an equation for A and B . Dimensionally correct, all terms required and no extras. Condone sign errors and sin/cos confusion. Correct mass-speed pairings used.	
A1	Correct unsimplified equation	
A1	Correct expression for V^2 Accept $1.1gd$ or better. Answer must be in terms of g and d	
(c) M1	Complete method to form an equation in w, d, g (their V must be substituted) Method 1: Use work-energy to form an equation for A moving a distance d . Dimensionally correct, all terms required and no extras. Condone sign errors and sin/cos confusion. Correct mass-speed pairings used Method 2: Use N2L for new acceleration and <i>suvat</i> to find w SC: Use work-energy to form an equation for A moving a distance $2d$. Dimensionally correct, all terms required and no extras. Condone sign errors and sin/cos confusion. Correct mass-speed pairings used	
A1	Unsimplified equation with at most one error. Allow their V (substituted) for this mark. Trig does not need substituting.	
A1	Correct unsimplified equation. Trig does not need substituting. Maybe implied by final answer.	
A1	Correct expression. Accept $0.38\sqrt{gd}$ or better. Answer must be in terms of g and d	

Pearson Edexcel International Advanced Level

Wednesday 21 January 2026

Morning (Time: 1 hour 30 minutes)

**Paper
reference**

WME03/01A

Mathematics

International Advanced Subsidiary/Advanced Level

Mechanics M3

Question Paper

You must have:

Answer Book (sent separately).

Mathematical Formulae and Statistical Tables (Yellow), calculator.

Turn over ►

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1. A particle P of mass 0.5 kg moves along the positive x -axis under the action of a single force of magnitude F newtons.

The force acts along the x -axis in the direction of x increasing.

When P is x metres from the origin O , it is moving away from O with

speed $\sqrt{\left(8x^{\frac{3}{2}} - 4\right)}\text{ m s}^{-1}$

Find F when P is 4 m from O .

(5)

(Total for Question 1 is 5 marks)



2. A spacecraft S of mass m moves in a straight line towards the centre of the Earth.

The Earth is modelled as a sphere of radius R and S is modelled as a particle.

When S is at a distance x , $x \geq R$, from the centre of the Earth, the force exerted by the Earth on S is directed towards the centre of the Earth.

The force has magnitude $\frac{K}{x^2}$, where K is a constant.

- (a) Show that $K = mgR^2$ (2)

When S is at a distance $3R$ from the centre of the Earth, the speed of S is V .

Assuming that air resistance can be ignored,

- (b) find, in terms of g , R and V , the speed of S as it hits the surface of the Earth. (7)

(Total for Question 2 is 9 marks)

3. A particle P is moving in a straight line with simple harmonic motion about the fixed point O as centre.

When P is a distance 0.02 m from O , the speed of P is 0.3 m s^{-1} and the magnitude of the acceleration of P is 0.5 m s^{-2}

- (a) Find the period of the motion.

(4)

The amplitude of the motion is a metres.

Find

- (b) the value of a ,

(3)

- (c) the total length of time during each complete oscillation for which P is within $\frac{1}{2}a$ metres of O .

(4)

(Total for Question 3 is 11 marks)



4. A light elastic string has natural length 5 m and modulus of elasticity 20 N.

The ends of the string are attached to two fixed points A and B , which are 6 m apart on a horizontal ceiling.

A particle P is attached to the midpoint of the string and hangs in equilibrium at a point which is 4 m below AB .

- (a) Calculate the weight of P .

(6)

The particle is now raised to the midpoint of AB and released from rest.

- (b) Calculate the speed of P when it has fallen 4 m.

(5)

(Total for Question 4 is 11 marks)

5.

**In this question you must show all stages of your working.
Solutions relying on calculator technology are not acceptable.**

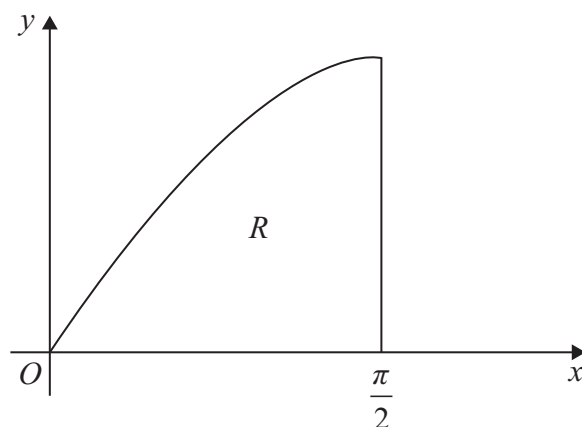


Figure 1

Figure 1 shows the finite region R which is bounded by part of the curve with equation $y = \sin x$, the x -axis and the line with equation $x = \frac{\pi}{2}$

A uniform solid S is formed by rotating R through 2π radians about the x -axis.

Using algebraic integration,

(a) show that the volume of S is $\frac{\pi^2}{4}$ (4)

(b) find, in terms of π , the x coordinate of the centre of mass of S . (7)

(Total for Question 5 is 11 marks)

- 6 The path followed by a motorcycle round a circular racetrack is modelled as a horizontal circle of radius 50 m. The track is banked at an angle θ to the horizontal, where $\sin \theta = \frac{3}{5}$. The motorcycle travels round the track at constant speed.

The motorcycle is modelled as a particle and air resistance can be ignored.

In an initial model it is assumed that there is no sideways friction between the motorcycle tyres and the track.

Using this model,

- (a) find the speed, in ms^{-1} , of the motorcycle.

(5)

In a refined model it is assumed that there is sideways friction.

The coefficient of friction between the motorcycle tyres and the track is $\frac{1}{4}$.

It is still assumed that air resistance can be ignored and that the motorcycle is modelled as a particle.

The motorcycle's path is unchanged.

Using this model,

- (b) find the maximum speed, in ms^{-1} , at which the motorcycle can travel without slipping sideways.

(8)

(Total for Question 6 is 13 marks)

7.

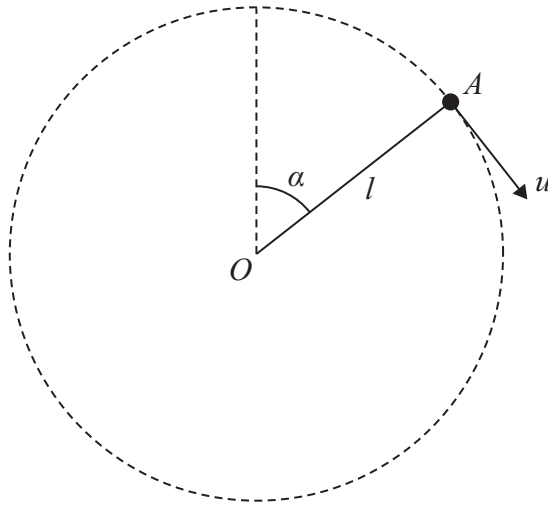


Figure 2

A particle of mass m is attached to one end of a light rod of length l . The other end of the rod is attached to a fixed point O . The rod can turn freely in a vertical plane about a horizontal axis through O .

The particle is projected with speed u from a point A , where OA makes an angle α with the upward vertical through O , as shown in Figure 2.

The particle moves in complete vertical circles.

Given that $\cos \alpha = \frac{4}{5}$

(a) show that $u > \sqrt{\frac{2gl}{5}}$ (4)

As the rod rotates, the least tension in the rod is T and the greatest tension is $4T$.

(b) Show that $u = \sqrt{\frac{17}{5}gl}$ (11)

(Total for Question 7 is 15 marks)

TOTAL FOR PAPER IS 75 MARKS



Please check the examination details below before entering your candidate information

Candidate surname

Other names

Centre Number

Candidate Number

Pearson Edexcel International Advanced Level

Wednesday 21 January 2026

Morning (Time: 1 hour 30 minutes)

Paper

reference

WME03/01A

Mathematics

International Advanced Subsidiary/Advanced Level

Mechanics M3

Answer Book

You must have:

Question paper (sent separately),

Mathematical Formulae and Statistical Tables (Yellow), calculator.

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Whenever a numerical value of g is required, take $g = 9.8 \text{ m s}^{-2}$ and give your answer to either 2 significant figures or 3 significant figures.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 7 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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Question 1

Write the answer to Question 1 on these 2 pages

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(Total for Question 1 is 5 marks)



Question 2

Write the answer to Question 2 on these 4 pages

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA



Question 2 continued

DO NOT WRITE IN THIS AREA

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DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(Total for Question 2 is 9 marks)



Question 3

Write the answer to Question 3 on these 4 pages

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DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA



Question 3 continued

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DO NOT WRITE IN THIS AREA

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(Total for Question 3 is 11 marks)



Question 4

Write the answer to Question 4 on these 4 pages

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DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA



Question 4 continued

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DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(Total for Question 4 is 11 marks)



Question 5

Write the answer to Question 5 on these 4 pages

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DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA



P 8 7 6 4 4 A 0 1 7 2 8

Question 5 continued

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DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(Total for Question 5 is 11 marks)



Question 6

Write the answer to Question 6 on these 4 pages

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DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA



Question 6 continued

DO NOT WRITE IN THIS AREA

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DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



Question 7

Write the answer to Question 7 on these 5 pages

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DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA



Question 7 continued

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA



Question 7 continued

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(Total for Question 7 is 15 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (Final)

January 2026

Pearson Edexcel International Advanced Level
In Mechanics M3 (WME03) Paper 01A

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January 2026

Question Paper Log Number P87599A

Publication Code WME03_01A_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)
 - Marks should not be subdivided.
3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN.

 - bod – benefit of doubt
 - ft – follow through
 - the symbol $\checkmark$ will be used for correct ft
 - cao – correct answer only
 - cso – correct solution only. There must be no errors in this part of the question to obtain this mark
 - isw – ignore subsequent working
 - awrt – answers which round to
 - SC: special case
 - oe – or equivalent (and appropriate)
 - d... or dep – dependent
 - indep – independent
 - dp decimal places
 - sf significant figures
 - * The answer is printed on the paper or ag- answer given
 - $\square$ or d... The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.
5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. If you are using the annotation facility on ePEN, indicate this action by 'MR' in the body of the script.
6. If a candidate makes more than one attempt at any question:
 - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
7. Ignore wrong working or incorrect statements following a correct answer.

General Principles for Mechanics Marking

(**N.B.** specific mark schemes may sometimes override these general principles)

- Rules for M marks:
 - correct number of terms
 - dimensionally correct
 - all terms that need resolving (i.e. *multiplied* by cos or sin) are resolved
 - only terms that need resolving are resolved
 - +/– errors are condoned
 - sin/cos confusion is condoned
- Omission or extra g in a resolution is an accuracy error not method error.
- Omission of mass from a resolution is a method error.
- Omission of a length from a moments equation is a method error.
- Omission of units or incorrect units is not (usually) counted as an accuracy error.
- DM indicates a dependent method mark, i.e. one that can only be awarded if a previous specified method mark(s) has been awarded.
- Any numerical answer which comes from use of $g = 9.8$ should be given as a decimal to 2 or 3 SF.
- Use of $g = 9.81$ should be penalised once per (complete) question.
 - N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *once* per complete question. However, premature approximation should be penalised every time it occurs.
- Marks must be entered in the same order as they appear on the mark scheme.
- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c)...then that working can only score marks for that part of the question.
- Accept column vectors in all cases.
- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft

1. A particle P of mass 0.5 kg moves along the positive x -axis under the action of a single force of magnitude F newtons.

The force acts along the x -axis in the direction of x increasing.

When P is x metres from the origin O , it is moving away from O with

speed $\sqrt{\left(8x^{\frac{3}{2}} - 4\right)} \text{ m s}^{-1}$

Find F when P is 4 m from O .

(5)

(Total for Question 1 is 5 marks)

Question Number	Scheme			Marks
1	A complete method to find acceleration by differentiating v or v^2			M1
	Method 1 $v^2 = 8x^{\frac{3}{2}} - 4$ $2v \frac{dv}{dx} = 12x^{\frac{1}{2}}$ $v \frac{dv}{dx} = 6x^{\frac{1}{2}}$	Method 2 $\frac{dv}{dx} = \frac{1}{2} \left(8x^{\frac{3}{2}} - 4 \right)^{-\frac{1}{2}} \times 12x^{\frac{1}{2}}$ $v \frac{dv}{dx} = \frac{1}{2} \times 12x^{\frac{1}{2}}$	Method 3 $\frac{dv}{dt} = \frac{1}{2} \left(8x^{\frac{3}{2}} - 4 \right)^{-\frac{1}{2}} \times 12x^{\frac{1}{2}} \times \frac{dx}{dt}$ $\frac{dv}{dt} = \frac{1}{2} \left(8x^{\frac{3}{2}} - 4 \right)^{-\frac{1}{2}} \times 12x^{\frac{1}{2}} \times \left(8x^{\frac{3}{2}} - 4 \right)^{\frac{1}{2}}$	A1 A1
	$F = 0.5 \times 6x^{\frac{1}{2}} = 3x^{\frac{1}{2}}$			DM1
	$x = 4 \Rightarrow F = 6$			A1
				(5)
	(5 marks)			
Notes				
M1	Complete method to find acceleration by differentiating in terms of x Must use correct form of acceleration (E.g. $\frac{dv}{dt} = \frac{1}{2} \left(8x^{\frac{3}{2}} - 4 \right)^{-\frac{1}{2}} \times 12x^{\frac{1}{2}}$ is M0)			
A1	Differentiation of their method with at most one numerical error (E.g. fraction or sign error)			
A1	Correct acceleration i.e. correct derivative used or for example “acceleration =” Could be implied by correct value used in $F = ma$			
DM1	Use of $F = 0.5a$ to obtain an expression in terms of x (seen or implied). Dependent on first M1.			
A1	Cao			

2. A spacecraft S of mass m moves in a straight line towards the centre of the Earth.

The Earth is modelled as a sphere of radius R and S is modelled as a particle.

When S is at a distance x , $x \geq R$, from the centre of the Earth, the force exerted by the Earth on S is directed towards the centre of the Earth.

The force has magnitude $\frac{K}{x^2}$, where K is a constant.

- (a) Show that $K = mgR^2$ (2)

When S is at a distance $3R$ from the centre of the Earth, the speed of S is V .

Assuming that air resistance can be ignored,

- (b) find, in terms of g , R and V , the speed of S as it hits the surface of the Earth. (7)

(Total for Question 2 is 9 marks)

Question Number	Scheme	Marks
2(a)	$mg = \frac{K}{R^2}$	M1
	$K = mgR^2$ *	A1*
		(2)
(b)	Equation of motion: $\frac{mgR^2}{x^2} = -mv \frac{dv}{dx}$	M1
	Integrate: $g \int \frac{R^2}{x^2} dx = - \int v dv$	DM1
	$-g \frac{R^2}{x} = -\frac{1}{2} v^2 (+c)$	A1ft
	Initial conditions: $x = 3R, v = V \Rightarrow -g \frac{R^2}{3R} = -\frac{1}{2} V^2 + c$	M1
	$c = -\frac{Rg}{3} + \frac{1}{2} V^2$	A1
	$\frac{1}{2} v^2 = -\frac{Rg}{3} + \frac{1}{2} V^2 + g \frac{R^2}{R}$	M1
	$v = \sqrt{V^2 + \frac{4Rg}{3}}$	A1
		(7)
(9 marks)		
Notes		
(a) M1	Sets “ F ” = mg and $x = R$	
A1*	Deduces given answer from correct working only with no errors seen. Do not allow recovery from an erroneous negative sign. Condone e.g. $F = mg = \frac{K}{x^2}$ followed by $mg = \frac{K}{R^2}$ Allow use of $F = \frac{GMm}{x^2}$ with $x = R$ and $F = mg$ as part of correct working.	
(b) M1	Attempts equation of motion with acceleration in the form $v \frac{dv}{dx}$. Allow without minus sign.	
DM1	Separates the variables and attempts to integrate. Dependent on first M1.	
A1ft	Correct integration but ft missing minus sign. Condone missing constant of integration.	
M1	Substitutes $x = 3R, v = V$ to form an equation for c .	
A1	Correct expression for c seen or implied or $3R$ and V correctly substituted	
M1	Substitute $x = R$ and find expression for v or v^2 .	
A1	cao	

Alt (b) M1	Attempts equation of motion with acceleration in the form $v \frac{dv}{dx}$. Allow without minus sign.
DM1	Separates the variables and attempts to integrate. Dependent on first M1.
A1ft	Correct integration but ft missing minus sign.
M1	Definite integration with limits $3R$ and R , V and “ v ” $\left[g \frac{R^2}{x} \right]_{3R}^R = \left[\frac{1}{2} v^2 \right]_V^v \Rightarrow \left[gR - \frac{gR}{3} \right] = \left[\frac{1}{2} v^2 - \frac{1}{2} V^2 \right]$
A1	Correct substitution of $3R$ and V seen or implied
M1	Substitute $x = R$ and find expression for v or v^2 .
A1	Cao

Alt (b) M1	Forms work-energy equation. Allow without minus sign.
DM1	$\frac{1}{2}mv^2 - \frac{1}{2}mV^2 = - \int_{3R}^R \frac{mgR^2}{x^2} dx.$
A1ft	Correct integration $\frac{1}{2}v^2 - \frac{1}{2}V^2 = \left[\frac{gR^2}{x} \right]_{3R}^R$
M1	Definite integration with $3R$ and R correct way round
A1	Correct substitution of $3R$ seen or implied and k.e. right way round
M1	Substitute $x = R$ and find expression for v or v^2 . $\frac{1}{2}v^2 = \frac{1}{2}V^2 + \frac{gR^2}{R} - \frac{gR^2}{3R}$
A1	cao

3. A particle P is moving in a straight line with simple harmonic motion about the fixed point O as centre.

When P is a distance 0.02 m from O , the speed of P is 0.3 m s^{-1} and the magnitude of the acceleration of P is 0.5 m s^{-2}

- (a) Find the period of the motion.

(4)

The amplitude of the motion is a metres.

Find

- (b) the value of a ,

(3)

- (c) the total length of time during each complete oscillation for which P is within $\frac{1}{2}a$ metres of O .

(4)

(Total for Question 3 is 11 marks)

Question Number	Scheme		Marks
3(a)	$\ddot{x} = -\omega^2 x \Rightarrow (\pm)0.5 = (\pm)0.02\omega^2$		M1
	$\omega = 5$		A1
	$T = \frac{2\pi}{\omega}$		M1
	$\frac{2\pi}{5} \text{ (s)}$		A1
			(4)
(b)	$v^2 = \omega^2 (a^2 - x^2)$		M1
	$0.3^2 = \omega^2 (a^2 - 0.02^2)$		A1ft
	$a = \frac{\sqrt{10}}{50} \text{ (m)}$		A1
			(3)
(c)	$x = a \sin \omega t$	$x = a \cos \omega t$	M1
	$t = \frac{1}{\omega} \sin^{-1}\left(\frac{1}{2}\right) = \frac{\pi}{30}$	$t = \frac{1}{\omega} \cos^{-1}\left(\frac{1}{2}\right) = \frac{\pi}{15}$	A1
	Time = $4 \times \frac{\pi}{30}$	Time = $\frac{2\pi}{5} - 4 \times \frac{\pi}{15}$	DM1
	$\frac{2\pi}{15} \text{ (s)}$		A1
			(4)
(11 marks)			
Notes			
(a) M1	Uses $\ddot{x}$ or $a = -\omega^2 x$ with $\ddot{x} = 0.5$ and $x = 0.02$ to form an equation for ω^2 . Condone sign errors.		
A1	Obtains correct value for ω or ω^2 from correct working ie no sign errors (E.g. $\omega^2 = -25$ leading to $\omega = 5$ scores M1A0)		
M1	Use of $T = \frac{2\pi}{\omega}$ with their value of ω		
A1	Accept 1.3 or better (1.256637061...) N.B. it is possible to score M1A0M1A1 in part (a)		
(b) M1	Use of $v^2 = \omega^2 (a^2 - x^2)$ with $v = 0.3$, $x = 0.02$ and their ω Must be correct substitution (e.g. not ω or T or a instead of ω^2)		
A1ft	Correct equation, follow through their ω		
A1	Accept 0.063 or better (0.0632455532...)		
(c) M1	Use of $x = a \sin \omega t$ or $x = a \cos \omega t$ with their ω and $x = \pm \frac{1}{2}a$. May see a or their value substituted.		
A1	Correct time from centre or end (0.1047... or 0.2094...)		
DM1	Correct method to find the required time. Depends on first M1.		
A1	Accept 0.42 or better (0.4188790205...)		

4. A light elastic string has natural length 5 m and modulus of elasticity 20 N.

The ends of the string are attached to two fixed points A and B , which are 6 m apart on a horizontal ceiling.

A particle P is attached to the midpoint of the string and hangs in equilibrium at a point which is 4 m below AB .

- (a) Calculate the weight of P .

(6)

The particle is now raised to the midpoint of AB and released from rest.

- (b) Calculate the speed of P when it has fallen 4 m.

(5)

(Total for Question 4 is 11 marks)

Question Number	Scheme	Marks
4(a)	Length of string/half string = 10 m / 5 m (or extension = 5 m / 2.5 m)	B1
	Hooke's Law	M1
	$T = \frac{\lambda x}{l} = \frac{20 \times 5}{5}, = 20$	A1
	Resolve vertically	M1
	$2 \times 20 \times \frac{4}{5} = W$	A1ft
	Weight = 32 (N)	A1
		(6)
(b)	Conservation of Energy	M1
	$\frac{1}{2} m v^2 = 32 \times 4 - \left(\frac{20 \times 5^2}{2 \times 5} - \frac{20 \times 1^2}{2 \times 5} \right)$	A1ft A1ft
	Substitute $m = \frac{32}{9.8}$ and solve	DM1
	$v = 7 \text{ (m s}^{-1}\text{)}$	A1
		(5)
(11 marks)		
Notes		
(a) B1	Correct length of complete or half string or correct extension(s) (seen or implied)	
M1	Apply Hooke's law. Condone mixed approach (E.g. two strings with $x = 2.5$ but $l = 5$)	
A1	Correct tension seen or implied	
M1	Resolving vertically. Must have both tensions. Condone sin/cos confusion.	
A1ft	Correct equation with their tension substituted. Allow mg for weight.	
A1	Cao (allow labelling as mg and isw if they give an answer of 32 but go on to find m)	
(b) M1	Energy Equation with all four terms. Condone sin/cos confusion and sign errors. The equation must be dimensionally correct.	
A1ft	Unsimplified equation with at most one error. Ft their W or m and allow with W or mg . An incorrect natural length or missing 2 on the denominator of both epe terms is one error.	
A1ft	Correct equation. Ft their W or m and allow with W or mg	
DM1	Substitutes their mass (not weight) into their equation. Dependent on first M1 in (b).	
A1	Cao (7, 7.0 or 7.00 only)	

5.

In this question you must show all stages of your working.
Solutions relying on calculator technology are not acceptable.

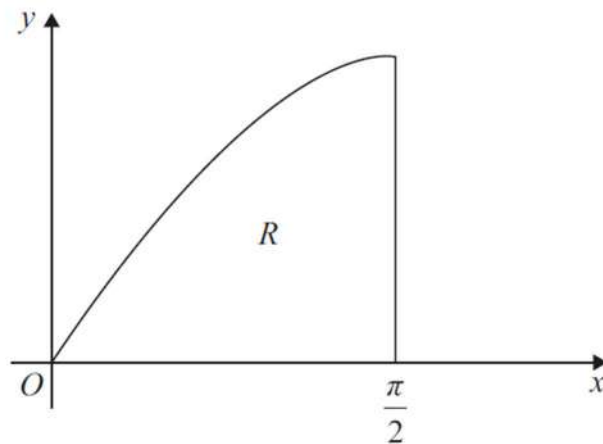


Figure 1

Figure 1 shows the finite region R which is bounded by part of the curve with equation $y = \sin x$, the x -axis and the line with equation $x = \frac{\pi}{2}$

A uniform solid S is formed by rotating R through 2π radians about the x -axis.

Using algebraic integration,

(a) show that the volume of S is $\frac{\pi^2}{4}$ (4)

(b) find, in terms of π , the x coordinate of the centre of mass of S . (7)

(Total for Question 5 is 11 marks)

Question Number	Scheme		Marks
5(a)	Volume = $\pi \int_0^{\frac{\pi}{2}} y^2 dx = \pi \int_0^{\frac{\pi}{2}} \sin^2 x dx$		M1
	$= \pi \int_0^{\frac{\pi}{2}} \frac{1}{2} (1 - \cos 2x) dx$		M1
	$= \pi \left[\frac{x}{2} - \frac{1}{4} \sin 2x \right]_0^{\frac{\pi}{2}} = \pi \left[\left(\frac{\pi}{4} - \frac{1}{4} \sin \pi \right) - \left(0 - \frac{1}{4} \sin 0 \right) \right]$		DM1
	$= \frac{\pi^2}{4} *$		A1*
			(4)
(b)	$\pi \int_0^{\frac{\pi}{2}} y^2 x dx = \pi \int_0^{\frac{\pi}{2}} x \sin^2 x dx$		M1
	Method 1: Double angle formula then integration by parts	$\pi \int_0^{\frac{\pi}{2}} \frac{x}{2} dx - \pi \int_0^{\frac{\pi}{2}} \frac{1}{2} x \cos 2x dx$	
		$= \left(\pi \left[\frac{x^2}{4} \right]_0^{\frac{\pi}{2}} \right) - \pi \left[\frac{x}{2} \times \frac{1}{2} \sin 2x \right]_0^{\frac{\pi}{2}} + \pi \int_0^{\frac{\pi}{2}} \frac{1}{2} \times \frac{1}{2} \sin 2x dx$	M1
		$= \frac{\pi^3}{16} \left(-\pi [0 - 0] - \pi \left[\frac{1}{8} \cos 2x \right]_0^{\frac{\pi}{2}} \right)$	B1
		$= \left(\frac{\pi^3}{16} \right) - \frac{\pi}{8} [\cos \pi - \cos 0]$	DM1
	Method 2: Integration by parts using result from part (a)	$= \pi \left[\frac{x}{2} \left(x - \frac{1}{2} \sin 2x \right) \right]_0^{\frac{\pi}{2}} - \pi \int_0^{\frac{\pi}{2}} \frac{1}{2} \left(x - \frac{1}{2} \sin 2x \right) dx$	M1
		$= \frac{\pi^3}{8} \left(-\pi \left[\frac{x}{4} \sin 2x \right]_0^{\frac{\pi}{2}} - \pi \left[\frac{x^2}{4} + \frac{1}{8} \cos 2x \right]_0^{\frac{\pi}{2}} \right)$	B1
		$= \left(\frac{\pi^3}{8} \right) - \pi \left([\sin \pi - \sin 0] + \left[\frac{\pi^2}{16} + \frac{1}{8} \cos \pi - \frac{1}{8} \cos 0 \right] \right)$	DM1
	$= \frac{\pi^3}{16} + \frac{\pi}{4}$		A1
	Complete method to find $\bar{x}$		DM1
	$\bar{x} = \frac{\frac{\pi^3 + 4\pi}{16}}{\frac{\pi^2}{4}} = \frac{\pi^2 + 4}{4\pi}$		A1
			(7)

(11 marks)	
Notes	
(a) M1	Forms the required integral, limits not needed but need to see π or justification at end.
M1	Use of $\sin^2 \theta = k(1 \pm \cos 2\theta)$ with $k = \pm \frac{1}{2}$ or ± 2 . Limits not needed. π not needed.
DM1	Integration of their function and substitution of correct limits. π may be missing. Integration requires powers of x to increase and sin/cos to become cos/sin. Depends on the first M mark only.
A1*	cso. Penalise incorrect signs on trig functions which become 0 on substitution of the limits. If π is missing but appears only in the last line can only score maximum M0M1M1A0. If explanation for inclusion of π is given all marks are available.
	N.B. the first 5 marks in (b) are available with or without π in front of the integration
(b) M1	Use of $\int y^2 x \, dx$ (limits not needed)
M1	Integration by parts of $x \cos 2x$, or of $x \sin^2 x$ using result from (a), with “ u ” = kx
B1	Correct integration of polynomial part: $\frac{\pi^3}{16}$ or $\frac{\pi^3}{8}$ (or $\frac{\pi^2}{16}$ or $\frac{\pi^2}{8}$ without π) or equivalent seen or implied.
DM1	Completing the integration. Dependent on the previous M mark.
A1	Correct integration seen or implied N.B. without limits the integral is $\frac{x^2}{4} - \frac{x}{4} \sin 2x - \frac{1}{8} \cos 2x \quad (+c)$
DM1	$\text{Use of } \bar{x} = \frac{(\pi) \int y^2 x \, dx}{(\pi) \int y^2 \, dx}$ π must be included for both integrals or neither. Dependent on second M mark i.e. must have attempted integration by parts. Denominator must be the given result from (a) (allow correctly cancelled π) Numerator must use their value.
A1	Cso. Accept any equivalent exact form. N.B. Question specifies need for algebraic working, so e.g. $\pi \int_0^{\frac{\pi}{2}} x \sin^2 x \, dx = \frac{\pi^3}{16} + \frac{\pi}{4}$ followed by answer with no algebraic working would score M1M0B0M0A0M0A0.

- 6 The path followed by a motorcycle round a circular racetrack is modelled as a horizontal circle of radius 50m. The track is banked at an angle θ to the horizontal, where $\sin \theta = \frac{3}{5}$. The motorcycle travels round the track at constant speed.

The motorcycle is modelled as a particle and air resistance can be ignored.

In an initial model it is assumed that there is no sideways friction between the motorcycle tyres and the track.

Using this model,

- (a) find the speed, in ms^{-1} , of the motorcycle.

(5)

In a refined model it is assumed that there is sideways friction.

The coefficient of friction between the motorcycle tyres and the track is $\frac{1}{4}$

It is still assumed that air resistance can be ignored and that the motorcycle is modelled as a particle.

The motorcycle's path is unchanged.

Using this model,

- (b) find the maximum speed, in ms^{-1} , at which the motorcycle can travel without slipping sideways.

(8)

(Total for Question 6 is 13 marks)

Question Number	Scheme	Marks
6(a)	Resolve Vertically $R \cos \theta = mg$	B1
	Resolve Horizontally	M1
	$R \sin \theta = \frac{mv^2}{r}$	A1ft
	$\tan \theta = \frac{3}{4} = \frac{v^2}{50g} \Rightarrow v = \dots$	DM1
	$v = 19 \text{ (m s}^{-1}\text{)}$	A1
		(5)
(b)	Resolve Vertically	M1
	$R \cos \theta - F \sin \theta = mg$	A1
	Resolve Horizontally	M1
	$R \sin \theta + F \cos \theta = \frac{mv^2}{r}$	A1 A1
	$F = \frac{1}{4} R$	B1
	Solve for v	DM1
	$v = 25 \text{ (m s}^{-1}\text{)}$	A1
		(8)
(13 marks)		
Notes		
(a) B1	Resolve vertically; correct equation only.	
M1	Equation of motion horizontally: allow any form for acceleration and condone sin/cos confusion. Award if their “ R ” is $mg \cos \theta$ but M0 for “ R ” = mg	
A1ft	Correct equation. Ft their “ R ”. N.B. The first three marks can be awarded for the equation $mg \tan \theta = \frac{mv^2}{r}$	
DM1	Substitute for trig ratios and reach $v^2 = \dots$ or $v = \dots$ Dependent on previous M mark.	
A1	19 or 19.2 only	
(b) M1	Resolve vertically. Must have all terms but condone sign errors and sin/cos confusion. M0 for use of their R from part (a)	
A1	Correct unsimplified equation	
M1	Resolve horizontally. Must have all terms but condone sign errors and sin/cos confusion. M0 for use of their R from part (a)	
A1	Unsimplified equation with at most one error. Acceleration must be in correct form.	
A1	Correct unsimplified equation	
B1	Use of $F = \frac{1}{4} R$ where R is the normal reaction in part (b) (E.g. not their R from (a), not mg , not $mg \cos \theta$) Must be substituted into an equation.	
DM1	Eliminate R and F to form equation in v . Dependent on both previous M marks.	
A1	25 or 24.6 only	

Alt (a)	For first three marks: resolve parallel to track $mg \sin \theta = \frac{mv^2}{r} \cos \theta$ M1 for both terms (condone sin/cos confusion); B1 one term correct, A1 both correct.
Alt (b)	For first 5 marks, resolve parallel and perpendicular to track: $F + mg \sin \theta = m \left(\frac{v^2}{r} \right) \cos \theta$ $R - mg \cos \theta = m \left(\frac{v^2}{r} \right) \sin \theta$ Score “best” equation seen as M1A1A1 and second equation as M1A1

7.

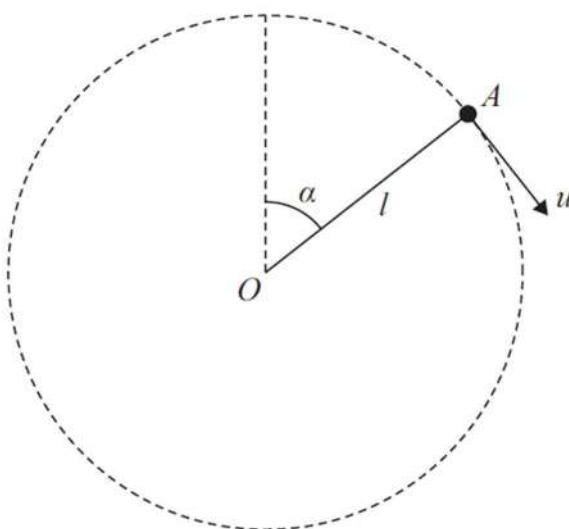


Figure 2

A particle of mass m is attached to one end of a light rod of length l . The other end of the rod is attached to a fixed point O . The rod can turn freely in a vertical plane about a horizontal axis through O .

The particle is projected with speed u from a point A , where OA makes an angle α with the upward vertical through O , as shown in Figure 2.

The particle moves in complete vertical circles.

Given that $\cos \alpha = \frac{4}{5}$

(a) show that $u > \sqrt{\frac{2gl}{5}}$ (4)

As the rod rotates, the least tension in the rod is T and the greatest tension is $4T$.

(b) Show that $u = \sqrt{\frac{17}{5}gl}$ (11)

(Total for Question 7 is 15 marks)

Question Number	Scheme	Marks
7(a)	For complete circles there must be speed at the top	B1
	Energy with $ke > 0$ at top $\frac{1}{2}mv^2 = \frac{1}{2}mu^2 - mg(l - l \cos \theta) > 0$	M1
	$\frac{1}{2}mu^2 > \frac{mgl}{5}$	A1
	$u > \sqrt{\frac{2gl}{5}} \quad *$	A1*
		(4)
(b)	Equation of motion at bottom	M1
	$T_{\max} - mg = m \frac{v_{\max}^2}{l}$	A1
	Energy equation to bottom	M1
	$\frac{1}{2}mv_{\max}^2 = \frac{1}{2}mu^2 + mgl(1 + \cos \alpha)$	A1
	$T_{\max} = \frac{mu^2}{l} + \frac{18mg}{5} + mg \quad \left(\text{or } T_{\min} = \frac{mu^2}{l} - \frac{2mg}{5} - mg \right)$	A1
	Equation of motion at top	M1
	$T_{\min} + mg = m \frac{v_{\min}^2}{l}$	A1
	Energy equation to top	M1
	$\frac{1}{2}mv_{\min}^2 = \frac{1}{2}mu^2 - mgl(1 - \cos \alpha)$	A1
	$T_{\max} = 4 \times T_{\min}$	M1
	$u = \sqrt{\frac{51gl}{15}} = \sqrt{\frac{17gl}{5}} \quad *$	A1*
		(11)
(15 marks)		
Notes		
(a) B1	Or equivalent statement seen or implied by working. Condone $v \geq 0$. N.B. this is a rod so $T > 0$ is B0.	
M1	Uses energy and $v > 0$ to form an inequality for u^2 If v is not explicitly seen then inequality must be justified by speed at top being positive. Use of equality followed by given answer without clear justification of the inequality is M0.	
A1	Correct inequality (allow $\geq$ for this mark)	
A1*	Deduces given result with no incorrect working seen. Allow consistent omission of m throughout.	
(b) M1	Equation of motion at lowest point. Condone sign errors.	
A1	Correct equation.	
M1	Energy equation to lowest point. Condone sign errors and sin/cos confusion.	
A1	Correct equation.	
A1	Eliminates v to get expression for tension in terms of m, g, l, u only. Award for correct expression for $T_{\max}$ or $T_{\min}$ seen or implied.	
M1	Equation of motion at highest point. Condone sign errors.	

A1	Correct equation. A0 if same velocity used for both equations of motion unless recovered later.
M1	Energy equation to highest point. Condone sign errors and sin/cos confusion.
A1	Correct equation. Award if energy equation from (a) is used in (b) A0 if same velocity used for both energy equations unless recovered later.
	N.B. Either energy equation could be replaced by an energy equation for top to bottom: $\frac{1}{2}mv_{\max}^2 = \frac{1}{2}mv_{\min}^2 + 2mgl$
M1	Compares the two tensions with 4 on the right side. This could be awarded if, e.g. T and $4T$ are used the right way round in the equations of motion.
A1*	Obtains given answer with no incorrect working seen (condone missing brackets and recovery from poor notation (e.g. both velocities as v) but not recovery of incorrect minus signs). Must see some working after the four equations of energy / motion.
	N.B. Some useful values: $T_{\max} = 8mg \quad T_{\min} = 2mg \quad v_{\max} = 7gl \quad v_{\min} = 3gl$

Please check the examination details below before entering your candidate information

Candidate surname					Other names				
Centre Number					Candidate Number				

Pearson Edexcel International Advanced Level

Wednesday 21 January 2026

Morning (Time: 1 hour 30 minutes) Paper reference **WME03/01**

Mathematics

International Advanced Subsidiary/Advanced Level

Mechanics M3

You must have:
Mathematical Formulae and Statistical Tables (Yellow), calculator

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Whenever a numerical value of g is required, take $g = 9.8 \text{ m s}^{-2}$, and give your answer to either two significant figures or three significant figures.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 8 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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1. A particle P is moving along the x -axis.

At time t seconds the displacement of P from the origin O is x metres, where

$$x = 0.6 \cos \left(kt + \frac{\pi}{4} \right) \text{ and } k \text{ is a positive constant.}$$

- (a) Prove that P is moving with simple harmonic motion by showing that

$$\ddot{x} = -k^2 x$$

(3)

- (b) State the amplitude of the motion of P

(1)

- (c) Find, in terms of k , the maximum speed of P

(1)

The period of the motion is 4 seconds.

- (d) Find k in terms of π

(2)

The points A and B lie on the x -axis, on opposite sides of O , with $OA = OB = 0.2$ m

- (e) Find the time taken by P to move directly from A to B

(4)



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Question 1 continued

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Question 1 continued

Handwriting practice area with horizontal lines.

(Total for Question 1 is 11 marks)



2.

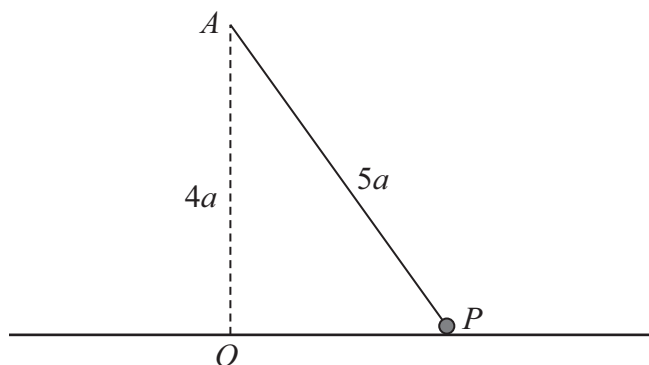


Figure 1

A particle P of mass m is attached to one end of a light inextensible string of length $5a$. The other end of the string is attached to a fixed point A above a smooth horizontal table. The particle moves in a horizontal circle on the table with the string taut. The centre O of the circle is vertically below A with $OA = 4a$, as shown in Figure 1.

The particle moves with constant angular speed ω and remains in contact with the table.

- (a) Find, in terms of m and g , the magnitude of the normal reaction between P and the

table when $\omega = \frac{1}{4}\sqrt{\frac{g}{a}}$

(6)

The angular speed ω is gradually increased and the particle remains in contact with the table.

- (b) Show that $\omega < \frac{1}{2}\sqrt{\frac{g}{a}}$

(2)



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Question 2 continued

Lined area for writing the answer to Question 2.



Question 2 continued

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Question 2 continued

Handwriting practice area with horizontal lines.

(Total for Question 2 is 8 marks)



3.

In this question you must show all stages of your working. Solutions relying entirely on calculator technology are not acceptable.

A particle P is moving along a straight line.

At time t seconds ($t \geq 0$), P is a distance x metres from a fixed point O on the line and

is moving away from O with speed $\frac{8x}{3+x^2} \text{ m s}^{-1}$

- (a) Find the magnitude of the acceleration of P when $x = 3$ (5)

Given that $x = 1$ when $t = 2$

- (b) find the exact value of t when $x = 3$ (5)



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Question 3 continued

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Question 3 continued

(Total for Question 3 is 10 marks)



4.

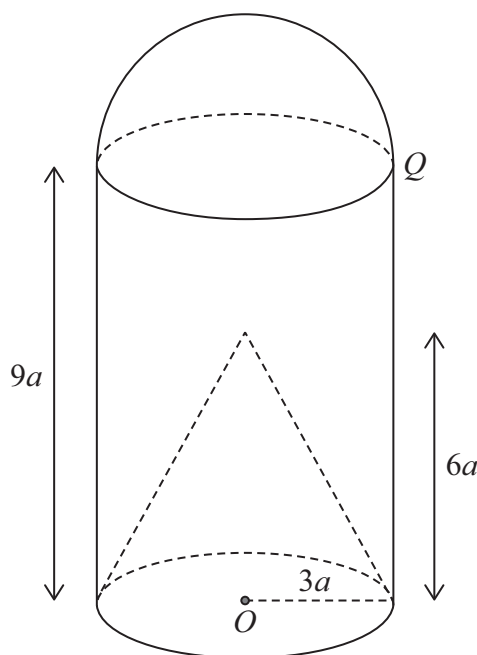


Figure 2

A uniform solid right circular cylinder has radius $3a$ and height $9a$

A uniform solid hemisphere of radius $3a$ is attached to the cylinder so that the plane face of the hemisphere coincides with one of the plane faces of the cylinder.

A solid right circular cone, of radius $3a$ and height $6a$, whose plane face is the other plane face of the cylinder, is now removed from the cylinder to form the uniform solid S . The point O is the centre of the circular base of S , as shown in Figure 2.

- (a) Show that the distance from O to the centre of mass of S is $\frac{77}{12}a$

(5)

The solid S is placed with its circular base on a rough horizontal surface.

The point Q , shown in Figure 2, lies on the circumference of the top of the cylinder.

A horizontal force of magnitude H is applied to S at Q

The force acts towards the axis of symmetry of S

The horizontal surface is sufficiently rough to prevent S from sliding.

The solid S is on the point of tipping.

Given that the weight of S is W

- (b) find H in terms of W

(2)



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Question 4 continued

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Question 4 continued

Lined area for writing the answer to Question 4.

(Total for Question 4 is 7 marks)



5.

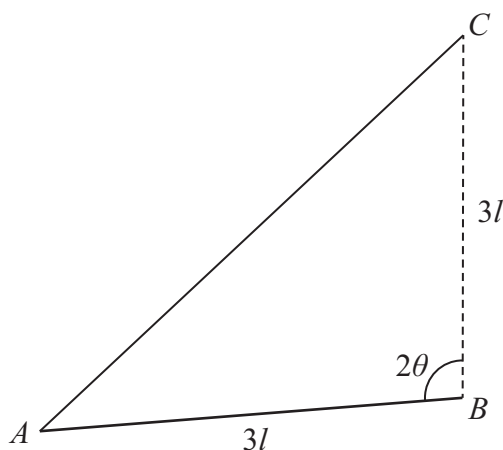


Figure 3

A uniform rod AB has mass M and length $3l$

The rod is free to move in a vertical plane about a fixed smooth horizontal axis through B

One end of a light elastic string, of natural length $2l$ and modulus of elasticity $\frac{5Mg}{8}$, is attached to the rod at A

The other end of the string is attached to the fixed point C , which is at a distance $3l$ vertically above B , as shown in Figure 3.

The rod is resting in equilibrium with angle $ABC = 2\theta$, where $0 < \theta < \frac{1}{2}\pi$

By taking moments about the horizontal axis through B , show that the extension of the string is $\frac{16}{7}l$

(7)



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Question 5 continued

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Question 5 continued

(Total for Question 5 is 7 marks)



6.

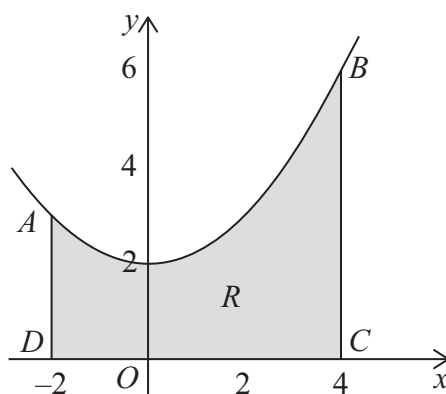


Figure 4

**In this question you must show all stages of your working.
Solutions relying entirely on calculator technology are not acceptable.**

A uniform lamina $ABCD$ is in the shape of the region R

The region R is bounded by the curve with equation $y = \frac{1}{4}(x^2 + 8)$, the line with equation $x = 4$, the x -axis and the line with equation $x = -2$, as shown shaded in Figure 4.

The area of R is 18

(a) Show that the x coordinate of the centre of mass of the lamina is $\frac{3}{2}$ (4)

(b) Show that the y coordinate of the centre of mass of the lamina is $\frac{17}{10}$ (4)

The lamina is freely suspended from B and hangs in equilibrium with BC at an angle θ to the downward vertical through B

(c) Find the exact value of $\tan \theta$ (2)



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Question 6 continued

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Question 6 continued

(Total for Question 6 is 10 marks)



7. One end of a light elastic **spring** is attached to a fixed point A
A particle of mass M is attached to the other end of the spring.

The spring has natural length $3a$ and modulus of elasticity $\frac{18Mg}{5}$

The particle is held at rest at the point B , where B is a distance $5a$ vertically below A

The particle is released from rest.

Air resistance is assumed to be negligible.

Use the **principle of conservation of mechanical energy** to

- (a) find, in terms of a and g , the speed of the particle at the instant when it is a distance $3a$ vertically below A

(4)

- (b) find, in terms of a , the distance of the particle below A when it first comes to instantaneous rest.

(4)



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Question 7 continued

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Question 7 continued

(Total for Question 7 is 8 marks)



8.

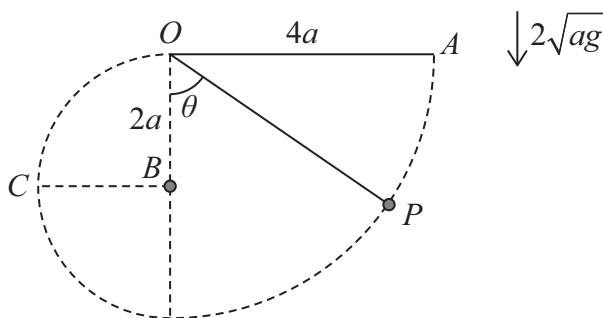


Figure 5

A particle P of mass m is attached to one end of a light inextensible string of length $4a$. The other end of the string is attached to a fixed point O . The particle is held at the point A , where $OA = 4a$, and OA is horizontal, as shown in Figure 5.

The particle is projected vertically downwards with speed $2\sqrt{ag}$.

When the string makes an angle θ ($0 \leq \theta \leq \frac{\pi}{2}$) with the downward vertical through O and the string is still taut, the tension in the string is T .

Air resistance is assumed to be negligible.

- (a) Show that $T = mg(1 + 3 \cos \theta)$ (6)
- (b) Find, in terms of a and g , the speed of P at the lowest point of its path. (2)

There is a fixed small horizontal peg at the point B , which is a distance $2a$ vertically below O . The peg is smooth and is perpendicular to the vertical plane of the motion of P and the string.

The string comes into contact with the peg and P continues to move clockwise in the same vertical plane. The point C is such that $CB = 2a$ and CB is horizontal, as shown in Figure 5.

When the particle passes through C , the string is still taut.

- (c) Find, in terms of a and g , the exact speed of the particle at the instant when it passes through C (3)
- (d) Find, in terms of m and g , the tension in the string at the instant when P reaches O (3)



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Question 8 continued

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Question 8 continued

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(Total for Question 8 is 14 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (Results)

January 2026

International Advanced Level in Mechanics M3

WME03/01

Edexcel and BTEC Qualifications

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January 2026

Question Paper Log Number P78916A

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)
 - Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN.

- bod – benefit of doubt
- ft – follow through
- the $\checkmark$ symbol will be used for correct ft
- cao – correct answer only
- cso – correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- d... or dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- * The answer is printed on the paper or ag- answer given
- $\square$ or d... The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.
5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. If you are using the annotation facility on ePEN, indicate this action by 'MR' in the body of the script.
6. If a candidate makes more than one attempt at any question:
 - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
7. Ignore wrong working or incorrect statements following a correct answer.

General Principles for Mechanics Marking

(**N.B.** specific mark schemes may sometimes override these general principles)

- Rules for M marks:
 - correct number of terms
 - dimensionally correct
 - all terms that need resolving (i.e. *multiplied* by cos or sin) are resolved
 - only terms that need resolving are resolved
 - $\pm$ errors are condoned
 - sin/cos confusion is condoned
- Omission or extra g in a resolution is an accuracy error not method error.
- Omission of mass from a resolution is a method error.
- Omission of a length from a moments equation is a method error.
- Omission of units or incorrect units is not (usually) counted as an accuracy error.
- DM indicates a dependent method mark, i.e. one that can only be awarded if a previous specified method mark(s) has been awarded.
- Any numerical answer which comes from use of $g = 9.8$ should be given as a decimal to 2 or 3 SF.
- Use of $g = 9.81$ should be penalised once per (complete) question.
 - N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *once* per complete question. However, premature approximation should be penalised every time it occurs.
- Marks must be entered in the same order as they appear on the mark scheme.
- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c)...then that working can only score marks for that part of the question.
- Accept column vectors in all cases.

- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft

Question Number	Scheme	Marks	Notes
2a			
	Resolve vertically	M1	Need all terms. Dimensionally correct. Condone sign error and sine / cosine confusion
	$R + T \sin \theta = mg$ $\left(R + \frac{4}{5}T = mg \right)$	A1	Correct unsimplified equation
	Equation for circular motion	M1	Dimensionally correct. Condone sign error and sine / cosine confusion
	$T \cos \theta = m \times 3a\omega^2$ $\left(\frac{3}{5}T = m \times 3a\omega^2 \right)$	A1	Correct unsimplified equation
	Substitute $\omega = \frac{1}{4} \sqrt{\frac{g}{a}}$ and obtain R	M1	As far as an equation in R, m and g
	$R = \frac{3mg}{4}$	A1	Or exact equivalent
		(6)	
2b	Use $mg - T \sin \theta > 0$ to obtain ω	M1	
	$\omega < \frac{1}{2} \sqrt{\frac{g}{a}}$ *	A1*	Given answer from correct working
		(2)	
		[8]	

Question Number	Scheme	Marks	Notes
3a	Use $\frac{dv}{dt} = \frac{dv}{dx} \times \frac{dx}{dt}$	M1	Use of chain rule or $\frac{d}{dx} \left(\frac{1}{2} v^2 \right)$
	Correct method for $\frac{dv}{dx}$	M1	Correct quotient rule or equivalent (allow one slip)
	Correct derivative	A1	e.g. $\frac{8x}{3+x^2} \times \frac{8(3+x^2)-16x^2}{(3+x^2)^2}$
	Substitute $x = 3$ into their derivative	DM1	Dependent on the first M1
	Obtain $\frac{2}{3} (\text{ms}^{-2})$	A1	Must be positive. Accept 0.67 or better
		(5)	
3b	$\frac{dx}{dt} = \frac{8x}{3+x^2}$	M1	Use of $v = \frac{dx}{dt}$
	$\int \frac{3+x^2}{8x} dx = \int 1 dt \quad \left(= \int \frac{3}{8x} + \frac{x}{8} dx \right)$	M1	Separate and attempt integration (as far as 2 terms of the correct form)
	$\frac{3}{8} \ln x + \frac{1}{16} x^2 = t (+C)$	A1	Correct integration. Allow if “+ C” not seen
	Use $x = 1$ when $t = 2$ to obtain C	M1	In an expression containing at least 2 of $p \ln x, qx^2, rt$
	$t = \frac{5}{2} + \frac{3}{8} \ln 3$	A1	Or exact equivalent
		(5)	
		[10]	

Question Number	Scheme					Marks	Notes
4a		H-sphere	Cylinder	Cone	S	B1 B1	
	Mass	$18\pi a^3$	$81\pi a^3$	$18\pi a^3$	$81\pi a^3$		
	To O	$9a + \frac{9a}{8}$	$\frac{9a}{2}$	$\frac{3a}{2}$	d		
	Moments about a horizontal axis through O					M1	Or a parallel axis. Dimensionally consistent. Need all terms. Condone sign errors.
	$18 \times \frac{81a}{8} + 81 \times \frac{9a}{2} - 18 \times \frac{3a}{2} = 81d$					A1	Correct unsimplified equation for their axis.
	$\frac{2079}{4}a = 81d \Rightarrow d = \frac{77a}{12}$ *					A1*	Obtain given answer from correct working
						(5)	
4b	Moments about toppling point, or equivalent complete method					M1	Dimensionally consistent. Using $9a$ and $3a$
	$9aH = 3aW \Rightarrow H = \frac{1}{3}W$					A1	
						(2)	
						[7]	
5	Moments about B					M1	Dimensionally correct. Condone sine / cosine confusion
	$Mg \times \frac{3l}{2} \sin 2\theta = T \cos \theta \times 3l$					A1 A1	Unsimplified equation in T or <i>their</i> T with at most one error. Correct unsimplified equation in T or <i>their</i> T
	$T = \frac{5Mgx}{8 \times 2l}$					M1	Correct use of Hooke's Law seen or implied.
	$Mg \times \frac{3l}{2} \times 2 \sin \theta \cos \theta = \frac{5Mgx}{16l} \cos \theta \times 3l$ $\left(\sin \theta = \frac{5x}{16l} \right)$					M1	Substitute for T and use double angle formula to obtain equation in x , l and θ
	$(\sin \theta =) \frac{l + \frac{1}{2}x}{3l} = \frac{5x}{16l}$					M1	Use trig to form an equation in x and l
	$\Rightarrow 16l + 8x = 15x \Rightarrow x = \frac{16l}{7}$ *					A1*	Obtain given answer from correct working.
						(7)	
						[7]	

Question Number	Scheme	Marks	Notes
6a	Moments about the y-axis	M1	Use of $\int xy dx$. Limits not needed. Powers going up by 1
	$\int_{-2}^4 \frac{1}{4}x^3 + 2x \, dx = \left[\frac{1}{16}x^4 + x^2 \right]_{-2}^4$	A1	Correct integration and correct limits seen
	$\bar{x} = \frac{\left[\frac{1}{16}x^4 + x^2 \right]_{-2}^4}{18}$	M1	Use of $\bar{x} = \frac{\int xy \, dx}{18}$
	$= \frac{27}{18} = \frac{3}{2} *$	A1*	Obtain given answer from correct working
		(4)	
6b	Moments about the x axis	M1	$\int \frac{1}{2}y^2 dx = \frac{1}{2} \int \frac{x^4}{16} + x^2 + 4 \, dx$ Correct squaring. Powers going up by 1. Condone if the half is missing.
	$\frac{1}{2} \left[\frac{x^5}{80} + \frac{x^3}{3} + 4x \right]_{-2}^4$	A1	Correct integration and correct limits seen or implied
	$\bar{y} = \frac{\frac{1}{2} \left[\frac{x^5}{80} + \frac{x^3}{3} + 4x \right]_{-2}^4}{18}$	M1	Use of $\bar{y} = \frac{\frac{1}{2} \int y^2 \, dx}{18}$
	$\bar{y} = \frac{153}{5 \times 18} = \frac{17}{10} *$	A1*	Obtain given answer from correct working
		(4)	
6c	Correct use of trig to find tangent of a relevant angle	M1	e.g. $\tan \theta = \frac{4 - \frac{3}{2}}{6 - \frac{17}{10}}$
	$\tan \theta = \frac{25}{43}$	A1	
		(2)	
		[10]	

Question Number	Scheme	Marks	Notes
7a	EPE at B = $\frac{18Mg \times (2a)^2}{5 \times 6a}$	M1	Correct form for EPE seen or implied. Allow if correct formula stated but slip in substitution.
	Work-energy equation	M1	Need all terms. Dimensionally correct. Condone sign errors
	$Mg \times 2a + \frac{1}{2}Mv^2 = \frac{18Mg \times (2a)^2}{5 \times 6a}$	A1	Correct unsimplified equation
	$v = \sqrt{\frac{4ag}{5}}$	A1	Accept exact equivalent or $0.89\sqrt{ag}$ or better
		(4)	
7b	Work-energy equation	M1	Need all terms. Dimensionally correct. Condone sign errors.
	$\frac{18Mg \times 4a^2}{5 \times 6a} = Mg(2a + x) + \frac{18Mg \times x^2}{5 \times 6a}$ or $\frac{1}{2}M \times \text{their } \frac{4ag}{5} = Mgx + \frac{18Mg \times x^2}{5 \times 6a}$ $(3x^2 + 5ax - 2a^2 = 0)$	A1 A1	Unsimplified equation in one unknown length with at most one error Correct unsimplified equation in one unknown length
	$x = \frac{a}{3} \Rightarrow \text{distance from A} = \frac{8a}{3}$	A1	2.7a or better
		(4)	
		[8]	

Question Number	Scheme	Marks	Notes
8a	Conservation of energy from A to general position	M1	Need all terms. Dimensionally correct. Condone sign errors and sine / cosine confusion
	$\frac{1}{2}m \times 4ag + mg \times 4a \cos \theta = \frac{1}{2}mv^2$	A1	Correct unsimplified equation
	Equation for circular motion	M1	Need all terms. Dimensionally correct. Condone sign errors and sine / cosine confusion
	$T - mg \cos \theta = \frac{mv^2}{4a}$	A1	Correct unsimplified equation
	Eliminate v^2 and solve for T	DM1	Dependent on both preceding M marks
	$\frac{mv^2}{4a} = T - mg \cos \theta = mg + 2mg \cos \theta$ $\Rightarrow T = mg(1 + 3 \cos \theta)$ *	A1*	Obtain given answer from correct working.
		(6)	
8b	Substitute $\theta = 0$ in the energy equation	M1	Or equivalent method to obtain the speed
	$4amg + 8amg = mv^2 \Rightarrow v = \sqrt{12ag}$	A1	$3.5\sqrt{ag}$ or better
		(2)	
8c	Conservation of energy from A to C	M1	Or equivalent. Need all terms. Dimensionally correct. Condone sign errors
	$\frac{1}{2}m \times 4ag + mg \times 2a = \frac{1}{2}mw^2$	A1	Correct unsimplified equation
	$w = \sqrt{8ag}$	A1	Or exact equivalent
		(3)	
8d	Speed of $P = 2\sqrt{ag}$	B1	Seen or implied
	Equation of motion: $T + mg = \frac{mv^2}{2a} \left(= \frac{m \times 4ag}{2a} \right)$	M1	Need all terms, with <i>their</i> v substituted. Condone sign errors.
	$T = mg$	A1	cso
		(3)	
		[14]	

Pearson Edexcel International Advanced Level

Thursday 8 January 2026

Morning (Time: 1 hour 30 minutes)

Paper

reference

WMA11/01A

Mathematics

International Advanced Subsidiary/Advanced Level

Pure Mathematics P1

Question paper

You must have:

Answer book (sent separately).

Do not return this question paper with the answer book.

Turn over ►

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C:1/1/




Pearson

1. **In this question you must show all stages of your working.**
Solutions relying on calculator technology are not acceptable.

Find the set of values of x for which

(a) $4(x - 5) < 2x - 9$ (2)

(b) $x(2x - 5) \leq 63$ (3)

(c) $4(x - 5) < 2x - 9$ and $x(2x - 5) \leq 63$ (1)

(Total for Question 1 is 6 marks)

2. **In this question you must show all stages of your working.**
Solutions relying on calculator technology are not acceptable.

(i) Using the laws of indices, solve the equation

$$4^{2y+1} = \frac{32^{4y}}{2}$$

(3)

(ii) Solve the equation

$$x\sqrt{27} + 21 = \frac{6x}{\sqrt{3}}$$

writing the answer in the form $a\sqrt{b}$ where a and b are integers. (4)

(Total for Question 2 is 7 marks)

3.
$$f(x) = \frac{(4 + 3\sqrt{x})^2}{x} \quad x > 0$$

(a) Find $f'(x)$, writing the answer in simplest form. (5)

(b) Hence find an equation of the tangent to the curve $y = f(x)$ at the point $(4, 25)$.

Write the answer in the form $y = mx + c$, where m and c are constants to be found. (3)

(Total for Question 3 is 8 marks)



4.

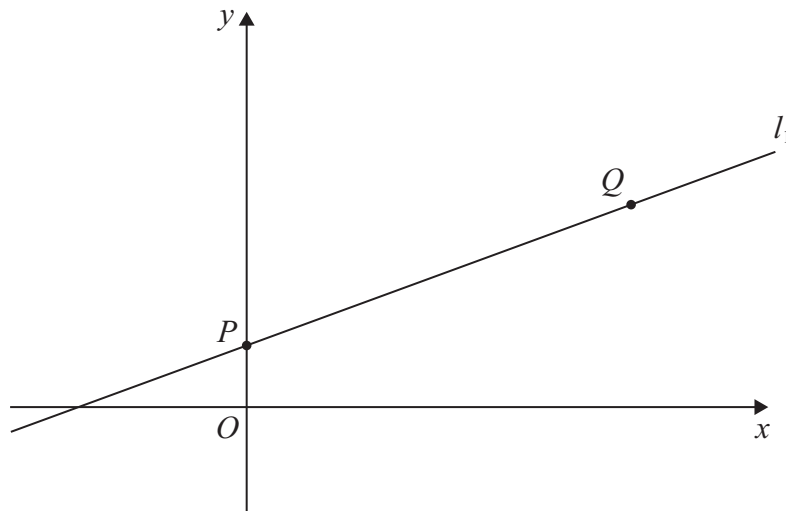


Figure 1

The line l_1 , shown in Figure 1, has equation $2y = 3x + 8$

The line l_1 intersects the y -axis at the point P and passes through the point Q with x coordinate 6

(a) Find

(i) the coordinates of P ,

(ii) the coordinates of Q .

(2)

The line l_2 is perpendicular to l_1 and passes through the point Q .

(b) Find an equation for l_2 , writing the answer in the form $ax + by + c = 0$, where a , b and c are integers.

(4)

The line l_2 cuts the x -axis at the point R .

(c) Find the area of quadrilateral $OPQR$, making the method clear.

(3)

(Total for Question 4 is 9 marks)

5.

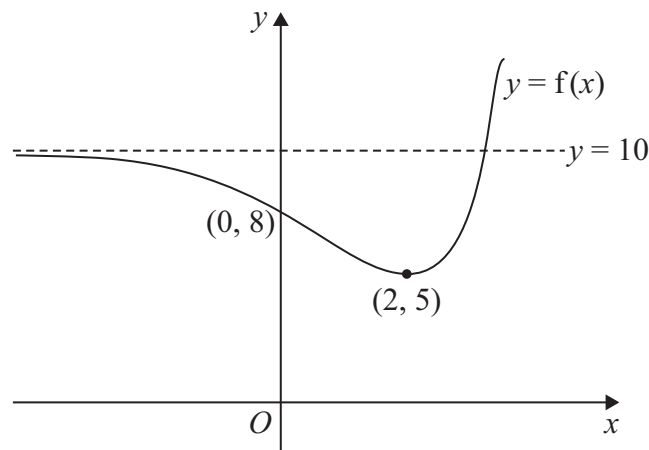


Figure 2

Figure 2 shows a sketch of part of the curve with equation $y = f(x)$.

The curve crosses the y -axis at the point $(0, 8)$.

The line with equation $y = 10$ is the only asymptote to the curve.

The curve has a single turning point, a minimum point at $(2, 5)$, as shown in Figure 2.

- (a) State the coordinates of the minimum point of the curve with equation $y = f\left(\frac{1}{4}x\right)$ (1)

- (b) State the equation of the asymptote to the curve with equation $y = f(x) - 3$ (1)

The curve with equation $y = f(x)$ meets the line with equation $y = k$, where k is a constant, at two distinct points.

- (c) State the set of possible values for k . (2)

- (d) Sketch the curve with equation $y = -f(x)$. On your sketch, show clearly the coordinates of the turning point, the coordinates of the intersection with the y -axis and the equation of the asymptote. (3)

(Total for Question 5 is 7 marks)

6.

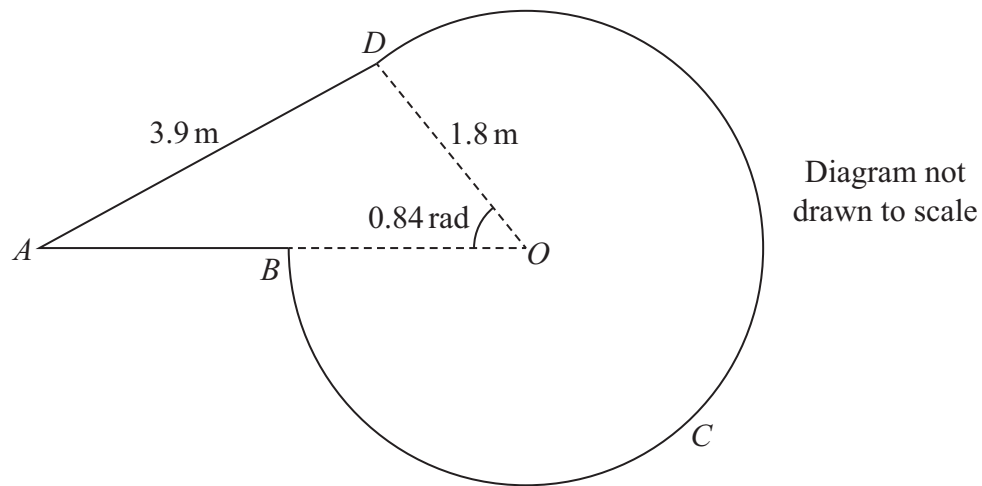


Figure 3

In this question you must show all stages of your working.

Figure 3 shows the design for a shop sign $ABCD A$.

The sign consists of a triangle AOD joined to a sector of a circle $DOBCD$ with radius 1.8 m and centre O .

The points A , B and O lie on a straight line.

Given that $AD = 3.9$ m and angle BOD is 0.84 radians,

- (a) calculate the size of angle DAO , giving the answer in radians to 3 decimal places. (2)
- (b) Find, in m, the length of AO giving the answer to 2 decimal places. (3)
- (c) Find, in m^2 , the area of the shop sign, giving the answer to one decimal place. (3)
- (d) Find, in m, the perimeter of the shop sign, giving the answer to one decimal place. (3)

(Total for Question 6 is 11 marks)

7. The curve C has equation $y = f(x)$, $x > 0$ where

$$f'(x) = 3\sqrt{x} - \frac{9}{x\sqrt{x}} + \frac{4}{3}$$

Given that the point $P(9, 20)$ lies on C ,

(a) find $f(x)$, simplifying the answer, (5)

(b) find an equation of the normal to C at the point P , giving the answer in the form $ax + by + c = 0$ where a , b and c are integers. (4)

(Total for Question 7 is 9 marks)

8. **In this question you must show all stages of your working.
Solutions relying on calculator technology are not acceptable.**

Find the range of values of k for which the quadratic equation

$$kx^2 + 8x + 2(k + 7) = 0$$

has no real roots. (6)

(Total for Question 8 is 6 marks)

9. Given that k is a constant, $0 < k < 1$, state the number of solutions of the equation

(a) $\sin x = k$ in the interval $0 < x \leq \pi$

(b) $\tan x = k$ in the interval $0 < x \leq \pi$

(c) $\cos 2x = k$ in the interval $0 < x \leq 100\pi$

(d) $\sin x = k + 1$ in the interval $-100\pi < x \leq 100\pi$ (4)

(Total for Question 9 is 4 marks)



10.

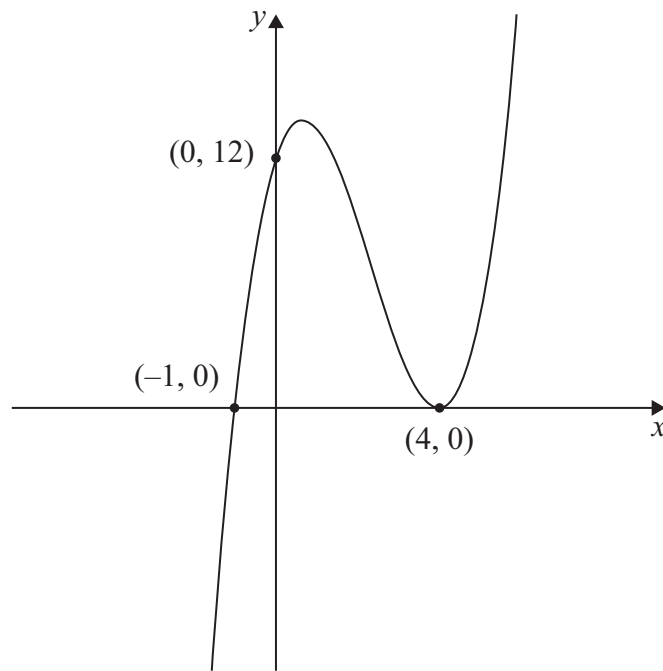


Figure 4

Figure 4 shows a sketch of the curve C_1 with equation $y = f(x)$ where $f(x)$ is a cubic function in x .

The curve

- cuts the x and y axes at $(-1, 0)$ and $(0, 12)$ respectively
- has a minimum turning point at $(4, 0)$

as shown in Figure 4.

(a) Find $f(x)$

(4)

The curve C_2 has equation $y = g(x)$ where $g(x) = 6(x + 1)(x - 2)$

(b) Find the exact x coordinates of the points of intersection of curves C_1 and C_2

(Solutions relying on calculator technology are not acceptable.)

(4)

(Total for Question 10 is 8 marks)

TOTAL FOR PAPER IS 75 MARKS

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Please check the examination details below before entering your candidate information

Candidate surname		Other names	
Centre Number		Candidate Number	

Pearson Edexcel International Advanced Level

Thursday 8 January 2026

Morning (Time: 1 hour 30 minutes) Paper reference **WMA11/01A**

Mathematics

International Advanced Subsidiary/Advanced Level

Pure Mathematics P1

Answer Book

You must have:
Question paper (sent separately),
Mathematical Formulae and Statistical Tables (Yellow), calculator

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 10 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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Question 1

Write the answer to Question 1 on these 2 pages

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(Total for Question 1 is 6 marks)



Question 2

Write the answer to Question 2 on these 2 pages

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DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(Total for Question 2 is 7 marks)



Question 3

Write the answer to Question 3 on these 2 pages

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DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA

Question 4

Write the answer to Question 4 on these 2 pages

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DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(Total for Question 4 is 9 marks)



Question 5

Write the answer to Question 5 on these 2 pages

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DO NOT WRITE IN THIS AREA

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Question 5 continued

This is the end of Question 5 answer space. Please turn the page for Question 6 answer space.

(Total for Question 5 is 7 marks)



Question 6

Write the answer to Question 6 on these 4 pages

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DO NOT WRITE IN THIS AREA



Question 6 continued

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Question 7

Write the answer to Question 7 on these 2 pages

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Question 8

Write the answer to Question 8 on these 2 pages

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DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(Total for Question 8 is 6 marks)



Question 9

Write the answer to Question 9 on these 2 pages

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DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(Total for Question 9 is 4 marks)



Question 10

Write the answer to Question 10 on these 3 pages

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DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA



Question 10 continued

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(Total for Question 10 is 8 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (Results)

January 2026

Pearson Edexcel International Advanced Level in
Pure Mathematics P1
WMA11/01A

Edexcel and BTEC Qualifications

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January 2026

Question Paper Log Number P87592A

Publication Code WMA11_01A_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
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- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
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- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN:

- bod – benefit of doubt
- ft – follow through
 - the symbol $\surd$ will be used for correct ft
- cao – correct answer only
- cso – correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC – special case
- oe – or equivalent (and appropriate)
- d... or dep – dependent
- indep – independent
- dp – decimal places
- sf – significant figures
- * – The answer is printed on the paper or ag- answer given

- $\square$ or d... – The second mark is dependent on gaining the first mark
4. All A marks are 'correct answer only' (cao), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.
 5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. If you are using the annotation facility on ePEN, indicate this action by 'MR' in the body of the script.
 6. If a candidate makes more than one attempt at any question:
 - a) If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - b) If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
 7. Ignore wrong working or incorrect statements following a correct answer.

General Principles for Pure Mathematics Marking

(NB specific mark schemes may sometimes override these general principles)

Method mark for solving 3 term quadratic:

1. Factorisation

$(x^2 + bx + c) = (x + p)(x + q)$, where $|pq| = |c|$ leading to $x = \dots$

$(ax^2 + bx + c) = (mx + p)(nx + q)$, where $|pq| = |c|$ and $|mn| = |a|$ leading to $x = \dots$

2. Formula

Attempt to use correct formula (with values for a, b and c)

3. Completing the square

Solving $x^2 + bx + c = 0$: $(x \pm \frac{b}{2})^2 \pm q \pm c$, $q \neq 0$ leading to $x = \dots$

Method marks for differentiation and integration:

1. Differentiation

Power of at least one term decreased by 1 ($x^n \rightarrow x^{n-1}$)

2. Integration

Power of at least one term increased by 1 ($x^n \rightarrow x^{n+1}$)

Use of a formula

Where a method involves using a formula that has been learnt, the advice given in recent examiners' reports is that the formula should be quoted first.

Normal marking procedure is as follows:

Method mark for quoting a correct formula and attempting to use it, even if there are small mistakes in the substitution of values.

Where the formula is not quoted, the method mark can be gained by implication from correct working with values, but may be lost if there is any mistake in the working.

Exact answers

Examiners' reports have emphasised that where, for example, an exact answer is asked for, or working with surds is clearly required, marks will normally be lost if the candidate resorts to using rounded decimals.

Answers without working

The rubric says that these may not gain full credit. Individual mark schemes will give details of what happens in particular cases. General policy is that if it could be done "in your head", detailed working would not be required. Most candidates do show working, but there are occasional awkward cases and if the mark scheme does not cover this, please contact your team leader for advice.

Question Number	Scheme	Marks
1(a)	$4(x-5) < 2x-9 \Rightarrow 4x-20 < 2x-9 \Rightarrow x < \dots$	M1
	$\Rightarrow x < \frac{11}{2}$	A1
		(2)
(b)	$2x^2 - 5x - 63 = 0 \Rightarrow (2x+9)(x-7) = 0 \Rightarrow x = -\frac{9}{2}, 7$	M1
	$-\frac{9}{2} \leq x \leq 7$	dM1 A1
		(3)
(c)	$-\frac{9}{2} \leq x < \frac{11}{2}$	B1
		(1)
		(6 marks)

Notes

(a)

M1: Attempts to expand the brackets or e.g. divide by 4, collect terms and proceeds to $x \square \dots$ where $\square$ is any inequality or “=”.

A1: $x < \frac{11}{2}$ oe e.g. $x < 5.5, (-\infty, 5.5)$ Apply isw once a correct answer is seen.

(b)

M1: Multiplies out the brackets, rearranges and attempts to solve a 3TQ by any **non-calculator** means. Apply the general guidance for solving a 3TQ by factorisation, formula or completing the square. If roots are just written down, this scores M0

Note that e.g. $2x^2 - 5x - 63 = 0 \Rightarrow x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = -\frac{9}{2}, 7$ scores M0

But $2x^2 - 5x - 63 = 0 \Rightarrow x = \frac{5 \pm \sqrt{5^2 - 4(-63)(2)}}{2 \times 2}$ or $\frac{5 \pm 23}{4} = -\frac{9}{2}, 7$ scores M1

dM1: Chooses the inside region for their critical values found via a non-calculator method.

Condone strict inequalities e.g. $-\frac{9}{2} < x < 7$ or e.g. $x > -\frac{9}{2}, x < 7$

Depends on the previous mark.

A1: $-\frac{9}{2} \leq x \leq 7$ Allow “ $x \geq -\frac{9}{2}$ **and** $x \leq 7$ ” or $\left[-\frac{9}{2}, 7\right]$ or $7 \geq x \geq -\frac{9}{2}$

but **not** “ $x \geq -\frac{9}{2}$ or $x \leq 7$ ” and not “ $x \geq -\frac{9}{2}, x \leq 7$ ”

Apply isw once a correct answer is seen but there must be no contradictory inequalities.

(c)

B1: $-\frac{9}{2} \leq x < \frac{11}{2}$ Allow “ $x \geq -\frac{9}{2}$ **and** $x < \frac{11}{2}$ ” or $\left[-\frac{9}{2}, \frac{11}{2}\right)$ or $\frac{11}{2} > x \geq -\frac{9}{2}$

but **not** “ $x \geq -\frac{9}{2}$ or $x < \frac{11}{2}$ ” and not “ $x \geq -\frac{9}{2}, x < \frac{11}{2}$ ”

Apply isw once a correct answer is seen but there must be no extra inequalities.

Question Number	Scheme	Marks
2(i)	Uses a correct law of indices on 4^{2y+1} or 32^{4y} The possibilities are endless but some more common examples are: For 4^{2y+1}: $4^{2y} \times 4$, $2^{2(2y+1)}$, $(2^2)^{2y} \times 2^2$ For 32^{4y}: $(2^5)^{4y}$, $2^{5 \times 4y}$, 2^{20y}, $\left(4^{\frac{5}{2}}\right)^{4y}$, 4^{10y}	M1
	e.g. $2^{4y+2} = \frac{2^{20y}}{2} \Rightarrow 2^{4y+3} = 2^{20y} \Rightarrow 4y+3 = 20y \Rightarrow y = \dots$ or e.g. $4^{2y+1} = \frac{4^{10y}}{2} \Rightarrow 4^{2y+1} = 4^{10y - \frac{1}{2}} \Rightarrow 2y+1 = 10y - \frac{1}{2} \Rightarrow y = \dots$	dM1
	$y = \frac{3}{16}$	A1
		(3)
(i) Notes This part of the question can be solved in many different ways. If you are unsure if a particular approach deserves credit, seek advice from your TL M1: This is effectively a B mark and is for applying a correct law of indices on 4^{2y+1} or 32^{4y} This may be seen in isolation i.e. not necessarily within the equation but not just e.g. $4 = 2^2$ See scheme for some examples. dM1: Reaches a value for y condoning arithmetic slips but with no incorrect index work e.g. $2 \times 4^{2y} = 8^{2y} \text{ or e.g. } \frac{4^{10y}}{2} = 2^{10y} \text{ or e.g. } \frac{32^{4y}}{2} = 16^{4y}$ See main scheme for examples of acceptable work. See also supplementary document for some example responses with marks. Depends on the first method mark. A1: Fully correct work leading to $y = \frac{3}{16}$ or e.g. $y = \frac{6}{32}$ or 0.1875 following award of both Method marks. Correct answers with no working in (i) score no marks.		

See extra document for some examples.

(ii)	$x\sqrt{27} + 21 = \frac{6x}{\sqrt{3}}$	
	E.g. $\sqrt{27} = 3\sqrt{3}$, $\frac{6}{\sqrt{3}} = \frac{6\sqrt{3}}{3}$ or $2\sqrt{3}$, $\sqrt{27} \times \sqrt{3} = 9$	B1
	$(3\sqrt{3} - 2\sqrt{3})x = -21$ or e.g. $3x = -21\sqrt{3}$	M1
	$x = -\frac{21}{\sqrt{3}} = -7\sqrt{3}$	dM1 A1
		(4)
		(7 marks)
(ii) Notes B1: Correct surd work seen. E.g. $\sqrt{27} = 3\sqrt{3}$, $\frac{6}{\sqrt{3}} = \frac{6\sqrt{3}}{3}$ or $2\sqrt{3}$, $\sqrt{27} \times \sqrt{3} = 9$ M1: Attempts to collect terms in x dM1: Attempts to write the answer in the form $a\sqrt{b}$ where $\sqrt{b}$ is irrational. Depends on the previous method mark. A1: cso $x = -7\sqrt{3}$ Correct answers with no working in (ii) score no marks.		

Question Number	Scheme	Marks
3(a)	$f(x) = \frac{16 + 24\sqrt{x} + 9x}{x}$	
	$= 16x^{-1} + 24x^{-\frac{1}{2}} + 9$	M1 A1
	$(f'(x) =) -16x^{-2} - 12x^{-\frac{3}{2}}$	M1 A1 A1cso
		(5)

(a) Notes

M1: Expands the numerator into a **3 or 4 term** quadratic expression in $\sqrt{x}$ **and** attempts to divide each term by x .

Award this mark for $(4 + 3\sqrt{x})^2 \rightarrow p + q\sqrt{x} + rx$ (or $(\sqrt{x})^2$), $p, q, r \neq 0$ followed by at least one of,

$\frac{p}{x}$ or $\frac{q}{\sqrt{x}}$ oe or r .

A1: Correct expression e.g. $16x^{-1} + 24x^{-\frac{1}{2}} + 9$ or equivalent e.g. $\frac{16}{x}$ for $16x^{-1}$ or $\frac{12}{\sqrt{x}} + \frac{12}{\sqrt{x}}$ for $24x^{-\frac{1}{2}}$

M1: Reduces a **correct index of x** by 1 when differentiating.

It is for one of $\dots x^{-1} \rightarrow \dots x^{-2}$ or $\dots x^{\frac{1}{2}} \rightarrow \dots x^{-\frac{1}{2}}$ or $\dots x^{-1} \rightarrow \dots x^{-1-1}$ or $\dots x^{\frac{1}{2}} \rightarrow \dots x^{-\frac{1}{2}-1}$

A1: One correct simplified term.

It is for $-16x^{-2}$ oe e.g. $-\frac{16}{x^2}$ or for $-12x^{-\frac{3}{2}}$ oe e.g. $-\frac{12}{x^{\frac{3}{2}}}$

Apply isw once a correct simplified term is seen.

A1cso: Fully correct and simplified expression $-16x^{-2} - 12x^{-\frac{3}{2}}$ oe e.g. $-\frac{16}{x^2} - \frac{12}{x^{\frac{3}{2}}}$

Do not allow e.g. $-\frac{16}{x^2} + -\frac{12}{x^{\frac{3}{2}}}$ and do not allow $-\frac{16}{x^2} - \frac{12}{x^{\frac{3}{2}}} + c$

Apply isw once a correct simplified expression is seen. " $f'(x) =$ " is not required.

See next page for attempts to use the product or quotient rule.

Special case:

It is possible to obtain a correct derivative with an incorrect expansion in the numerator e.g.

$$f(x) = \frac{16 + 24\sqrt{x} + kx}{x} = \frac{16}{x} + 24x^{-\frac{1}{2}} + k \Rightarrow (f'(x) =) -16x^{-2} - 12x^{-\frac{3}{2}}$$

If k is incorrect, this scores SC M1A0M1A1A0 in (a) but allow full recovery in (b)

(b)	$f'(4) = -1 - \frac{12}{8} = -2\frac{1}{2}$	M1
	$y - 25 = -\frac{5}{2}(x - 4) \Rightarrow y = -\frac{5}{2}x + 35$ or $y = -\frac{5}{2}x + c \Rightarrow 25 = -\frac{5}{2} \times 4 + c \Rightarrow c = \dots$ $\Rightarrow y = -\frac{5}{2}x + 35$	dM1 A1
		(3)
		8 marks

(b) Notes

M1: Substitutes $x = 4$ into their $f'(x)$ from part (a) to find a value which may be implied. There must have been an attempt to differentiate so do not allow for finding e.g. $f(4)$. If no substitution is seen and their value is incorrect for their derivative (you may need to check) then score M0

dM1: Attempts an equation of the tangent (**not the normal**) at (4, 25) using a correct method with the values correctly placed. If using $y = mx + c$ must reach as far as finding a value for c .

Depends on the first method mark.

A1: $y = -\frac{5}{2}x + 35$ or e.g. $y = -2.5x + 35$

Part (a) Using quotient rule:

$$f(x) = \frac{(4 + 3\sqrt{x})^2}{x} \Rightarrow f'(x) = \frac{x \times 2(4 + 3\sqrt{x}) \times \frac{3}{2}x^{-\frac{1}{2}} - (4 + 3\sqrt{x})^2}{x^2}$$

$$\text{M1 for } f'(x) = \frac{\dots x(4 + 3\sqrt{x}) \times x^{-\frac{1}{2}} - (4 + 3\sqrt{x})^2}{x^2}$$

A1 can then be scored for fully correct differentiation

Then,

M1 for an attempt to expand, collect terms and simplify to obtain $\frac{\dots x^{\frac{1}{2}} + \dots}{x^2}$

$$\text{A1 for } \frac{-12x^{\frac{1}{2}} - 16}{x^2}$$

$$\text{A1 for } -\frac{16}{x^2} - \frac{12}{x^{\frac{3}{2}}}$$

Part (a) Using product rule:

$$f(x) = \frac{(4 + 3\sqrt{x})^2}{x} = x^{-1}(4 + 3\sqrt{x})^2 \Rightarrow f'(x) = x^{-1} \times 2(4 + 3\sqrt{x}) \times \frac{3}{2}x^{-\frac{1}{2}} + (4 + 3\sqrt{x})^2 \times -x^{-2}$$

$$\text{M1 for } f'(x) = \dots x^{-1}(4 + 3\sqrt{x}) \times x^{-\frac{1}{2}} + \dots (4 + 3\sqrt{x})^2 x^{-2}$$

A1 can then be scored for fully correct differentiation

Then,

M1 for an attempt to expand, collect terms and simplify to obtain $\dots x^{-\frac{3}{2}}$ or $\dots x^{-2}$
Then the **A** marks as in the main scheme.

Question Number	Scheme	Marks
4(a)(i)	(0, 4)	B1
(ii)	(6, 13)	B1
(a) Notes (i) B1: Allow the coordinates to be written separately as $x = \dots, y = \dots$ and allow $y = 4$ as long as there is no suggestion that x is anything other than 0. Condone missing brackets e.g. 0, 4 or unusual punctuation e.g. (0;4) or a vector e.g. $\begin{pmatrix} 0 \\ 4 \end{pmatrix}$ Do not allow coordinates the wrong way round unless the correct answer is seen previously then apply isw. Condone $\frac{8}{2}$ for 4. Do not allow $P = 4$ (ii) B1: Allow the coordinates to be written separately as $x = \dots, y = \dots$ Condone missing brackets e.g. 6, 13 or unusual punctuation e.g. (6;13) or a vector e.g. $\begin{pmatrix} 6 \\ 13 \end{pmatrix}$ Do not allow coordinates the wrong way round unless the correct answer is seen previously then apply isw. Condone $\frac{26}{2}$ for 13. Allow work that implies the correct coordinates e.g. $x = 6 \rightarrow 2y = 18 + 8 = 26 \rightarrow y = 13$		

(b)	The gradient of line $l_1 = \frac{3}{2}$ oe	B1
	Perpendicular gradient " $-\frac{2}{3}$ "	M1
	$y - "13" = "-\frac{2}{3}"(x - 6)$ or $y = "-\frac{2}{3}"x + c \Rightarrow "13" = "-\frac{2}{3}" \times 6 + c \Rightarrow c = \dots$	M1
	$2x + 3y - 51 = 0$	A1
		(4)
(c)	$y = 0 \Rightarrow 2x - 51 = 0 \Rightarrow x = \dots \left(\frac{51}{2} \right)$	M1
	Full and correct method of finding required area e.g. trapezium + triangle: $\frac{6}{2}("4" + "13") + \frac{1}{2} \times "13" \times \left(" \frac{51}{2} " - 6 \right)$	dM1
	$= 177.75$	A1
		(3)
		(9 marks)

Notes

(b)

B1: The gradient of line $l_1 = \frac{3}{2}$ oe which may be implied.

M1: Attempts $l_2 = -\frac{1}{\text{their gradient of } l_1}$ which may be implied.

M1: Uses $x = 6$ and their y coordinate of Q with a changed " $\frac{3}{2}$ " in an attempt to find an equation for l_2 using a correct method with the values correctly placed.

If using $y = mx + c$ must reach as far as finding a value for c .

A1: $2x + 3y - 51 = 0$ or any integer multiple of this equation. (Allow terms in any order).

(c)

M1: Substitutes $y = 0$ into their equation from part (b) to find the x coordinate of R .

dM1: For a full and correct method using their values to find the area of shape $OPQR$
e.g. trapezium + triangle. (See scheme)

e.g. rectangle + triangle + triangle $"4" \times 6 + \frac{6}{2}("13" - "4") + \frac{1}{2} \times "13" \times \left(" \frac{51}{2} " - 6 \right)$

e.g. triangle PQR + triangle OPR $\frac{1}{2} \sqrt{\left(6 - " \frac{51}{2} " \right)^2 + "13"^2} \times \sqrt{6^2 + ("13" - "4")^2} + \frac{1}{2} \times " \frac{51}{2} " \times "4"$

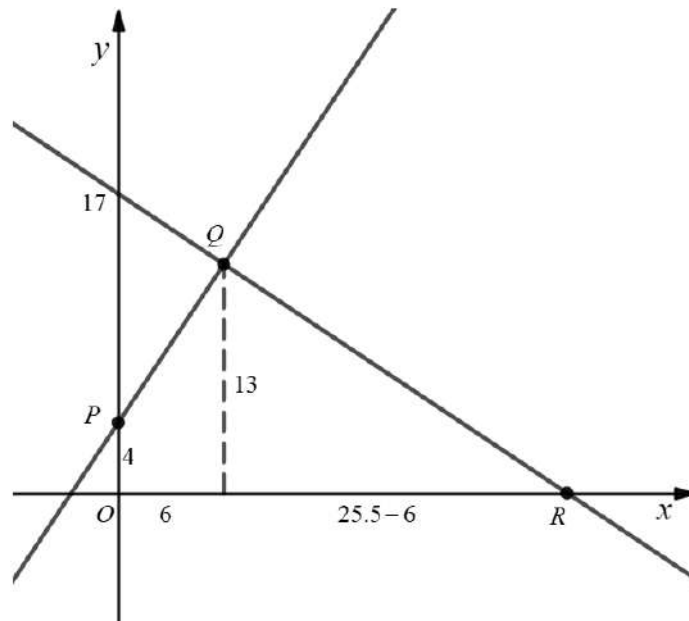
e.g. rectangle + triangle - triangle $6 \times "13" - \frac{1}{2}("13" - "4") \times 6 + \frac{1}{2} \times "13" \times \left(" \frac{51}{2} " - 6 \right)$

May see shoelace method for areas e.g. for PQR : $\frac{1}{2} \begin{vmatrix} 0 & \frac{51}{2} & 6 & 0 \\ 4 & 0 & 13 & 4 \end{vmatrix} = \frac{1}{2} \left(\frac{51}{2} \times 13 + 6 \times 4 - \frac{51}{2} \times 4 \right)$

Depends on the first method mark.

A1: 177.75 oe e.g. $\frac{711}{4}$

4(c) Further guidance:



There are lots of different methods to find the total area so look carefully at their work.

e.g. triangle – triangle: $\frac{1}{2} \times 17 \times 25.5 - \frac{1}{2} (17 - 4) \times 6$

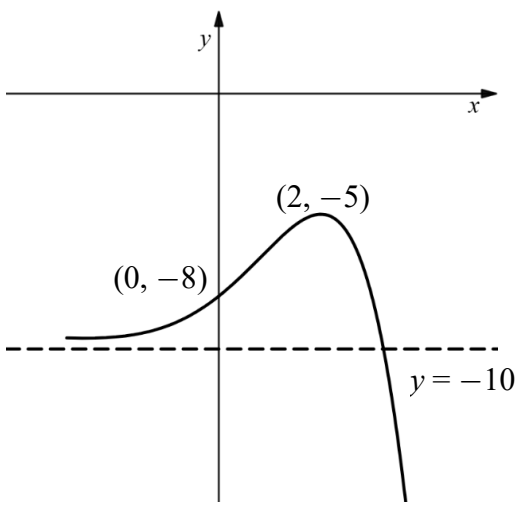
An unusual one is triangle OPQ + triangle OQR = $\frac{1}{2} \times 4 \times 6 + \frac{1}{2} \times 25.5 \times 13$

Allow integration attempts e.g. $\int_0^6 \left(\frac{3}{2}x + 4 \right) dx + \int_6^{25.5} \left(17 - \frac{2}{3}x \right) dx = \dots$

In this case, an attempt to evaluate the expression as shown is fine for the method mark and allow A1 if correctly evaluated on a calculator.

If you are unsure if a particular method deserves credit then use Review.

Question Number	Scheme	Marks
5(a)	(8, 5)	B1
		(1)
(b)	$y = 7$	B1
		(1)
(c)	$5 < k < 10$	M1A1
		(2)
Notes		
(a)		
B1: Accept (8, 5) or $x = 8, y = 5$ or a sketch of $y = f\left(\frac{1}{4}x\right)$ with a minimum point marked at (8, 5)		
Condone missing brackets e.g. 8, 5 or unusual punctuation e.g. (8; 5) or a vector e.g. $\begin{pmatrix} 8 \\ 5 \end{pmatrix}$		
Do not allow coordinates the wrong way round unless the correct form is seen previously then apply isw.		
(b)		
B1: $y = 7$. It must be an equation and not just '7'		
(c)		
M1: For one “end” of the interval condoning strictness so allow for $k > 5$, $k \geq 5$, $k < 10$, $k \leq 10$		
Condone use of x or y rather than k for this mark.		
A1: $5 < k < 10$. Allow “ $k > 5$ and $k < 10$ ”, $(5, 10)$, $\{k \in \mathbb{R} : 5 < k < 10\}$		
Must be in terms of k .		
Do not allow “ $k > 5$ or $k < 10$ ” or “ $k > 5$, $k < 10$ ”		

(d)		Shape	B1
		(0, -8) and (2, -5)	B1
		Asymptote	B1
			(3)
			(7 marks)

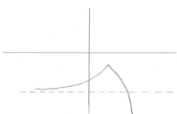
(d) Notes

There must be a sketch to score any marks.

If the original curve is included on their sketch it can be ignored.

If more than 1 sketch is given, mark the final attempt.

- B1: For a reflection of the original curve in the x -axis.
 The curve must be in quadrants 3 and 4 only.
 There should be a maximum in quadrant 4.

Condone a maximum that is cusp-like e.g.  as long as the intention is clear.

The right hand tail should be below the left hand tail i.e. must at least touch the asymptote if it was drawn.

Condone a right hand tail that starts to bend to the right as long as it does not head back towards the x -axis to create a clear minimum.

The coordinates of the y intercept, the maximum and the position of the asymptote can be ignored for this mark.

- B1: For the intercept of (0, -8) and the maximum point (2, -5) correctly labelled that correspond with the sketch.

Allow -8 marked in the correct place and condone (-8, 0) as long as it is the correct place.

Allow the (2, -5) to be indicated by the labels 2 and -5 on the appropriate axes.

Allow to appear away from the sketch but they must be fully correct.

If there is any ambiguity, the sketch takes precedence.

- B1: For the asymptote equation of $y = -10$ that corresponds with their sketch.

It must be an **equation** i.e. not just -10 marked on the y -axis.

The curve must be asymptotic to $y = -10$ from above for one of the branches.

See extra document for some example sketches.

Question Number	Scheme	Marks
6(a)	$\frac{\sin DAO}{1.8} = \frac{\sin 0.84}{3.9} \Rightarrow DAO = \text{awrt } 0.351$ (NB $\sin DAO = 0.343681\dots$)	M1A1
		(2)
(b)	Angle $ADO = \pi - 0.84 - '0.351' = (1.95)$	M1
	Uses $AO^2 = 1.8^2 + 3.9^2 - 2 \times 1.8 \times 3.9 \cos '1.95' \Rightarrow AO = \dots$	M1
	$AO = \text{awrt } 4.86 \text{ (m)}$	A1
		(3)
	(b) Alternative 1	
	$3.9^2 = 1.8^2 + AO^2 - 2 \times 1.8 \times AO \cos 0.84$	M1
	$AO^2 - 2.41AO - 11.97 = 0 \Rightarrow AO = 4.86, \cancel{2.46}$	M1A1
	(b) Alternative 2	
	$1.8^2 = 3.9^2 + AO^2 - 2 \times 3.9 \times AO \cos '0.351'$	M1
	$AO^2 - 7.32AO + 11.97 = 0 \Rightarrow AO = 4.86, \cancel{2.46}$	M1A1
	(b) Alternative 3	
	$ON = 1.8 \cos 0.84$ or $AN = 3.9 \cos '0.351'$ (See diagram below for position of N)	M1
	$AO = 1.8 \cos 0.84 + 3.9 \cos '0.351' = \dots$	M1
	$AO = \text{awrt } 4.86 \text{ (m)}$	A1

Notes

(a)

M1: Uses the sine rule in an attempt to find angle DAO which is not their $\sin DAO$.

The sides and angles must be in the correct position within the formula.

A1: Proceeds correctly to obtain $DAO = \text{awrt } 0.351$

Do not be concerned with incorrect labels or notation e.g. $AOD = \text{awrt } 0.351$ if the intention is clear.

For the rest of the question, allow the method marks for the use of what they think is angle DAO e.g. even if they use 0.3436...

(b)

M1: States or uses angle $ADO = \pi - 0.84 - \text{their } 0.351$ (Must be seen in (b))

May be implied by $ADO = \text{awrt } 1.95$ (rads) or by their value.

M1: Uses $AO^2 = 1.8^2 + 3.9^2 - 2 \times 1.8 \times 3.9 \cos(k\pi - 0.84 - \text{their } 0.351)$ or

$$\frac{AO}{\sin(k\pi - 0.84 - \text{their } 0.351)} = \frac{3.9}{\sin 0.84} \text{ with } k = 1 \text{ or } 2 \text{ in an attempt to find a value for } AO.$$

A1: For $AO = \text{awrt } 4.86 \text{ (m)}$ Units are not required but if any are given they must be correct.

Alternative 1:

M1: Sets up a correct quadratic equation in AO using the cosine rule with angle AOD .

M1: Collects terms, simplifies and solves a 3TQ in AO or their variable.

A1: For $AO = \text{awrt } 4.86 \text{ (m)}$ Units are not required but if any are given they must be correct.

Alternative 2:

M1: Sets up a correct quadratic equation in AO using the cosine rule with angle DAO .

M1: Collects terms, simplifies and solves a 3TQ in AO or their variable.

A1: For $AO = \text{awrt } 4.86 \text{ (m)}$ Units are not required but if any are given they must be correct.

Alternative 3:

M1: Correct attempt at either ON or AN

M1: Complete method to find a value for AO

A1: For $AO =$ awrt 4.86 (m) Units are not required but if any are given they must be correct.

Must come from correct work in part (a) unless they re-start.

(c)	$\text{Area of sector} = \frac{1}{2} \times 1.8^2 \times (2\pi - 0.84) \quad (= \text{awrt } 8.8)$ $(\text{NB } 2\pi - 0.84 = 5.44318\dots)$ or $\text{Area of triangle} = \frac{1}{2} \times 1.8 \times "4.9" \times \sin 0.84 \quad (= \text{awrt } 3.3)$ $\text{Or Area of triangle} = \frac{1}{2} \times 1.8 \times 3.9 \times \sin(\pi - 0.84 - "0.351") \quad (= \text{awrt } 3.3)$	M1
	$\text{Total Area} = \frac{1}{2} \times 1.8^2 \times (2\pi - 0.84) + \frac{1}{2} \times 1.8 \times "4.9" \times \sin 0.84 = \dots$	dM1
	$= 12.1 \text{ (m}^2\text{)}$	A1
		(3)
(d)	$\text{Arc } BCD = 1.8 \times (2\pi - 0.84) \quad (= 9.8)$	M1
	$'9.8' + 3.9 + "4.86" - 1.8 = \dots \text{ or e.g.}$ $2\pi \times 1.8 - 0.84 \times 1.8 + "4.86" - 1.8 + 3.9 = \dots$	dM1
	$\text{Perimeter of shop sign} = 16.8 \text{ (m)}$	A1
		(3)
		(11 marks)

Notes

(c)

M1: Correct attempt at the area of sector *DOBCD* **or** the area of triangle *ADO* following through their *AO* from part (b). There may be other methods seen for these areas e.g.

The area of the sector may be seen as $\pi \times 1.8^2 - \frac{1}{2} \times 1.8^2 \times 0.84$

The area of the triangle may be seen as $\frac{1}{2} \times 1.8 \times 3.9 \times \sin(\pi - 0.84 - "0.351")$ or

$\frac{1}{2} \times (1.8 \cos 0.84 + 3.9 \cos "0.351") \times 1.8 \sin 0.84$ or $= \frac{1}{2} \times 3.9 \times "4.86" \times \sin "0.351"$

dM1: Complete and correct attempt at the area of the shop sign e.g.

$$\frac{1}{2} \times 1.8^2 \times (2\pi - 0.84) + \frac{1}{2} \times 1.8 \times "4.9" \times \sin 0.84$$

Depends on the previous mark.

A1: For awrt 12.1 Units are not required but if any are given they must be correct.

Note that it is also possible via Circle + Triangle – Minor sector

e.g. $\pi \times 1.8^2 + \frac{1}{2} \times 1.8 \times "4.9" \times \sin 0.84 - \frac{1}{2} \times 1.8^2 \times 0.84$

In these cases, the scheme can be applied in the same way i.e. M1 for area of Circle – Minor sector or area of triangle and dM1 for a complete and correct method Circle + Triangle – Minor sector

Must come from correct work in part (a) unless they re-start.

(d)

M1: Attempt to find the length of the major arc using a correct method.

Accept $1.8 \times (2\pi - 0.84)$ or equivalent e.g. $2\pi \times 1.8 - 0.84 \times 1.8$

dM1: Complete and correct method for the perimeter.

A1: Awrt 16.8 Units are not required but if any are given they must be correct.

Must come from correct work in parts (a) and (b) unless they re-start.

Attempts using **degrees** are acceptable and values and example working are as follows:

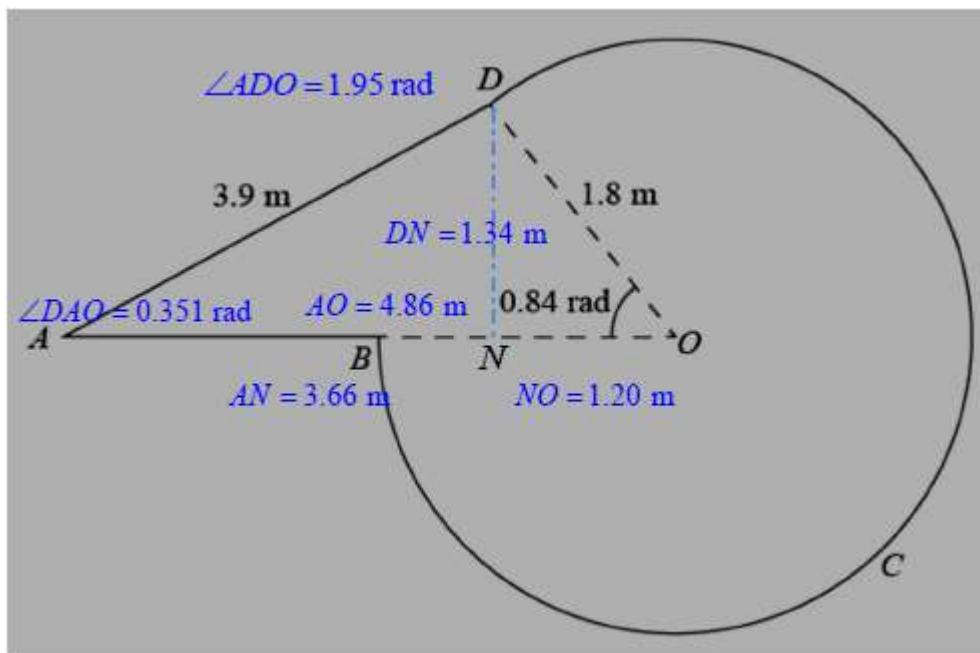
(a) M1: $\frac{\sin DAO}{1.8} = \frac{\sin 48}{3.9}$ A1: $DAO = 20.1^\circ = \text{awrt } 0.351$

(b) M1: $ADO = \pi - 48^\circ - \text{their } 20.1^\circ$ M1: $AO^2 = 1.8^2 + 3.9^2 - 2 \times 1.8 \times 3.9 \cos 111.8^\circ$

(c) M1: $\frac{360^\circ - 48^\circ}{360} \times \pi \times 1.8^2$ or $\frac{1}{2} \times 1.8 \times 4.9 \sin 48^\circ$ dM1 $\frac{360^\circ - 48^\circ}{360} \times \pi \times 1.8^2 + \frac{1}{2} \times 1.8 \times 4.9 \sin 48^\circ$

(d) M1: Arc length $\frac{360^\circ - 48^\circ}{360} \times 2\pi \times 1.8$

Diagram for reference:



Question Number	Scheme	Marks
7(a)	$(f(x)=) \int \left(3\sqrt{x} - \frac{9}{x\sqrt{x}} + \frac{4}{3} \right) dx = \int \left(3x^{\frac{1}{2}} - 9x^{-\frac{3}{2}} + \frac{4}{3} \right) dx$ $= \frac{3x^{\frac{3}{2}}}{\frac{3}{2}} - \frac{9x^{-\frac{1}{2}}}{-\frac{1}{2}} + \frac{4}{3}x (+c)$	M1 A1 A1
	$x = 9, y = 20 \rightarrow 20 = \frac{3(9)^{\frac{3}{2}}}{\frac{3}{2}} - \frac{9(9)^{-\frac{1}{2}}}{-\frac{1}{2}} + \frac{4}{3}(9) + c \Rightarrow c = \dots$	dM1
	$(f(x)=) 2x^{\frac{3}{2}} + 18x^{-\frac{1}{2}} + \frac{4}{3}x - 52$	A1
		(5)

(a) Notes

M1: Evidence of integration, so $x^n \rightarrow x^{n+1}$ at least once on a correct index.

It is for $3\sqrt{x} \rightarrow \dots x^{\frac{3}{2}}$ or $\frac{9}{x\sqrt{x}} \rightarrow \dots x^{-\frac{1}{2}}$ or $\frac{4}{3} \rightarrow \frac{4}{3}x$

Allow unprocessed indices e.g. $3\sqrt{x} \rightarrow \dots x^{\frac{1}{2}+1}$ or $\frac{9}{x\sqrt{x}} \rightarrow \dots x^{-\frac{3}{2}+1}$ or $\frac{4}{3} \rightarrow \frac{4}{3}x^{0+1}$

A1: One correct term which may be unsimplified but indices must be processed.

A1: Fully correct unsimplified or simplified expression.

The “+ c” is not required and $f(x) =$ is not required.

Ignore any spurious notation e.g. integral symbols.

dM1: Uses $x = 9$ and $y = 20$ in a changed expression to find their c .

Dependent upon the first method mark.

A1: $(f(x)=) 2x^{\frac{3}{2}} + 18x^{-\frac{1}{2}} + \frac{4}{3}x - 52$

Allow simplified equivalents e.g. $(f(x)=) 2x\sqrt{x} + \frac{18}{\sqrt{x}} + \frac{4}{3}x - 52$

$f(x) =$ is not required so just look for the correct expression.

Apply isw once a correct expression is seen.

If they find their constant in (b), allow the marks for that work to be scored here.

(b)	$f'(9) = 10$	B1
	Gradient of normal is $-\frac{1}{f'(9)}$	M1
	$(y - 20) = -\frac{1}{10}(x - 9)$ or $y = -\frac{1}{10}x + c \Rightarrow 20 = -\frac{1}{10} \times 9 + c \Rightarrow c = \dots$	dM1
	$x + 10y - 209 = 0$	A1
		(4)
		9 marks

(b) Notes

B1: For $f'(9) = 10$ which may be implied by the gradient of normal $= -\frac{1}{10}$

M1: For gradient of normal $= -\frac{1}{\text{their } f'(9)}$ where $f'(9)$ is an attempt to substitute $x = 9$ into the given $f'(x)$

dM1: Correct method for the equation of the normal using $x = 9, y = 20$ and a changed $f'(9)$ with the values correctly placed.

If they use $y = mx + c$ they must proceed as far as finding a value for c .

Dependent upon the previous method mark.

A1: cso $x + 10y - 209 = 0$ or any integer multiple of this equation in the required form.

Question Number	Scheme	Marks
8	$kx^2 + 8x + 2(k+7) = 0$	
	$b^2 - 4ac = 8^2 - 4k \times 2(k+7)$	M1
	$8^2 - 4k \times 2(k+7) = 64 - 8k^2 - 56k$	A1
	Attempts to solve $b^2 - 4ac \dots 0 \Rightarrow k^2 + 7k - 8 \dots 0 \Rightarrow k =$	dM1
	Critical values of 1 and -8	A1
	$k > 1$ or $k < -8$	ddM1 A1
		(6)
		6 marks

Notes

M1: Attempts $b^2 - 4ac$ with $a = k$, $b = 8$ and $c = 2(k+7)$

Condone slips with the $2(k+7)$ e.g. uses $2k+7$ or $k+7$ and condone missing brackets e.g.

$$b^2 - 4ac = 8^2 - 4k \times 2k + 14$$

May be seen embedded in an attempt to use the quadratic formula.

May also be seen in an attempt at an equation or inequality e.g. $b^2 - 4ac \dots 0$ or $b^2 < 4ac$ or e.g.

$$b^2 > 4ac$$

A1: Correct 3 term quadratic expression seen e.g. $64 - 56k - 8k^2$ which may be seen as an inequality or an equation e.g. $64 < 56k + 8k^2$ or $64 = 56k + 8k^2$ or $8 - 7k - k^2$. Allow 8^2 for 64.

Any brackets must be removed.

dM1: Attempts to find the critical values from a 3 term quadratic equation or inequality resulting from $b^2 - 4ac \dots 0$ or equivalent where ... can be any inequality or equality via **non calculator** methods.

Depends on the first method mark.

Do not allow for quoting the quadratic formula quoted followed by values e.g.

$$8k^2 + 56k - 64 = 0 \Rightarrow k = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = 1, -8 \text{ is M0}$$

$$\text{But allow e.g. } 8k^2 + 56k - 64 = 0 \Rightarrow k = \frac{-56 \pm \sqrt{56^2 - 4 \times 8 \times (-64)}}{2 \times 8} = 1, -8 \text{ is M1}$$

Do not allow obvious use of a calculator where the factors do not correspond with their 3TQ

$$\text{e.g. } 8k^2 + 56k - 64 = 0 \Rightarrow (k-1)(k+8) = 0 \Rightarrow k = 1, -8 \text{ is M0}$$

$$\text{but allow e.g. } 8k^2 + 56k - 64 = 0 \Rightarrow 8(k-1)(k+8) = 0 \Rightarrow k = 1, -8 \text{ is M1}$$

A1: Correct critical values. May be implied by e.g. $k^2 + 7k - 8 > 0 \Rightarrow (k-1)(k+8) > 0 \Rightarrow k > 1, k < -8$

ddM1: Chooses the outside region for their critical values. Condone e.g. $1 < k < -8$ for this mark.

Condone the boundaries being included in the inequality and condone the use of x rather than k . The evidence for choosing the outside region must be taken from what they write down and not from e.g. a sketch.

It is dependent upon both previous Method marks.

A1: CSO $k > 1$ or $k < -8$ o.e. Must be in terms of k .

The following are acceptable:

$k > 1, k < -8$	$k > 1 \text{ and } k < -8$	$k > 1 \text{ or } k < -8$	$k > 1 \cup k < -8$
$(0, -8), (1, \infty)$	$\{k : k > 1, k < -8\}$	$k > 1 \quad k < -8$	

Question Number	Scheme	Marks
9(a)	2	B1
		(1)
(b)	1	B1
		(1)
(c)	200	B1
		(1)
(d)	0	B1
		(1)
		4 marks

Notes

You may see diagrams, calculations etc, BUT you are looking for the final answers of:

(a)

B1: 2 or equivalent e.g. “two”

(b)

B1: 1 or equivalent e.g. “one”

(c)

B1: 200 or equivalent e.g. “two hundred”

(d)

B1: 0 or equivalent e.g. “none”, “no solutions”, “no real solutions”

If more than one answer is given in any part, mark the final answer.

Question Number	Scheme	Marks
10(a)	$(f(x)=)k(x+1)(x-4)^2$	M1 A1
	Uses $(0,12) \Rightarrow 12 = 16k \Rightarrow k = \dots$	dM1 A1
	$(f(x)=)\frac{3}{4}(x+1)(x-4)^2$	
		(4)
	(a) Alternative 1 by simultaneous equations	
	$(f(x)=)ax^3 + bx^2 + cx + d$ $(0, 12) \rightarrow d = 12$ $(-1, 0) \rightarrow 0 = -a + b - c + 12$ $(4, 0) \rightarrow 0 = 64a + 16b + 4c + 12$ $f'(x) = 3ax^2 + 2bx + c \rightarrow 0 = 48a + 8b + c$	M1 A1
	$a = \frac{3}{4}, b = -\frac{21}{4}, c = 6 \rightarrow (f(x)=)\frac{3}{4}x^3 - \frac{21}{4}x^2 + 6x + 12$	dM1 A1
	(a) Alternative 2 using roots	
	$(f(x)=)ax^3 + bx^2 + cx + d$ $(0, 12) \rightarrow d = 12$ Sum: $4 + 4 - 1 = -\frac{b}{a}$, Pair sum: $-4 - 4 + 16 = \frac{c}{a}$, product: $-16 = -\frac{12}{a}$	M1 A1
	$a = \frac{3}{4}, b = -\frac{21}{4}, c = 6 \rightarrow (f(x)=)\frac{3}{4}x^3 - \frac{21}{4}x^2 + 6x + 12$	dM1 A1

(a) Notes

In part (a) “f(x)=” is not required so just look the correct expression.

M1: States or implies that $(f(x)=)k(x \pm 1)(x \pm 4)^2$ allowing for $k = 1$

A1: States or implies that $(f(x)=)k(x+1)(x-4)^2$ allowing for $k = 1$

dM1: Uses $(0,12)$ in $(f(x)=)k(x \pm 1)(x \pm 4)^2$ to find a value for k

Depends upon the first method mark.

A1: $(f(x)=)\frac{3}{4}(x+1)(x-4)^2$ oe e.g. $(f(x)=)\frac{3}{4}(x+1)(4-x)^2$

Condone a spurious “= 0” e.g. $(f(x)=)\frac{3}{4}(x+1)(x-4)^2 = 0$ Apply isw once a correct answer is seen.

Alternative 1:

M1: Starts with a general cubic and uses the given information to produce 3 equations in 3 unknowns.

A1: Correct equations including $d = 12$.

dM1: Solves to find all unknowns. You do not need to check the working as long as all values are found.

A1: $(f(x)=)\frac{3}{4}x^3 - \frac{21}{4}x^2 + 6x + 12$ oe. Condone a spurious “= 0” e.g. $(f(x)=)\frac{3}{4}x^3 - \frac{21}{4}x^2 + 6x + 12 = 0$

Apply isw once a correct answer is seen.

Alternative 2:

M1: Starts with a general cubic and uses the correct roots to produce 3 equations in 3 unknowns.

A1: Correct equations including $d = 12$.

dM1: Solves to find all unknowns. You do not need to check the working as long as all values are found.

A1: $(f(x)=)\frac{3}{4}x^3 - \frac{21}{4}x^2 + 6x + 12$ oe. Condone a spurious “= 0” e.g. $(f(x)=)\frac{3}{4}x^3 - \frac{21}{4}x^2 + 6x + 12 = 0$

Apply isw once a correct answer is seen.

A correct function with no working scores 4/4 in (a)

(b)	$x = -1$	B1
	$\frac{3}{4} \cancel{(x+1)} (x-4)^2 = 6 \cancel{(x+1)} (x-2) \Rightarrow x^2 - 16x + 32 = 0$	M1
	$x^2 - 16x + 32 = 0 \Rightarrow (x-8)^2 = 32 \Rightarrow x = 8 \pm 4\sqrt{2}$	dM1 A1
		(4)
(b) Alternative by expanding.		
	$x = -1$	B1
	$\frac{3}{4}x^3 - \frac{21}{4}x^2 + 6x + 12 = 6(x+1)(x-2) = 6x^2 - 6x - 12$ $\Rightarrow \frac{3}{4}x^3 - \frac{45}{4}x^2 + 12x + 24 = 0$	M1
	$\frac{3}{4}x^3 - \frac{45}{4}x^2 + 12x + 24 = 0 \Rightarrow (x+1)\left(\frac{3}{4}x^2 - 12x + 24\right) = 0$ $\frac{3}{4}x^2 - 12x + 24 = 0 \Rightarrow x = \frac{12 \pm \sqrt{12^2 - 4 \times \frac{3}{4} \times 24}}{2 \times \frac{3}{4}} = 8 \pm 4\sqrt{2}$	dM1 A1
		8 marks
(b) Notes		
(b)		
B1: States $x = -1$ Condone $(-1, 0)$ You do not need to be concerned where this comes from.		
M1: Sets their $\frac{3}{4} \cancel{(x+1)} (x-4)^2 = 6 \cancel{(x+1)} (x-2)$ cancels $(x+1)$ and proceeds to a 3TQ or factorises out $(x+1)$ to obtain a 3 term quadratic factor which must be seen and it cannot be implied by their final answer(s). It is dependent upon having achieved $f(x) = k(x+1)(x-4)^2 \quad k \neq 1$		
dM1: Dependent upon the previous method mark, it is for a non-calculator method for solving their 3TQ leading to at least one value for x .		
A1: $x = 8 \pm 4\sqrt{2}$ o.e.		
Alternative:		
B1: States $x = -1$ Condone $(-1, 0)$ You do not need to be concerned where this comes from.		
M1: Expands both sides and collects terms to one side to obtain a 4 term cubic equation and then uses the factor $(x+1)$ to find a 3 term quadratic factor which must be seen and it cannot be implied by their final answer(s). It is dependent upon having achieved $f(x) = k(x+1)(x-4)^2 \quad k \neq 1$ from the main scheme or $f(x) = ax^3 + bx^2 + cx + d, \quad a \neq 1$ from alternatives 1 and 2		
dM1: Dependent upon the previous method mark, it is for a non-calculator method for solving their 3TQ leading to at least one value for x .		
A1: $x = 8 \pm 4\sqrt{2}$ o.e.		

Please check the examination details below before entering your candidate information

Candidate surname		Other names	
Centre Number		Candidate Number	

Pearson Edexcel International Advanced Level

Thursday 8 January 2026

Morning (Time: 1 hour 30 minutes) Paper reference **WMA11/01**

Mathematics ▲ ▲

International Advanced Subsidiary/Advanced Level

Pure Mathematics P1

You must have:
Mathematical Formulae and Statistical Tables (Yellow), calculator

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 9 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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1. $y = 4x^3 + \frac{3}{2\sqrt{x}} - 8 \quad x > 0$

Find, in simplest form,

(a) $\frac{dy}{dx}$ (3)

(b) $\int y \, dx$ (3)



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Question 1 continued

(Total for Question 1 is 6 marks)



2.

**In this question you must show all stages of your working.
Solutions relying on calculator technology are not acceptable.**

(a) Given

$$y - x = 4$$

and

$$2x^2 - xy = 8$$

show that

$$x^2 - 4x - 8 = 0 \quad (2)$$

(b) Hence solve the simultaneous equations

$$y - x = 4$$

$$2x^2 - xy = 8$$

writing the answers in the form $p + q\sqrt{3}$, where p and q are integers to be found.

(4)



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Question 2 continued

Handwriting practice area with 20 horizontal lines.

(Total for Question 2 is 6 marks)



3. (i) Find the range of values of z for which

$$\frac{4}{z} < 8$$

giving the answer in simplest form.

(2)

(ii)

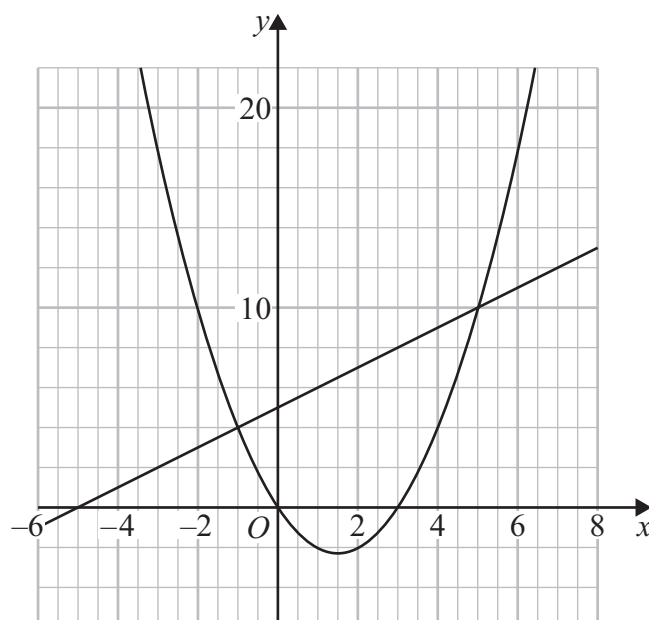


Figure 1

Figure 1 shows a plot of

- the line with equation $y = x + 5$
- the curve with equation $y = x(x - 3)$

On the opposite page there is a copy of Figure 1 labelled Diagram 1.

On Diagram 1 represent the following inequality graphically.

$$x + 5 \leq y \leq x(x - 3) \quad \text{for } x \geq -2$$

(3)

Question 3 continued

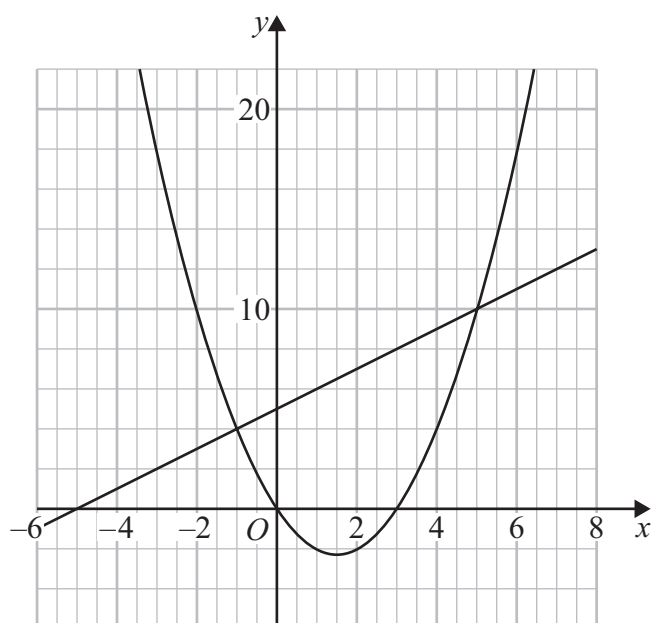


Diagram 1

(Total for Question 3 is 5 marks)

4.

In this question you must show all stages of your working.
Solutions relying on calculator technology are not acceptable.

The point $A(-1, 8)$ and the point $B(7, 2)$ lie on the line L_1

- (a) Find an equation for L_1 in the form $ax + by + c = 0$, where a , b and c are integers. (3)

The line L_2

- passes through A and is perpendicular to L_1
- cuts the x -axis at the point C

- (b) Find the coordinates of C . (3)

- (c) Hence find the area of triangle ABC . (3)



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Question 4 continued

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Question 4 continued

(Total for Question 4 is 9 marks)



5.

In this question you must show all stages of your working. Solutions relying entirely on calculator technology are not acceptable.

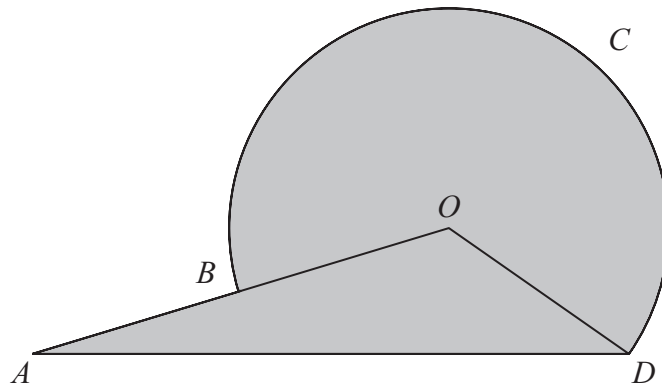


Diagram NOT
to scale

Figure 2

Figure 2 shows the logo for the tourist board of an island.

The logo consists of a sector $BODCB$ of a circle centre O joined to a triangle AOD .

Given that

- ABO is a straight line
- $OD = 3\text{ cm}$
- $AD = 8\text{ cm}$
- angle $AOD = 2.5$ radians

(a) show that angle ODA is 0.415 radians to 3 significant figures.

(3)

(b) Find the total area of the logo, in cm^2 , to one decimal place.

(3)

(c) Find the perimeter of the logo, $ABCD$, in cm, to one decimal place.

(3)

[illegible]

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P 8 3 1 7 1 A 0 1 3 2 8

Question 5 continued

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6.

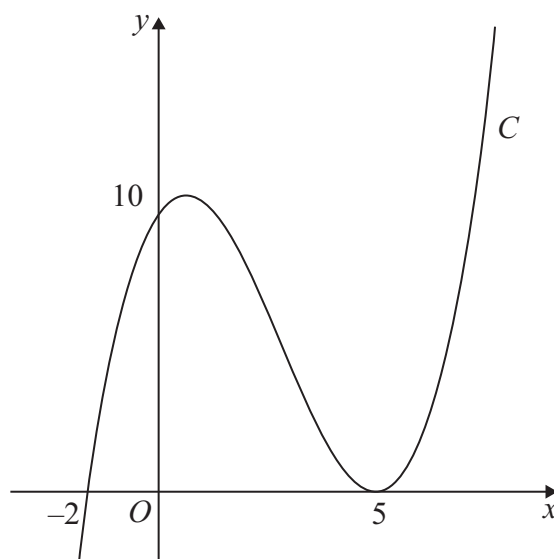


Figure 3

Figure 3 shows a sketch of the curve C with equation $y = f(x)$ where $f(x)$ is a cubic function in x .

The curve C

- cuts the x -axis at $(-2, 0)$ and cuts the y -axis at $(0, 10)$
- touches the x -axis at $(5, 0)$

as shown in Figure 3.

(a) Deduce the roots of the equation

(i) $f\left(\frac{1}{3}x\right) = 0$

(ii) $f(x - 3) = 0$

(2)

(b) Find an expression for $f(x)$. You should leave your answer in factorised form.

(3)

The curve C intersects the straight line $y = 10(x + 2)$ at exactly three points.

(c) Use algebra to find the exact x coordinates of the three points of intersection.

(Solutions based entirely on calculator technology are not acceptable.)

(4)



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Question 6 continued

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Question 6 continued

(Total for Question 6 is 9 marks)



7. The curve C has equation

$$y = \frac{2}{3}x^3 - 8x^2 + 43x - \frac{20}{3}$$

(a) Show that $\frac{dy}{dx}$ can be written in the form

$$p(x+q)^2+r$$

where p, q and r are constants to be found.

(5)

(b) Hence state

(i) the minimum value of $\frac{dy}{dx}$

(ii) the value of x at which this minimum value occurs.

(2)

Given that S is the point on C at which the gradient is a minimum,

(c) find the equation of the tangent to C at S , giving your answer in the form $y = mx + c$, where m and c are constants.

(3)

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

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Question 7 continued

(Total for Question 7 is 10 marks)



8.

In this question you must show all stages of your working. Solutions relying on calculator technology are not acceptable.

A curve C has equation $y = f(x)$, $x > 0$

A point P lies on C .

Given that

- $f'(x) = 4x^2 + \frac{6}{x^2} - 4$
- the equation of the tangent to C at P is $y = 10x - 6\sqrt{3}$

- (a) (i) verify that $\sqrt{3}$ is a possible x coordinate of P ,
(ii) find, using algebra, the other possible x coordinate of P .

(6)

Given that the x coordinate of P is $\sqrt{3}$

- (b) find an equation of the normal to C at P .

(2)

- (c) Find $f(x)$, writing your answer in simplest form.
You must show each stage of your working.

(4)



DO NOT WRITE IN THIS AREA



Question 8 continued

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Question 8 continued

(Total for Question 8 is 12 marks)



9.

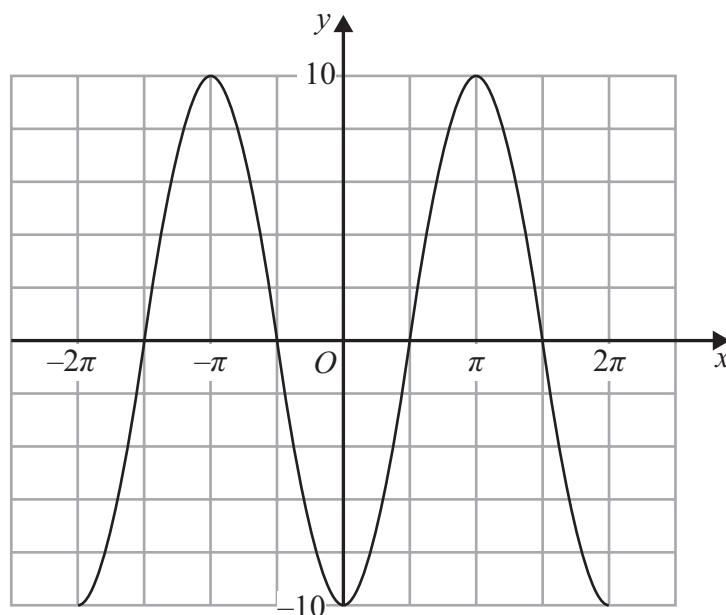


Figure 4

Figure 4 shows a sketch of part of the graph of the trigonometric function with equation $y = f(x)$.

(a) Write down an expression for $f(x)$.

(2)

Copies of Figure 4 (labelled Diagram 1 and Diagram 2) can be found on the following pages.

(b) (i) On Diagram 1 sketch a graph of the curve with equation

$$y = 10 - x^2$$

(ii) Hence find the **number** of solutions of the equation

$$f(x) = 10 - x^2 \quad \text{in the interval} \quad -100\pi \leq x \leq 100\pi$$

(3)

(c) (i) On Diagram 2 sketch a graph of the curve with equation

$$y = \tan x \quad -2\pi \leq x \leq 2\pi$$

(ii) Hence find the **number** of solutions of the equation

$$f(x) = \tan x \quad \text{in the interval} \quad -100\pi \leq x \leq 100\pi$$

giving a reason for your answer.

(4)



Question 9 continued

(a) _____

(b)(i)

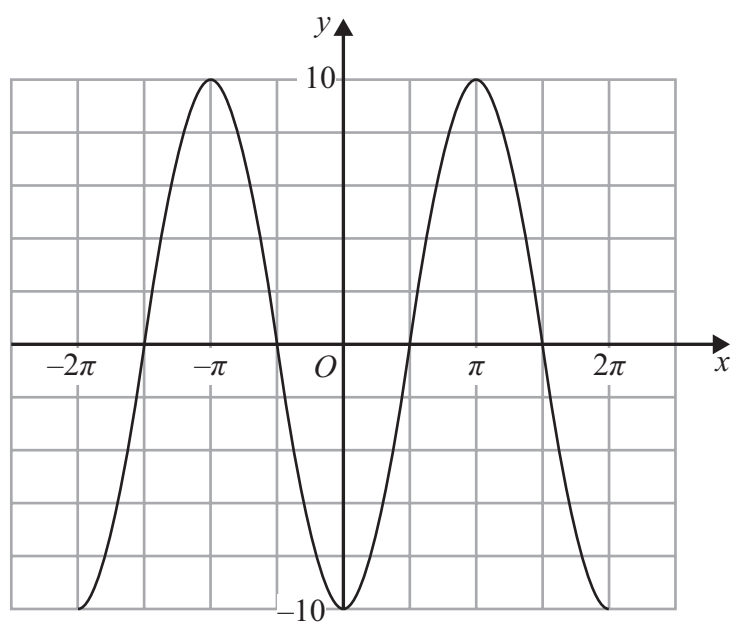
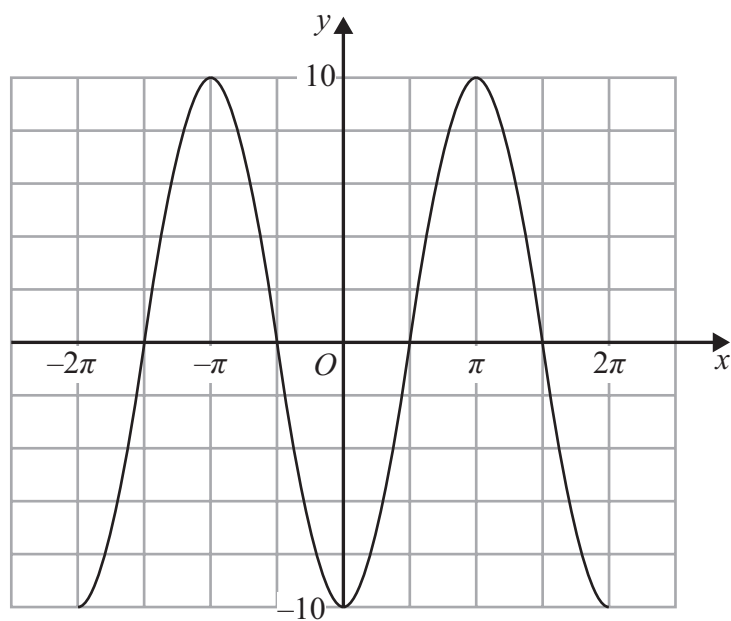


Diagram 1



Copy of Diagram 1

Only use this copy if you need to redraw your graph.

(b)(ii) _____

Question 9 continued

(c)(i)

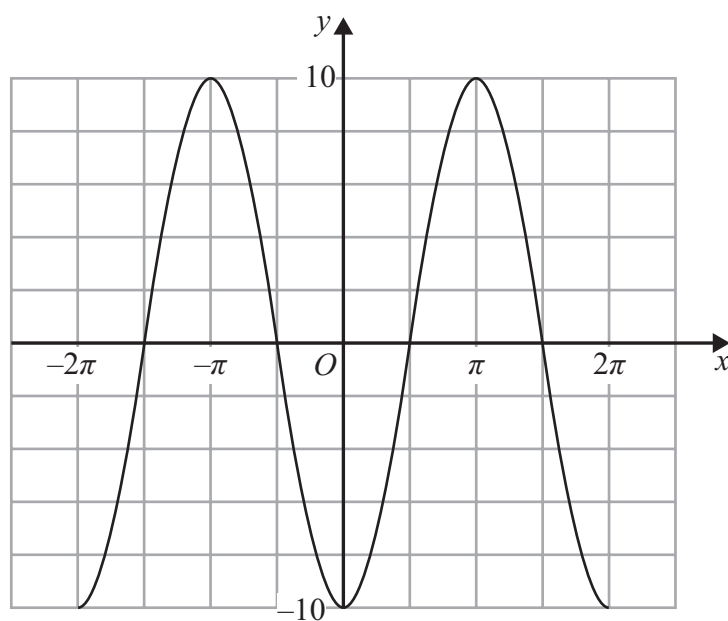
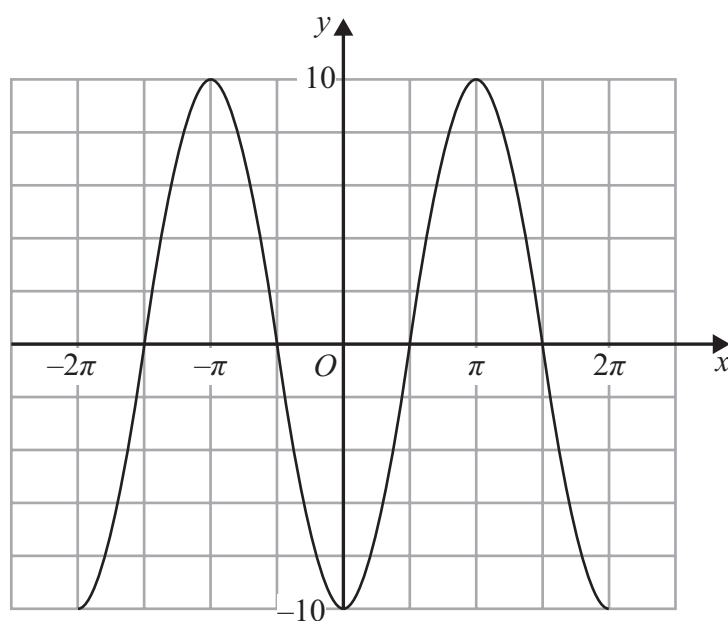


Diagram 2



Copy of Diagram 2

Only use this copy if you need to redraw your graph.

(c)(ii)

(Total for Question 9 is 9 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (Results)

January 2026

Pearson Edexcel International Advanced Level in
Pure Mathematics P1
WMA11/01

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January 2026

Question Paper Log Number P83171A

Publication Code WMA11_01_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN:

- bod – benefit of doubt
- ft – follow through
 - the symbol $\surd$ will be used for correct ft
- cao – correct answer only
- cso – correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC – special case
- oe – or equivalent (and appropriate)
- d... or dep – dependent
- indep – independent
- dp – decimal places
- sf – significant figures
- * – The answer is printed on the paper or ag- answer given

- $\square$ or d... – The second mark is dependent on gaining the first mark
4. All A marks are 'correct answer only' (cao), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.
 5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. If you are using the annotation facility on ePEN, indicate this action by 'MR' in the body of the script.
 6. If a candidate makes more than one attempt at any question:
 - a) If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - b) If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
 7. Ignore wrong working or incorrect statements following a correct answer.

General Principles for Pure Mathematics Marking

(NB specific mark schemes may sometimes override these general principles)

Method mark for solving 3 term quadratic:

1. Factorisation

$(x^2 + bx + c) = (x + p)(x + q)$, where $|pq| = |c|$ leading to $x = \dots$

$(ax^2 + bx + c) = (mx + p)(nx + q)$, where $|pq| = |c|$ and $|mn| = |a|$ leading to $x = \dots$

2. Formula

Attempt to use correct formula (with values for a, b and c)

3. Completing the square

Solving $x^2 + bx + c = 0$: $(x \pm \frac{b}{2})^2 \pm q \pm c$, $q \neq 0$ leading to $x = \dots$

Method marks for differentiation and integration:

1. Differentiation

Power of at least one term decreased by 1 ($x^n \rightarrow x^{n-1}$)

2. Integration

Power of at least one term increased by 1 ($x^n \rightarrow x^{n+1}$)

Use of a formula

Where a method involves using a formula that has been learnt, the advice given in recent examiners' reports is that the formula should be quoted first.

Normal marking procedure is as follows:

Method mark for quoting a correct formula and attempting to use it, even if there are small mistakes in the substitution of values.

Where the formula is not quoted, the method mark can be gained by implication from correct working with values, but may be lost if there is any mistake in the working.

Exact answers

Examiners' reports have emphasised that where, for example, an exact answer is asked for, or working with surds is clearly required, marks will normally be lost if the candidate resorts to using rounded decimals.

Answers without working

The rubric says that these may not gain full credit. Individual mark schemes will give details of what happens in particular cases. General policy is that if it could be done "in your head", detailed working would not be required. Most candidates do show working, but there are occasional awkward cases and if the mark scheme does not cover this, please contact your team leader for advice.

Question Number	Scheme	Marks
1.(a)	$y = 4x^3 + \frac{3}{2\sqrt{x}} - 8$ $\left(\frac{dy}{dx}\right) = 12x^2 - \frac{3}{4}x^{-\frac{3}{2}}$	M1, A1, A1 (3)
(b)	$\int 4x^3 + \frac{3}{2\sqrt{x}} - 8 \, dx = x^4 + 3x^{\frac{1}{2}} - 8x + c$	M1, A1, A1 (3) (6 marks)

Advice for examiners;

If labelled (a), (b) or even (i) and (ii) mark according to the scheme as below.

If it is obvious, i.e marked $\frac{dy}{dx} = ..$ and $\int$ = mark according to the scheme as given no matter what the order

If there are no labels, mark the first answer as their attempt at $\frac{dy}{dx}$ and the second as their attempt at $\int$

If you are not sure then please use review

(a)

M1: Correct attempt at differentiation.

Award for one correct index which must be processed ie $x^3 \rightarrow x^2$ (not x^{3-1}) including $-8 \rightarrow 0$

A1: One correct and simplified term in x . So, award for sight of $12x^2$ or $-\frac{3}{4}x^{-\frac{3}{2}}$ (or exact equivalent).

A1: $\left(\frac{dy}{dx}\right) = 12x^2 - \frac{3}{4}x^{-\frac{3}{2}}$ or exact simplified equivalent such as $12x^2 - \frac{3}{4x^{\frac{3}{2}}}$ Condone $12x^2 + -\frac{3}{4}x^{-\frac{3}{2}}$.

There must be no extra terms such as $+ c$. ISW after correct answer. There is no need to have the $\frac{dy}{dx}$

(b)

M1: Correct attempt at integration.

Award for achieving one correct index which must be processed.

Look for one of $x^3 \rightarrow x^4$, $x^{-\frac{1}{2}} \rightarrow x^{\frac{1}{2}}$ or $-8 \rightarrow -8x$

A1: Two correct and simplified terms in x

A1: $x^4 + 3x^{\frac{1}{2}} - 8x + c$ or simplified equivalent such as $1x^4 + 3\sqrt{x} - 8x^1 + c$ including the $+ c$

Condone extra spurious notation, e.g. $\int x^4 + 3x^{\frac{1}{2}} - 8x + c$. ISW after correct answer.

Question Number	Scheme	Marks
2.(a)	Attempts to substitute $y = x + 4$ into $2x^2 - xy = 8 \Rightarrow 2x^2 - x(x + 4) = 8$ $\Rightarrow 2x^2 - x^2 - 4x = 8 \Rightarrow x^2 - 4x - 8 = 0^*$	M1 A1* (2)
(b)	$x^2 - 4x - 8 = 0 \Rightarrow (x - 2)^2 = 12$ $\Rightarrow x = 2 \pm 2\sqrt{3}$ Attempts y for either value $\Rightarrow y = 2 + 2\sqrt{3} + 4 = \dots$ $\Rightarrow x = 2 + 2\sqrt{3}, y = 6 + 2\sqrt{3}$ AND $x = 2 - 2\sqrt{3}, y = 6 - 2\sqrt{3}$	M1 A1 M1 A1 (4) (6 marks)

(a)

M1: Awarded for an attempt to substitute $y = \pm x \pm 4$ into $2x^2 - xy = 8 \Rightarrow 2x^2 - x(\pm x \pm 4) = 8$

This may be seen with or without the bracket so look for either $2x^2 - x(\pm x \pm 4) = 8$ or $2x^2 \pm x^2 \pm 4x = 8$

A1*: Proceeds to the given answer showing all necessary steps and no errors.

For example, look for intermediate working showing ALL of the following

- $y - x = 4$ being adapted to $y = x + 4$
- A line of $2x^2 - x(x + 4) = 8$ or equivalent such as $2x^2 - x^2 - 4x - 8 = 0$
- The given answer $x^2 - 4x - 8 = 0$

(b)

M1: Shows a non-calculator method of solving the given $x^2 - 4x - 8 = 0$, not any incorrect version.

Do not accept factorisation.

For completing the square look for $x^2 - 4x - 8 = 0 \Rightarrow (x - 2)^2 = k, k > 0 \Rightarrow x = \dots$

For use of formula look, for example, for $x^2 - 4x - 8 = 0 \Rightarrow x = \frac{4 \pm \sqrt{16 - (-32)}}{2}$ or $x = \frac{4 \pm \sqrt{48}}{2}$

You cannot accept the correct simplified solutions following a quoted formula (with no additional working shown, i.e embedded values).

A correct quoted formula followed by an unsimplified solution with a slip E.g. $x = \frac{-4 \pm \sqrt{(-4)^2 - (-32)}}{2}$ or

$x = \frac{-4 \pm \sqrt{48}}{2}$ would score M1, A0 even if followed by the correct solutions and then potentially M1, A0

A1: Correctly finds both x values in an allowable form. Look for $2 + 2\sqrt{3}$ and $2 - 2\sqrt{3}$. Condone values written in the partially simplified form of $x = 2 \pm \sqrt{12}$ but not $x = \frac{4 \pm \sqrt{48}}{2}$. Award this mark even if one value is subsequently rejected. **This can only be scored following the award of M1**

M1: Find a y value by adding 4 to an x value.

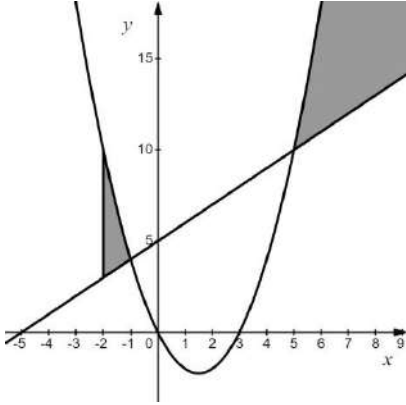
It is not dependent so 0,0,1,0 is possible for candidates who write down solutions for the equation in x . So $x^2 - 4x - 8 = 0 \Rightarrow x = 2 \pm 2\sqrt{3}$ without working followed by $y = 6 \pm 2\sqrt{3}$ scores 0, 0, 1, 0

A1: Both pairs correctly matched up, and in the form requested by the question, i.e $p + q\sqrt{3}$

Allow $x = 2 \pm 2\sqrt{3}, y = 6 \pm 2\sqrt{3}$ Must follow M1, A1, M1

Note that a pair is matched up when you see $x = 2 + 2\sqrt{3}, y = 4 + 2 + 2\sqrt{3} = 6 + 2\sqrt{3}$

SC: Some candidates may ignore part (a) and produce a quadratic in y . They will score no marks in part (a) but we will allow all marks for a correct solution for part (b). FYI $y^2 - 12y + 24 = 0 \Rightarrow y = 6 \pm 2\sqrt{3}$. The first M1 is scored for a valid non-calculator method followed by A1 for both y values.

Question Number	Scheme	Marks
3 (i)	$z < 0$ or $z > \frac{1}{2}$	M1, A1
(ii)	 Correctly draws $x = -2$ Correct left or right-hand region shaded Correct left and right-hand region shaded	(2) B1 B1 B1 (3) (5 marks)

(i)

M1: For an attempt, graphical, algebraic or otherwise that reaches either inequality.

Score for one of $z < 0$, $z > \frac{1}{2}$ Allow non-strict inequalities here. **No working is necessary**

Award even in cases where the solution(s) seem contradictory. E.g. $z > \frac{1}{2}$, $z < \frac{1}{2}$

Condone an un-simplified version for this mark. E.g. $\frac{4}{z} < 8 \Rightarrow z > \frac{4}{8}$

Alternatively score for an attempt that proceeds to **both** critical values

A1: Correct answer which must be in simplest form.

Condone the appearance of a comma or the word “and” between the two inequalities

If set notation is used accept versions such as $\{z \in \mathbb{R} : z < 0\} \cup \left\{z \in \mathbb{R} : z > \frac{1}{2}\right\}$ but not with $\cap$

If they write $0 > z > \frac{1}{2}$ would score M1, A0

(ii)

Advice for examiners:

You may see the representation of the inequalities on Figure 1 and/or Diagram 1.

- If only Figure 1 is used mark Figure 1
- If both Figure 1 and Diagram 1 are used Diagram 1 takes precedence.

B1: Correctly draws the line with equation $x = -2$ (at least drawn between the line and curve)

Allow this line to be dotted.

Alternatively has $x = -2$ as the boundary of a shaded region (at least drawn between the line and curve)

Be tolerant of slips of the pen here or gaps in the boundary of the shaded region

B1: Shading implies a correct and distinct left-hand **OR** right-hand region shaded.

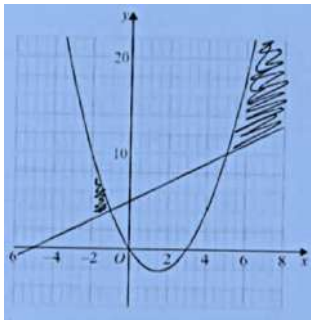
For the left-hand region, it is acceptable for the boundary line $x = -2$ to be ‘dotted’ or implied (by shading)

B1: Shading implies a correct and distinct left-hand and a correct and distinct right-hand region **ONLY**.

There must be an attempt to shade/include the whole of the left and right-hand region.

The line or the shading at the boundary at $x = -2$ must now be solid

Examples of how to apply the mark scheme;



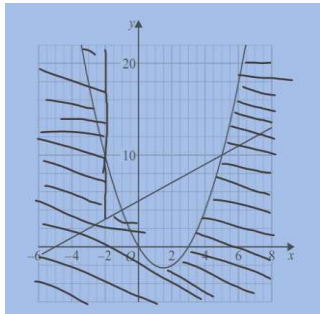
Award 1,1,0

B1: $x = -2$ is the boundary of a shaded region

B1: There is an acceptable attempt at shading either region.

Note that we could award this mark for either region

B0: There is not a solid line or completely shaded up to $x = -2$ boundary, so we have not got a fully correct diagram

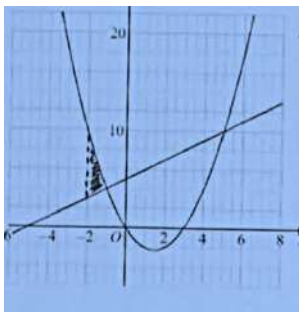


Award 1,0,0

B1: $x = -2$ is drawn (at least between the line and curve)

B0: No acceptable distinct region is indicated.

B0: Follows B0

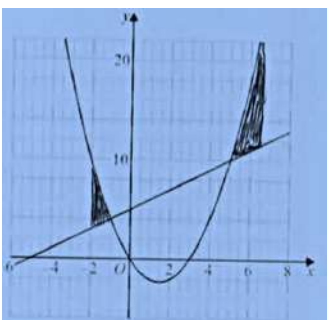


Award 1,1,0

B1: $x = -2$ drawn between the line and curve (accept dotted)

B1: There is an acceptable attempt at shading the left-hand region.

B0: There is no attempt to shade the right-hand region. Even if this right hand region had been shaded in, this mark would not be awarded due to the dotted line

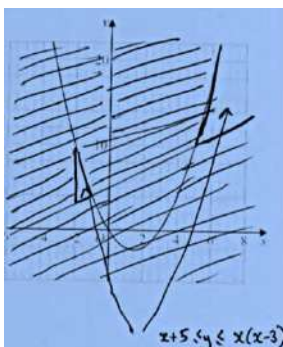


award 1,1,0

B1: $x = -2$ is the boundary of a shaded region

B1: There is an acceptable attempt at shading the left-hand region.

B0: The shading on right-hand region is incomplete



Award 1,1,1

Candidates were not told to shade the required region so it is acceptable for them to indicate it in other ways as below

B1: $x = -2$ is drawn between the line and curve

B1: There is an acceptable attempt at indicating either region.

B1: There is an acceptable way of indicating the complete region

Alternatively, if they have drawn $x = -2$ with a solid line and write R in BOTH regions they can be awarded BOD 1,1,1

Question Number	Scheme	Marks
4 (a)	$\text{Grad } AB = \frac{8-2}{-1-7} = \left(-\frac{3}{4}\right)$ $y-2 = -\frac{3}{4}(x-7) \Rightarrow 3x+4y-29=0$	M1 dM1, A1 (3)
(b)	Equation line L_2 $y-8 = \frac{4}{3}(x+1)$ Substitutes $y=0$ $0-8 = \frac{4}{3}(x+1) \Rightarrow x=-7$ So $(-7, 0)$	M1 dM1, A1 (3)
(c)	Attempts one required length. E.g. $AB^2 = 8^2 + 6^2 \Rightarrow AB = 10$ Area $ABC = \frac{1}{2} AB \times AC = \frac{1}{2} 10 \times 10 = 50$	M1 dM1, A1 (3) (9 marks)

(a)

M1: Correct attempt at gradient.

It must be an attempt at $\frac{\Delta y}{\Delta x}$ with attempt at subtraction at least once

dM1: Correct attempt at equation of line L_1 using their found gradient and either of the points.

It is dependent upon the previous M mark. Look for an attempted application of $y - y_1 = -\frac{3}{4}(x - x_1)$.

You may well see $\frac{y-8}{x+1} = \frac{8-2}{-1-7}$ o.e. which would score M1, dM1

If they use the form $y = mx + c$ it must lead as far as $c = \dots$

A1: $3x+4y-29=0$ but accept any integer multiple of this. Accept terms in a different order

.....
Alt (a)

M1: Attempts to substitute BOTH $A(-1, 8)$ and $B(7, 2)$ into $ax+by+c=0$ or $y=mx+c$

dM1: And solves using non calculator methods to find values of a, b and c or m and c .

The solution is not unique if using $ax+by+c=0$ so they may start by stating a value for c , e.g. $c=2$

A1: $3x+4y-29=0$ but accept any integer multiple

.....
(b)

M1: Uses the negative reciprocal of their gradient in (a) with $A(-1, 8)$ to form equation of L_2

dM1: Substitutes $y=0$ in a correctly attempted L_2 and finds $x = \dots$

It is dependent upon the previous M so L_2 must have been formed correctly

Condone slips where L_2 has been incorrectly adapted and $y=0$ is substituted into this to find x .

A1: $(-7, 0)$ but condone $x=-7$ following substitution of $y=0$

This is a non calculator question so this must follow M1, dM1

.....

Alternatives in (b) are possible: For example via similar triangles or methods without fully forming the equation of L_2

Note that it is possible to find the coordinates of C without fully forming the equation of L_2

For example, letting the coordinates of C to be $(k, 0)$ and using gradient AC leads to the equation

$$\frac{8}{-1-k} = \frac{4}{3} \Rightarrow k = -7. \text{ Score M1 for using the negative reciprocal of their gradient in (a) with } A(-1, 8)$$

to set up an equation in k . Score dM1 for solving it.

.....
(c)

M1: Attempts one required length. E.g. $AB^2 = 8^2 + 6^2 \Rightarrow AB = \dots$ OR $AC^2 = 8^2 + 6^2 \Rightarrow AC = \dots$

It is acceptable to award this from a diagram where you see the lengths 6 and 8 followed by AB or AC as 10. **There must be some evidence for this award.**

dM1: Correct attempt at area triangle ABC . It is dependent upon the previous M

A1: 50

.....
Alternatives for part (c) exist so look carefully at what is attempted.

Alt I: Area of rectangle – area of three triangles

M1: Correct attempt at 3 of the 4 necessary shapes

$$\text{Area rectangle} = 14 \times 8 = (112) \quad \text{Area triangles} = \frac{1}{2} \times 8 \times 6 = (24), \quad \frac{1}{2} \times 8 \times 6 = (24), \quad \frac{1}{2} \times 14 \times 2 = (14)$$

$$\text{dM1: Complete area} = 14 \times 8 - \left\{ \frac{1}{2} \times 8 \times 6 + \frac{1}{2} \times 8 \times 6 + \frac{1}{2} \times 14 \times 2 \right\}$$

A1: 50

Alt II Let point D be the point at which L_1 crosses the x -axis (which is $\frac{29}{3}$ for a correctly found eqn)

$$\text{M1: Correct attempt to find the area of triangle } ACD = \frac{1}{2} \times \left(7 + \frac{29}{3} \right) \times 8 \text{ or triangle } BCD = \frac{1}{2} \times \left(7 + \frac{29}{3} \right) \times 2$$

$$\text{dM1: Attempts area triangle } ACD - \text{triangle } BCD = \frac{1}{2} \times \left(7 + \frac{29}{3} \right) \times 8 - \frac{1}{2} \times \left(7 + \frac{29}{3} \right) \times 2$$

A1: 50

Alt III: If the coordinates of C are correct, triangle ABC is isosceles with AB and AC equal.

Therefore, only allow this method to score marks if they have a correct answer to part (b)

Let the mid- point of CB be M .

$$\text{In a correct calculation } M = (0, 1) \text{ and area } ABC = \frac{1}{2} \times BC \times AM = \frac{1}{2} \times 10\sqrt{2} \times 5\sqrt{2}$$

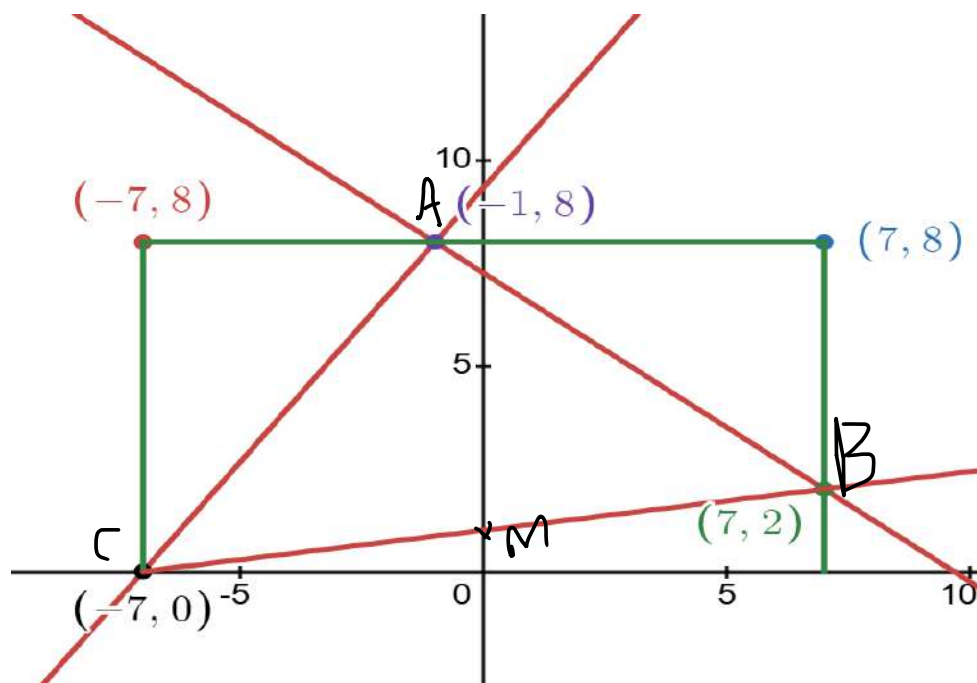
$$\text{M1: Correct attempt at one length, e.g. } BC = \sqrt{14^2 + 2^2} = (10\sqrt{2}) \quad \text{dM1: Complete attempt}$$

Alt IV: The shoelace method

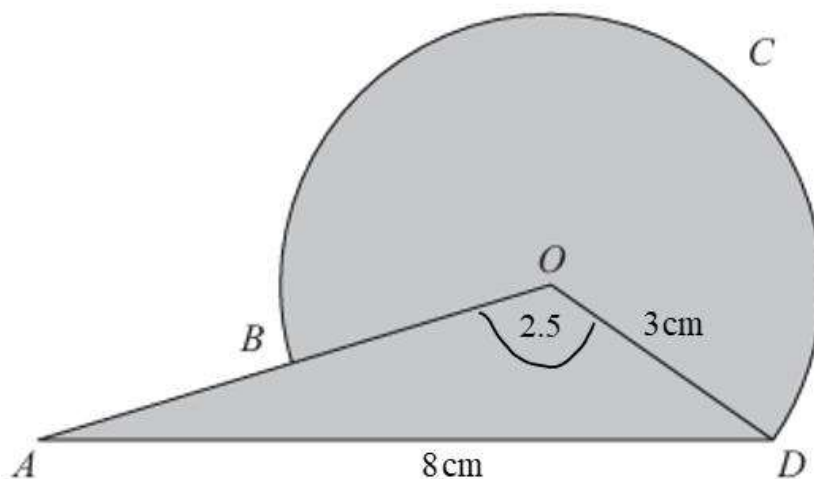
$$\begin{array}{r} -7 \quad 0 \\ \swarrow \quad \searrow \\ -1 \quad 8 \\ \swarrow \quad \searrow \\ 7 \quad 2 \\ \swarrow \quad \searrow \\ -7 \quad 0 \end{array}$$

$$\frac{1}{2} | (-7 \times 8 - 1 \times 2 + 7 \times 0) - (0 \times -1 + 8 \times 7 + 2 \times -7) | = 50$$

If you are unaware of this method, please look it up. You require the coordinates of the vertices



Question Number	Scheme	Marks
5 (a)	$\frac{\sin(OAD)}{3} = \frac{\sin 2.5}{8} \Rightarrow \sin(OAD) = 0.2244...$ $(\text{Angle } (ODA)) = \pi - 2.5 - \arcsin(0.2244...) = \pi - 2.5 - 0.226355... = 0.415 *$	M1 dM1, A1* (3)
(b)	Attempts either $\frac{1}{2} \times 3^2 \times (2\pi - 2.5) = (17.02)$ or $\frac{1}{2} \times 3 \times 8 \times \sin 0.415 = (4.838...)$ Complete attempt at area = $\frac{1}{2} \times 3^2 \times (2\pi - 2.5) + \frac{1}{2} \times 3 \times 8 \times \sin 0.415$ = awrt 21.9 cm ²	M1 dM1 A1 (3)
(c)	Attempts either $3(2\pi - 2.5) = (11.349...)$ or $AO^2 = 3^2 + 8^2 - 2 \times 3 \times 8 \cos(0.415) = (29.07...)$ Complete attempt at perimeter = $3(2\pi - 2.5) + 8 + \sqrt{3^2 + 8^2 - 2 \times 3 \times 8 \cos(0.415)} - 3 = 11.35 + 8 + 5.39 - 3$ = awrt 21.7 cm	M1 dM1 A1 (3) (9 marks)



Be aware that it is possible that the whole question could be done in degrees with 2.5 radians converted to 143.23°, 143.24° or better. Provided this accuracy is used full marks are possible, but the final conversion from 23.79° to 0.415 must be shown. If less accuracy is used, e.g 143.2° or 143° only the method marks are available in part (a), BUT full marks are possible in parts (b) and (c)

FYI. Angle AOD = 143.23° or 143.24°, Angle OAD = 12.96° or 12.97° Angle ODA = 23.79° or 23.80°

(a) This is a given answer and it is important that a full method is shown.

Candidates will NOT gain credit in part (a) when starting with or using angle ODA = 0.415

M1: Attempts to use the sine rule with the angles and lengths in the correct position.

Allow OAD = θ or any other variable. Condone slips in the labelling of the angle.

The calculation must lead at least as far as $\sin OAD = ...$

E.g. $\frac{3}{\sin x} = \frac{8}{\sin 2.5} \Rightarrow \sin x = (0.2244...) \text{ OR } x = \arcsin(0.2244...) = (0.22635...)$

dM1: Full attempt at finding angle ODA. It is dependent upon the previous M1

Look for example, sight of $\pi - 2.5 - \arcsin("0.2244..")$ OR $3.14 - 2.5 - "0.226"$

A1*: Uses sufficient accuracy to achieve the given answer of 0.415 or the more accurate awrt 0.4152
Intermediate working must show or imply that the necessary accuracy has been achieved.
If a candidate achieves the correct answer of 0.4152... or better this is sufficient evidence
Additionally, a candidate could give intermediate answers to 4dp or better (rounded or truncated).
E.g. $\pi - 2.5 - \arcsin(0.2244)$, $\pi - 2.5 - 0.2263$, $\pi - 2.5 - 0.2264$.
If a decimal approximation of π is used it must be 3.142 or better
Note that the calculation $\pi - 2.5 - 0.226 = 0.415$ is M1, dM1, A0

.....
Alt (a) using the cosine rule

M1: Uses the cosine rule to find OA .

Look for a correctly set up quadratic equation with an allowable attempt to solve

$$\text{E.g. } 8^2 = 3^2 + y^2 - 2 \times 3 \times y \cos(2.5) \Rightarrow y^2 - 6y \cos 2.5 - 55 = 0 \Rightarrow y = 5.3924..$$

dM1: Uses the sine rule with the sides and angles in the correct places. Dependent upon previous M.

$$\frac{\sin x}{\text{"5.394"}} = \frac{\sin 2.5}{8} \Rightarrow \sin x = (0.4034.....)$$

A1*: Achieves awrt 0.415 following accuracy to 4dp throughout
.....

(b) Note that we are told that angle $ODA = 0.415$ radians so if used in (b) and (c) it must be correct or a more accurate value

M1: Attempts either

- the area of the sector $\frac{1}{2} \times 3^2 \times (2\pi - 2.5) = (17.02)$ or decimal equivalent with accuracy to at least $\frac{1}{2} \times 3^2 \times (6.28 - 2.5)$
- or the area of the triangle E.g. $\frac{1}{2} \times 3 \times 8 \times \sin 0.415 = (4.838...)$ (other alternatives exist)

dM1: Complete attempt at area = $\frac{1}{2} \times 3^2 \times (2\pi - 2.5) + \frac{1}{2} \times 3 \times 8 \times \sin 0.415$ or its decimal equivalent

A1: awrt 21.9 cm². There is no requirement for the units, so they may be ignored even if incorrect

(c)

M1: Attempts either

- length of arc $BCD = 3(2\pi - 2.5)$ or decimal equivalent of $3(6.28 - 2.5)$ or greater accuracy
- or length $AO^2 = 3^2 + 8^2 - 2 \times 3 \times 8 \cos(0.415)$ or equivalent

Alternatives for length OA include a sine rule approach or an area approach.

Be aware that AO may have been found in part (a) and it is fine just to use this in part (c) for the M1

dM1: Complete attempt at perimeter

$$\text{E.g. } 3(2\pi - 2.5) + 8 + \sqrt{3^2 + 8^2 - 2 \times 3 \times 8 \cos(0.415)} - 3$$

or decimal equivalent such as $3 \times 3.78 + 5 + \frac{8 \sin(0.415)}{\sin(2.5)}$ where π is used as 3.14 or better

.....
A1: awrt 21.7 cm. There is no requirement for the units, so they may be ignored even if incorrect

Question Number	Scheme	Marks
6 (a)	(i) -6 and 15 (ii) 1 and 8	B1 B1 (2)
(b)	$(f(x)) = k(x+2)(x-5)^2$ $(0,10) \Rightarrow 10 = k(0+2)(-5)^2 \Rightarrow k = \dots$ $(f(x)) = \frac{1}{5}(x+2)(x-5)^2$	M1 dM1 A1 (3)
(c)	Correctly deduces that $x = -2$ $\frac{1}{5}(x+2)(x-5)^2 = 10(x+2) \Rightarrow (x-5)^2 = 50$ $\Rightarrow x-5 = \pm\sqrt{50} \Rightarrow x = 5 \pm 5\sqrt{2}$	B1 M1 dM1, A1 (4)
		(9 marks)

(a)(i)

B1: Requires both -6 and 15. May be seen within the question. Condone repetitions, e.g -6,15 and 15
Condone roots being expressed as (-6,0) and (15,0) only if there are no other coordinates, e.g (0, 10)

(a)(ii)

B1: Requires both 1 and 8 May be seen within the question. Condone repetitions, e.g 1, 8 and 8

Condone roots being expressed as (1,0) and (8,0) only if there are no other coordinates, e.g (3, 10)

SC: If a candidate writes down three coordinates for (i) including (-6,0) and (15,0)

and three coordinates for (ii) including (1,0) and (8,0)

they should be awarded SC: B1, B0. This may be also awarded from the result of two sketches

(b)

M1: States or implies that $f(x)$ or $y = k(x \pm 2)(x \pm 5)^2$. Allow with $k = 1$

dM1: Substitutes (0, 10) in $f(x) = k(x \pm 2)(x \pm 5)^2$ and finds a value for k

A1: States or implies that $f(x)$ or y is $\frac{1}{5}(x+2)(x-5)^2$ o.e. ISW after a correct answer

Some candidates may be able to write this down with little or no working which is fine for 3 marks

Alt (b) Note that the demand is that they should (**but not must**) leave $f(x)$ in a factorised form

So, if a candidate attempts to use the form $f(x) = ax^3 + bx^2 + cx + d$ and

- substitutes $(-2,0)$, $(5,0)$ and $(0,10)$ in $f(x) = ax^3 + bx^2 + cx + d$
- substitutes $(5,0)$ in $f'(x) = 3ax^2 + 2bx + c$

they can score M1, dM1 for an attempt at values for a , b , c and d and A1 for $f(x) = \frac{1}{5}x^3 - \frac{8}{5}x^2 + x + 10$

.....
(c) M1, dM1, A1 can only be scored if they have a valid answer to part (b). That is $f(x) = k(x+2)(x-5)^2$

B1: Correctly deduces that $x = -2$ is one of the solutions.

This may be scored at any point in the solution but must be from a non-calculator method

Examples of ways this may be deduced are

- sight of $x = -2$ being substituted into $y = 10(x+2)$ showing $y = 0$
- $(x+2)$ being divided or factored out of an equation
- sketching $y = 10(x+2)$ on the Figure and showing an intersection at $(-2, 0)$

M1: $k \cancel{(x+2)} (x-5)^2 = 10 \cancel{(x+2)} \Rightarrow (x-5)^2 = \beta, \beta > 0$

Factorises or cancels out the $(x+2)$ term leading to a quadratic factor/equation.

Allow with $k=1$. Note that many will expand and form a 3TQ

dM1: Proceeds to at least one value for x using a correct NON-CALCULATOR method.

A1: $x = 5 \pm 5\sqrt{2}$ o.e such as $x = 5 \pm \sqrt{50}$

We may have candidates who attempt part (c) via WMA12 methods.

These can be scored in an identical way. They must start with an $f(x)$ in a suitable form which must be

- either $f(x) = k(x+2)(x-5)^2$
- or $f(x) = \frac{1}{5}x^3 - \frac{8}{5}x^2 + x + 10$ or multiple thereof

Example of a correct solution

$$x^3 - 8x^2 - 45x - 50 = 0$$

$$(x+2)(x^2 - 10x - 25) = 0$$

$$\Rightarrow x = -2, x = \frac{10 \pm \sqrt{100 + 100}}{2}$$

$$\Rightarrow x = -2, x = 5 \pm \sqrt{50}$$

B1: Correctly deduces that $x = -2$ is one of the solutions.

This may be scored at any point in the solution but must be from a non-calculator method

M1: After reaching a cubic form, attempts to factorise out (or divide by) the $(x+2)$ term leading to a 3TQ equation. They cannot just write down the solutions of their cubic from the calculator

dM1: Proceeds to at least one value for x using a correct NON-CALCULATOR method.

A1: $x = 5 \pm 5\sqrt{2}$ o.e such as $x = 5 \pm \sqrt{50}$

Example of a solution that scores no marks

$$x^3 - 8x^2 - 45x - 50 = 0$$

$$\Rightarrow x = -2, x = 5 \pm \sqrt{50}$$

B1 (for $x = -2$) would only be awarded if they gave some additional evidence.

For example, they state $x = -2$ ($y = 0$) lies on both graphs.

It cannot be just awarded from their calculator solution to the cubic equation

Question Number	Scheme	Marks
7 (a)	$\left(\frac{dy}{dx}\right) = 2x^2 - 16x + 43$ $= 2x^2 - 16x + 43 \equiv 2(x^2 - 8x) + \dots \equiv 2(x - 4)^2 \dots$ $\equiv 2(x - 4)^2 + 11$	M1, A1 B1 ft, dM1 A1 (5)
(b)(i)	States minimum value of $\frac{dy}{dx}$ is 11.	B1 ft
(ii)	States that the x coordinate is 4	B1 ft (2)
(c)	Attempts $\frac{2}{3} \times 4^3 - 8 \times 4^2 + 43 \times 4 - \frac{20}{3} (= 80)$ Attempts equation of tangent $y - 80 = 11(x - 4)$ $y = 11x + 36$	M1 dM1 A1 (3)
		(10 marks)

(a)

M1: Reduces the index on any term including $\frac{20}{3} \rightarrow 0$. The index must be processed for this award

A1: $\left(\frac{dy}{dx}\right) = 2x^2 - 16x + 43$ or exact equivalent. There should not be any extra terms such as $+ c$

B1 ft: Takes out a correct factor of '2' from their $2x^2 - 16x + 43$

This will be implied by the correct value of p for their $2x^2 - 16x + 43$

dM1: Achieves a correct value for q for their $2x^2 - 16x + 43$. Look for " $\frac{-16}{2p}$ "

It is dependent upon having differentiated (i.e scoring the first M1)

A1: CAO $2(x - 4)^2 + 11$

(b) The question states hence so ideally, answers in (b) should follow their part (a).

A method must be seen so don't allow answers in (b) following no working in (a).

Condone solutions in (b) arising from the second derivative. E.g. $\frac{d^2y}{dx^2} = 4x - 16 = 0 \Rightarrow x = 4$

(b)(i) Do not award marks in (b) for just writing down (4, 11)

B1 ft: States 11 but follow through on their r from part (a) as long as $\frac{dy}{dx} = p(x + q)^2 + r$

Also allow candidates to substitute $x = 4$ in $\frac{dy}{dx}$ to reach 11. Ignore incorrect labelling such as $y = 11$

(b)(ii)

B1 ft: States that the x coordinate is 4 but follow through on their $-q$ from part (a)

(c)

M1: Attempts to find the y coordinate of C using their $x = 4$.

dM1: Correct attempt at equation of tangent using their 11 and a correctly found y coordinate

It is dependent upon the previous M1

A1: $y = 11x + 36$

Question Number	Scheme	Marks
8 (a)(i)	$f'(x) = 4x^2 + \frac{6}{x^2} - 4$	
	Substitutes $x = \sqrt{3}$ in $f'(x) = 4 \times 3 + \frac{6}{3} - 4$ $= 10$ which is the same as the gradient of the tangent *	M1 A1*
	(a)(ii)	
	$4x^2 + \frac{6}{x^2} - 4 = 10 \Rightarrow 2x^4 - 7x^2 + 3 = 0$ $\Rightarrow (2x^2 - 1)(x^2 - 3) = 0 \Rightarrow x^2 = \frac{1}{2} \Rightarrow x = \frac{\sqrt{2}}{2}$	M1, A1 dM1, A1
	(b)	(6)
(c)	States/implies that gradient of normal at P is $-\frac{1}{10}$ or y coordinate is $4\sqrt{3}$ Equation is $y - 4\sqrt{3} = -\frac{1}{10}(x - \sqrt{3})$	M1 A1
	$f'(x) = 4x^2 + \frac{6}{x^2} - 4 \Rightarrow f(x) = \frac{4}{3}x^3 - \frac{6}{x} - 4x + c$ Uses $(\sqrt{3}, 4\sqrt{3}) \Rightarrow 4\sqrt{3} = \frac{4}{3} \times 3\sqrt{3} - \frac{6}{\sqrt{3}} - 4 \times \sqrt{3} + c \Rightarrow c = \dots$ $f(x) = \frac{4}{3}x^3 - \frac{6}{x} - 4x + 6\sqrt{3}$	M1, A1 dM1 A1
		(4) (12 marks)

(a)(i)

M1: Substitutes $x = \sqrt{3}$ in $f'(x)$. There must be evidence of this so award for sight of

$$f'(x) = 4 \times 3 + \frac{6}{3} - 4, f'(x) = 4 \times (\sqrt{3})^2 + \frac{6}{(\sqrt{3})^2} - 4 \text{ or } f'(x) = 12 + 2 - 4$$

A1*: Achieves $f'(\sqrt{3}) = 10$ and alludes to the fact that this is equal to the gradient of the tangent.
Condone a minimal response here.

.....
Note that it is possible to combine both parts of (a) even if it is labelled (i) and find the two possible coordinates of P .

If this is attempted $x = \sqrt{3}$ could be substituted into any of the following equations

$$4x^2 + \frac{6}{x^2} - 4 = 10 \Rightarrow 4x^2 + \frac{6}{x^2} - 14 = 0 \Rightarrow 4x^4 - 14x^2 + 6 = 0 \Rightarrow 2x^4 - 7x^2 + 3 = 0$$

It is also possible to prove that $x = \sqrt{3}$ by solving $2x^4 - 7x^2 + 3 = 0$ via $(2x^2 - 1)(x^2 - 3) = 0$

The M1 is scored when they attempt to solve their quartic using a non-calculator method and the A1 when they solve correctly and proceed to $x = \sqrt{3}$

.....

(a)(ii)

M1: Sets $4x^2 + \frac{6}{x^2} - 4 = 10$ and attempts to simplify.

Award for

- either collecting constant terms $4x^2 + \frac{6}{x^2} - 4 = 10 \Rightarrow 4x^2 + \frac{6}{x^2} - 14 = 0$
- or else attempting to multiply through by x^2 seen in at least 3 of the 4 terms

A1: $2x^4 - 7x^2 + 3 = 0$ o.e. such as $4x^4 - 14x^2 + 6 = 0$. The $= 0$ may be implied by subsequent work

dM1: Makes suitable progress towards solving their quadratic in x^2 using non calculator methods. Allow

- factorisation ' $2x^4 - 7x^2 + 3 = 0 \Rightarrow (ax^2 + b)(cx^2 + d) = 0$ ' with $|ac| = 2$ and $|bd| = 3$
- completion of square ' $2x^4 - 7x^2 + 3 = 0 \Rightarrow \left(x^2 - \frac{7}{4}\right)^2 = k$,
- formula ' $2x^4 - 7x^2 + 3 = 0 \Rightarrow x^2 = \frac{7 \pm \sqrt{49 - 24}}{4}$

Condone attempts where a factor of 2 seemingly disappears.

E.g. $4x^4 - 14x^2 + 6 = 0 \Rightarrow (2x^2 - 1)(x^2 - 3) = 0$

Condone attempts in which the roots would not be real, E.g. $k < 0$, their discriminant < 0

A1: Selects/finds $x = \frac{\sqrt{2}}{2}$ or equivalent $\frac{1}{\sqrt{2}}$ as the other possible x coordinate

Any other value found apart from $\sqrt{3}$, e.g. $x = -\frac{\sqrt{2}}{2}$, must be either rejected or not selected

(b)

M1: States or implies that gradient at P is $-\frac{1}{10}$ **OR** the y coordinate of P is $4\sqrt{3}$

A1: $y - 4\sqrt{3} = -\frac{1}{10}(x - \sqrt{3})$ ISW after a correct answer

You may see $y = -\frac{1}{10}x + \frac{41}{10}\sqrt{3}$ if the form $y = mx + c$ is used

(c) The two marks for the integration may be awarded **anywhere** in Qu 8 as long as they state $f(x) = \dots$ or $y = \dots$. If it is clearly labelled or used in part (c) then the $f(x) = \dots$ or $y = \dots$ are not necessary

M1: Integrates with **TWO** terms having a correct index which must be processed.

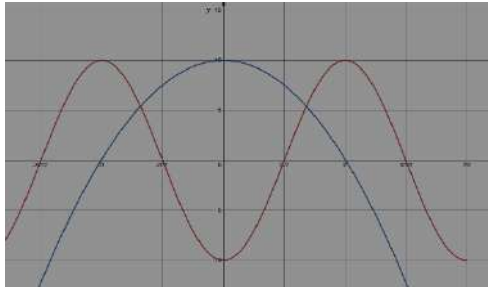
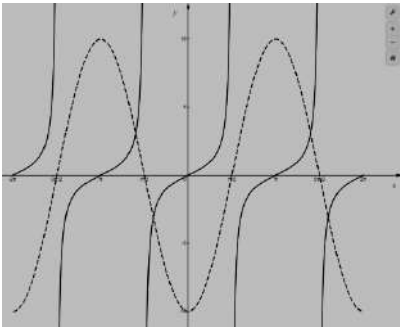
Condone the omission of the $+ c$

A1: Integrates to $\frac{4}{3}x^3 - \frac{6}{x} - 4x + c$ with the constant of integration

dM1: Uses $x = \sqrt{3}$, $y = 4\sqrt{3}$ in their integrated function and finds a value for c .

It is dependent upon the previous M. Condone the use of decimal values for this mark only.

A1: States $\frac{4}{3}x^3 - \frac{6}{x} - 4x + 6\sqrt{3}$ It is not necessary to have the $f(x)$ or the y

Question Number	Scheme	Marks
9. (a)	$-10\cos x$ or equivalent such as $10\sin\left(x - \frac{\pi}{2}\right)$	M1, A1 (2)
(b) (i)	 ∩ shaped curve symmetrical about y axis passing through (0, 10) x intercepts at approximately $\pm\pi$	M1 A1
(ii)	2 solutions	B1 (3)
(c)(i)	 Correct shape with intercepts every π rads ...and asymptotes at $(2p+1)\frac{\pi}{2}$	M1 A1
(ii)	4 roots in the interval $-2\pi \leq x \leq 2\pi$ so $50 \times 4 = 200$	B1, B1 (4) (9 marks)

(a) **Candidates cannot write down multiple attempts at this sort of question.**

If there are two or three different answers mark their final full attempt only

M1: Writes down a suitable expression for $f(x)$, for example, $k \cos x$, $k \in \mathbb{R}$ E.g $\cos x$

or equivalent such as $p \sin\left(x - \frac{\pi}{2}\right)$ or $p \cos(x \pm \pi)$ with k and p constants.

Score $10 \cos(-x)$ M1, A0

A1: Completely correct expression for $f(x)$, for example, $-10 \cos x$ which may be unsimplified
 $\cos x \times -10$

or equivalent such as $10 \sin\left(x - \frac{\pi}{2}\right)$, $10 \cos(x - \pi)$ or $10 \cos(x + \pi)$

Please check the question space for possible answers to this

(b) **Scored on Diagram 1 or its Copy**

(b) (i)

M1: $\cap$ shaped curve symmetrical about y axis passing through $(0, 10)$

Be tolerant of slips of the pen, slight asymmetry and a pointy maximum.

Condone a graph just meeting the x -axis rather than passing through it

A1: As above with x intercepts at approximately $\pm\pi$. Look for a tolerance of $\frac{1}{2}$ a square
The graph must now pass through the x -axis

(b)(ii)

B1: States 2. No reason is required and no sketch is required.

(c) **Scored on Diagram 2 or its Copy. Take care as some students may use the Copy of Diagram 1. The shape of the graphs in (i) and (ii) are significantly different so mark positively.**

If you feel that candidates have not understood the instructions and deserve credit use review.

(c)(i)

M1: Correct shape for a tangent graph with x intercepts at $-\pi, 0$ and π radians in the interval
 $-2\pi < x < 2\pi$.

Be tolerant of the exact position of the asymptotes (allow a tolerance of $\frac{1}{2}$ a square) and allow if there are only 3 cycles. Ignore the graph outside the given domain

A1: Fully correct with asymptotes at $(2p+1)\frac{\pi}{2}$, $p \in \mathbb{Z}$ Ignore the graph outside the given domain

(c)(ii) Full marks can only be awarded following M1 in (c)(i).

Candidates cannot score B0, B1 but M1, A0, B1, B1 is possible

B1: Either states 200 or gives a suitable explanation.

E.g. it is $50 \times$ the number of their roots in the interval $-2\pi \leq x \leq 2\pi$

B1: Having scored M1 in (c)(i) and B1 in (c)(ii) candidates must

- State 200
- And give a suitable explanation. E.g. explains it is $50 \times$ the number of roots in the interval $-2\pi \leq x \leq 2\pi$. There are other ways of explaining this so look carefully at what is written down. For example, candidates may state 2 roots every 2π radians so $100 \times 2 = 200$

Pearson Edexcel International Advanced Level

Tuesday 13 January 2026

Morning (Time: 1 hour 30 minutes)

Paper

reference

WMA12/01A

Mathematics

International Advanced Subsidiary/Advanced Level

Pure Mathematics P2

Question paper

You must have:

Answer book (sent separately).

Do not return this question paper with the answer book.

Turn over ►

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1.

**In this question you must show all stages of your working.
Solutions relying on calculator technology are not acceptable.**

An arithmetic series has first term a and common difference d .

Given that the sum of the first 9 terms is 54

(a) show that

$$a + 4d = 6 \quad (2)$$

Given also that the 8th term is half the 7th term,

(b) find the values of a and d . (4)

(Total for Question 1 is 6 marks)

2.

**In this question you must show all stages of your working.
Solutions relying on calculator technology are not acceptable.**

A sequence is defined by

$$u_1 = 3$$

$$u_{n+1} = 2 - \frac{4}{u_n} \quad n \geq 1$$

Find the exact values of

(a) u_2 , u_3 and u_4 (3)

(b) u_{61} (1)

(c) $\sum_{i=1}^{99} u_i$ (2)

(Total for Question 2 is 6 marks)



3.

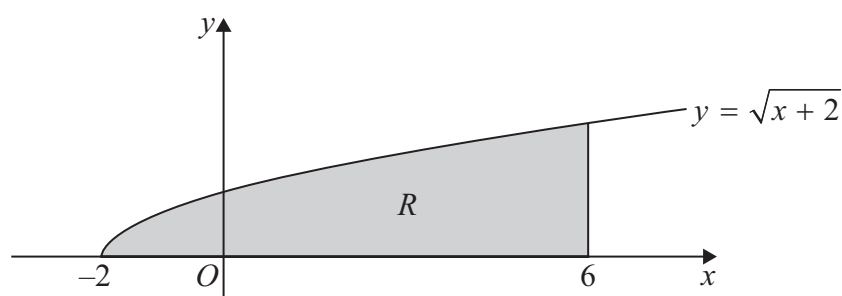


Figure 1

Figure 1 shows a sketch of part of the curve with equation $y = \sqrt{x+2}$ $x \geq -2$

The finite region R , shown shaded in Figure 1, is bounded by the curve, the x -axis and the line with equation $x = 6$

The table below shows corresponding values of x and y for $y = \sqrt{x+2}$

x	-2	0	2	4	6
y	0	1.4142	2	2.4495	2.8284

- (a) Use the trapezium rule, with all of the values of y in the completed table, to find an approximate value for the area of R , giving your answer to 3 decimal places.

(3)

Use your answer to part (a) to find the approximate value of

(b) $\int_{-2}^6 (2x + \sqrt{4x+8}) dx$

(3)

(Total for Question 3 is 6 marks)

4.

**In this question you must show all stages of your working.
Solutions relying on calculator technology are not acceptable.**

$$f(x) = 3x^3 + ax^2 + bx - 10$$

Given that $(x - 2)$ is a factor of $f(x)$,

- (a) use the factor theorem to show that $2a + b = -7$ (2)

Given also that when $f(x)$ is divided by $(x + 1)$ the remainder is -36

- (b) find the value of a and the value of b . (4)

- (c) Hence find the quotient and remainder when $f(x)$ is divided by $(x - 5)$ (3)

(Total for Question 4 is 9 marks)

5.

**In this question you must show all stages of your working.
Solutions relying on calculator technology are not acceptable.**

Given that k is a constant and

$$\int_2^4 \left(\frac{4}{\sqrt{x}} + k \right) dx = 30$$

- find the exact value of k . (5)

(Total for Question 5 is 5 marks)



6.

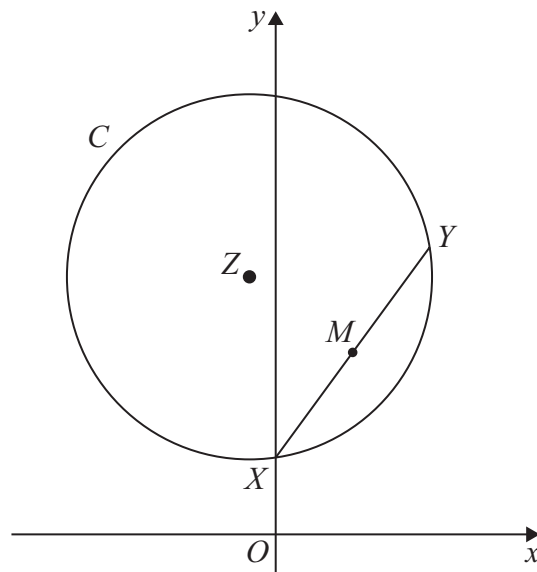


Diagram **NOT**
drawn to scale

Figure 2

Figure 2 shows a circle C with centre Z

Points X and Y lie on C and have coordinates $(0, 3)$ and $(6, 11)$ respectively.

Given that M is the midpoint of XY

- (a) Find an equation for the straight line which passes through Z and M , giving your answer in the form $ax + by + d = 0$ where a , b and d are integers. (4)

Given that the y coordinate of Z is 10

- (b) Find the x coordinate of Z (2)

- (c) Hence find an equation of C (3)

The point W lies on C such that angle $WXY = 90^\circ$

- (d) Find the coordinates of W (2)

(Total for Question 6 is 11 marks)

7.

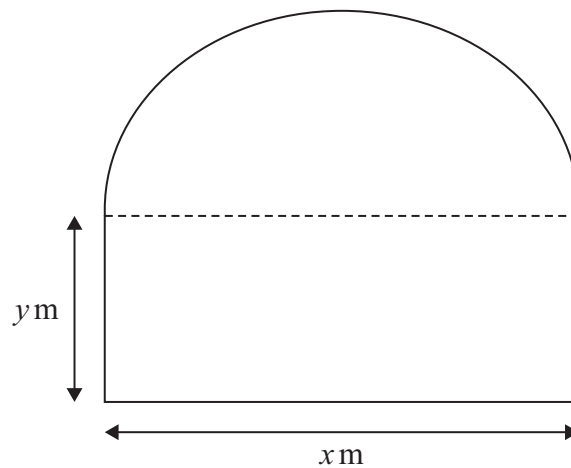


Diagram **NOT**
drawn to scale

Figure 3

**In this question you must show all stages of your working.
Solutions relying entirely on calculator technology are not acceptable.**

Figure 3 shows the plan view of a garden. The shape of this garden consists of a rectangle joined to a semicircle.

The rectangle has length x metres and width y metres.

The area of the garden is 100 m^2 .

- (a) Show that the perimeter, P metres, of the garden is given by

$$P = \frac{1}{4}x(4 + \pi) + \frac{200}{x} \quad (4)$$

- (b) Use calculus to find the exact value of x for which the perimeter of the garden is a minimum.

(3)

- (c) Justify, by further use of calculus, that the value of x found in part (b) gives a minimum value for P .

(2)

- (d) Find the minimum perimeter of the garden, giving your answer in metres to one decimal place.

(2)

(Total for Question 7 is 11 marks)



8.

**In this question you must show all stages of your working.
Solutions relying on calculator technology are not acceptable.**

Given the first three terms of a geometric sequence are

$$2 \sin \theta, \cos \theta \text{ and } 1 + \sin \theta$$

where θ is a constant

(a) show that

$$3 \sin^2 \theta + 2 \sin \theta - 1 = 0 \quad (3)$$

Given that θ is acute,

(b) use trigonometric identities to find the exact value of the second term in the sequence.

(3)

(c) find the value of the 11th term in the sequence.

(3)

(Total for Question 8 is 9 marks)

9.

**In this question you must show all stages of your working.
Solutions relying on calculator technology are not acceptable.**

Given that a and b are positive constants, solve the simultaneous equations

$$ab = 25$$

$$\log_4 a - \log_4 b = 3$$

Show each step of your working, giving exact values for a and b .

(4)

(Total for Question 9 is 4 marks)

10.

**In this question you must show all stages of your working.
Solutions relying entirely on calculator technology are not acceptable.**

The binomial expansion, in ascending powers of x , of $(1 + kx)^n$ is

$$1 + 36x + 567x^2 + px^3 + \dots$$

where k and p are non-zero constants and n is an integer greater than 1.

- (a) Use this information to set up and solve two simultaneous equations to find the value of k and the value of n .

(6)

- (b) Hence find the value of p .

(2)

(Total for Question 10 is 8 marks)

TOTAL FOR PAPER IS 75 MARKS



Please check the examination details below before entering your candidate information

Candidate surname

Other names

Centre Number

Candidate Number

Pearson Edexcel International Advanced Level

Tuesday 13 January 2026

Morning (Time: 1 hour 30 minutes)

Paper

reference

WMA12/01A

Mathematics

International Advanced Subsidiary/Advanced Level

Pure Mathematics P2

Answer Book

You must have:

Question paper (sent separately).

Mathematical Formulae and Statistical Tables (Yellow), calculator.

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 10 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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Question 1

Write the answer to Question 1 on these 2 pages

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

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(Total for Question 1 is 6 marks)



Question 2

Write the answer to Question 2 on these 2 pages

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DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(Total for Question 2 is 6 marks)



Question 3

Write the answer to Question 3 on these 2 pages

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DO NOT WRITE IN THIS AREA

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DO NOT WRITE IN THIS AREA

(Total for Question 3 is 6 marks)



Question 4

Write the answer to Question 4 on these 2 pages

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DO NOT WRITE IN THIS AREA

(Total for Question 4 is 9 marks)



Question 5

Write the answer to Question 5 on these 2 pages

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DO NOT WRITE IN THIS AREA

(Total for Question 5 is 5 marks)



Question 6

Write the answer to Question 6 on these 2 pages

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DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(Total for Question 6 is 11 marks)



Question 7

Write the answer to Question 7 on these 4 pages

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DO NOT WRITE IN THIS AREA

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Question 7 continued

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(Total for Question 7 is 11 marks)



Question 8

Write the answer to Question 8 on these 2 pages

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DO NOT WRITE IN THIS AREA

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DO NOT WRITE IN THIS AREA

(Total for Question 8 is 9 marks)



Question 9

Write the answer to Question 9 on these 2 pages

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Question 10

Write the answer to Question 10 on these 3 pages

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DO NOT WRITE IN THIS AREA



Question 10 continued

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(Total for Question 10 is 8 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (Results)

January 2026

Pearson Edexcel International Advanced Level in
Pure Mathematics P2

WMA12/ 01A

Edexcel and BTEC Qualifications

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January 2026

Question Paper Log Number P87593A

Publication Code WMA12_01A_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN:

- bod – benefit of doubt
 - ft – follow through
 - the symbol $\checkmark$ will be used for correct ft
 - cao – correct answer only
 - cso – correct solution only. There must be no errors in this part of the question to obtain this mark
 - isw – ignore subsequent working
 - awrt – answers which round to
 - SC – special case
 - oe – or equivalent (and appropriate)
 - d... or dep – dependent
 - indep – independent
 - dp – decimal places
 - sf – significant figures
 - * – The answer is printed on the paper or ag- answer given
 - $\square$ or d... – The second mark is dependent on gaining the first mark
4. All A marks are 'correct answer only' (cao), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a

misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. If you are using the annotation facility on ePEN, indicate this action by 'MR' in the body of the script.
6. If a candidate makes more than one attempt at any question:
 - a) If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - b) If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
7. Ignore wrong working or incorrect statements following a correct answer.

General Principles for Pure Mathematics Marking

(NB specific mark schemes may sometimes override these general principles)

Method mark for solving 3 term quadratic:

1. Factorisation

$(x^2 + bx + c) = (x + p)(x + q)$, where $|pq| = |c|$ leading to $x = \dots$

$(ax^2 + bx + c) = (mx + p)(nx + q)$, where $|pq| = |c|$ and $|mn| = |a|$ leading to $x = \dots$

2. Formula

Attempt to use correct formula (with values for a, b and c)

3. Completing the square

Solving $x^2 + bx + c = 0 : (x \pm \frac{b}{2})^2 \pm q \pm c$, $q \neq 0$ leading to $x = \dots$

Method marks for differentiation and integration:

1. Differentiation

Power of at least one term decreased by 1 ($x^n \rightarrow x^{n-1}$)

2. Integration

Power of at least one term increased by 1 ($x^n \rightarrow x^{n+1}$)

Use of a formula

Where a method involves using a formula that has been learnt, the advice given in recent examiners' reports is that the formula should be quoted first.

Normal marking procedure is as follows:

Method mark for quoting a correct formula and attempting to use it, even if there are small mistakes in the substitution of values.

Where the formula is not quoted, the method mark can be gained by implication from correct working with values, but may be lost if there is any mistake in the working.

Exact answers

Examiners' reports have emphasised that where, for example, an exact answer is asked for, or working with surds is clearly required, marks will normally be lost if the candidate resorts to using rounded decimals.

Answers without working

The rubric says that these may not gain full credit. Individual mark schemes will give details of what happens in particular cases. General policy is that if it could be done "in your head", detailed working would not be required. Most candidates do show working, but there are occasional awkward cases and if the mark scheme does not cover this, please contact your team leader for advice.

Question Number	Scheme	Marks
1 (a)	$54 = \frac{9}{2}(2a + 8d)$ $\Rightarrow a + 4d = 6 \quad *$	M1 A1* (2)
(b)	Correct equation $a + 7d = \frac{1}{2}(a + 6d)$ Substitutes or eliminate terms $\Rightarrow 6 - 4d + 7d = \frac{1}{2}(6 - 4d + 6d)$ $\Rightarrow d = \dots$ (or $a = \dots$) $d = -1.5 \text{ (o.e.)}, a = 12$	B1 (M1 on EPEN) M1 A1, A1 (4) (6 marks)

(a)

M1: Attempts to use e.g. $S_9 = \frac{9}{2}(2a + 8d)$ or $S_9 = \frac{9}{2}(2a + (9-1)d)$ with $S_9 = 54$

Alternatively uses $S_9 = \frac{9}{2}(a + l)$ with $S_9 = 54$ and $l = a + 8d$

or lists terms $a + a + d + \dots + a + 8d = 54 \Rightarrow 9a + 36d = 54$ scored when a correct equation is achieved (i.e. without ...).

There is no need to see the notation S_9

A1*: Proceeds to the given answer via a correct equation as in the main scheme.

There is no need to see any rearranging between this and the given answer.

Just $9a + 36d = 54 \Rightarrow a + 4d = 6$ scores M0A0*: a valid formula or listing of terms in a sum must be seen.

(b)

B1: Correct equation e.g., $a + 7d = \frac{1}{2}(a + 6d)$ or $2(a + (8-1)d) = a + (7-1)d$

There is no need to see any notation e.g. u_8

Note that the simplified equation is $a + 8d = 0$

M1: Uses both equations, condoning a slip such as misplacing the $\frac{1}{2}$, e.g., $\frac{1}{2}(a + 7d) = a + 6d$,

and solves simultaneously to find a value for **a** **or** **d**.

This mark depends on the use of acceptable expressions for u_7 and u_8 .

Don't be concerned with the process of solving their simultaneous equations provided they have two acceptable equations and arrive at a solution for **a** **or** **d**.

A1: Either $d = -1.5$ o.e. **or** $a = 12$

A1: Both $d = -1.5$ o.e. **and** $a = 12$

Note that solving $u_8 = 2u_7$ (should) lead to $d = -6$ and $a = 30$ and scores B0M1A0A0.

Question Number	Scheme	Marks
2 (a)	$u_2 = 2 - \frac{4}{3} = \frac{2}{3}, \quad u_3 = 2 - \frac{4}{\text{"}\frac{2}{3}\text{"}} = -4, \quad u_4 = 2 - \frac{4}{\text{"}-4\text{"}} = 3$	M1 A1 A1 (3)
(b)	$\{u_{61} = \} 3$	B1 (1)
(c)	$\left\{ \sum_{i=1}^{99} u_i = \right\} \frac{99}{3} \times \left(3 + \text{"}\frac{2}{3}\text{"} + \text{"}-4\text{"} \right)$ $= -11$	M1 A1 (2)
		(6 marks)

(a)

M1: Attempts to use the formula correctly using **values** at least once which may be implied by $u_2 = \frac{2}{3}$
or

e.g. by $u_2 = 5, u_3 = \frac{6}{5}$ where their u_3 follows from their u_2 Not scored for e.g. just $u_2 = 2 - \frac{4}{u_1}$

A1: 2 correct answers. Do not allow e.g. 0.66 or 0.66... for $\frac{2}{3}$ but allow $0.\dot{6}$

A1: All 3 correct. If the terms are not labelled, then the order must be clear to score this mark.

(b)

B1: cao. Must be clearly identified as their answer to part (b) or labelled as u_{61}

They do not need to show that they have used a period of 3 in their answer, but if they have **clearly** used a period of e.g. 4 in part (b), withhold the mark.

(c)

M1: Uses a valid method. Note that $3 + \frac{2}{3} - 4 = -\frac{1}{3}$ and you might see $99 + 22 - 132 = -11$

A1: cao. Answer only scores both marks.

Question Number	Scheme	Marks
3 (a)	“Strip width” or $h = 2$ Area $\approx \frac{h}{2} (\{0+\} 2.8284 + 2 \times (1.4142 + 2 + 2.4495))$ $= \text{awrt } 14.556$	B1 M1 A1 (3)
(b)	$\left\{ \int_{-2}^6 (2x + \sqrt{4x+8}) dx = \right\} [x^2]_{-2}^6 + 2 \times "14.556"$ $= 6^2 - (-2)^2 + 2 \times "14.556"$ $= \text{awrt } 61.1\text{S}$	M1 dM1 A1 (3) (6 marks)

(a) **Note: Algebraic integration in part (a) scores 000. They can go on to score 110 in part (b).**

B1: Uses a strip width of 2 units. This may be embedded in the (correct) trapezium rule or seen as $h = 2$.

M1: Uses the correct form of the trapezium rule.

Look for $\frac{h}{2} (2.8284 + 2 \times (1.4142 + 2 + 2.4495))$ condoning transcription errors but they must be using the y values in the correct places.

Just $2.8284 + 2 \times (1.4142 + 2 + 2.4495)$ scores B1M1 (and the A1 is available if they get awrt 14.556)

Note that $\frac{2}{2} (0 + 2.8284) + 2 \times (1.4142 + 2 + 2.4495)$ is acceptable unless it follows an incorrect formula e.g. $\frac{h}{2} (y_0 + y_4) + 2 \times (y_1 + y_2 + y_3)$

A1: awrt 14.556. Note the unrounded value is 14.5558 and scores full marks.

Calculator integration achieves 15.085 (to 3 d.p.) and scores no marks unless a valid attempt is seen. Ignore any units or e.g. u^2 if seen.

(b)

M1: For an attempt to split up the integral and achieve an expression of one of the below forms:

Look for e.g. $[x^2]_{-2}^6 + k \times "14.556"$ **or** $32 + k \times "14.556"$ **or** $[\alpha x^n]_{-2}^6 + 2 \times "14.556"$ with $n \neq 1$

but allow $k = 1$ for this mark. They may attempt the two parts separately but must combine for M1.

The $[x^2]_{-2}^6$ might be seen as e.g. $\frac{1}{2} \times 6 \times 12 - \frac{1}{2} \times 2 \times 4$ or $\frac{1}{2} \times 6 \times 12 + \frac{1}{2} \times 2 \times (-4)$ if they treat it as the area of two triangles or they might apply the trapezium rule to $2x$ only (which should give the correct 32).

Condone slips in the base and/or height of the triangles if the other aspect $2 \times "14.556"$ is correct.

dM1: Full and correct **method** using their answer to part (a) to find a value.

Condone the use of a calculator to find $\int_{-2}^6 2x \, dx = 32$ and condone a sign slip/bracketing error

when substituting their limits in e.g. $6^2 - -2^2 + 2 \times "14.556"$ but not just $6^2 + 2^2 + 2 \times "14.556"$ (they must clearly be subtracting).

A minimally acceptable response is e.g. $32 + 2 \times "14.556" = \dots$

A1: awrt 61.1 following award of M1 and dM1. If they just have 61.1 with no working send to review. Note that calculator integration achieves 62.169889... and will score no marks unless other valid attempts are seen. If they start again with the trapezium rule allow SC 100 if they achieve awrt 61.1

Question Number	Scheme	Marks
4 (a)	$f(2) = 0 \Rightarrow 24 + 4a + 2b - 10 = 0$ $\Rightarrow 2a + b = -7$ *	M1 A1* (2)
(b)	$f(-1) = -36 \Rightarrow -3 + a - b - 10 = -36 \Rightarrow a - b = -23$ Solve simultaneously $\Rightarrow a = -10, b = 13$	M1, A1 dM1, A1 (4)
(c)	$f(x) = 3x^3 - 10x^2 + 13x - 10$ Full method to find both quotient and remainder e.g. $3x^3 - 10x^2 + 13x - 10 \equiv (x - 5)(3x^2 + 5x + 38) + 180$ States quotient is $(3x^2 + 5x + 38)$ and remainder is 180	M1, A1 A1 (3) (9 marks)

(a) **Note that attempts using algebraic division in part (a) score no marks.**

M1: Attempts to set $f(2) = 0$ to form an equation in a and b , e.g., $3(2)^3 + a(2)^2 + 2b - 10 = 0$
The $= 0$ may be implied for this mark only, by e.g., $f(2) = 24 + 4a + 2b - 10 \Rightarrow -14 = 4a + 2b$
but not by proceeding directly to the given answer e.g. $f(2) = 24 + 4a + 2b - 10 \Rightarrow -7 = 2a + b$

A1*: Shows that $2a + b = -7$ via an intermediate line.

$f(2) = 0$ must be present but may be seen as e.g. $f(2) = \dots = 0$

Allow e.g. when $x = 2$, $f(x) = \dots = 0$

Some examples:

$f(2) = 3(2)^3 + a(2)^2 + 2b - 10 \Rightarrow 2a + b = -7$ scores M0A0* (no equation prior to given answer)

$3(2)^3 + a(2)^2 + 2b - 10 = 24 + 4a + 2b - 10 = 0 \Rightarrow 2a + b = -7$ scores M1A0* (no $f(2) = 0$)

$f(2) = 24 + 4a + 2b - 10 = 0 \Rightarrow 2a + b = -7$ scores M1A1*

$f(2) = 24 + 4a + 2b - 10 \Rightarrow 14 + 4a + 2b = 0 \Rightarrow 2a + b = -7$ scores M1A1*

(b)

M1: Sets $f(-1) = -36$ to form an equation in a and b , e.g., $3(-1)^3 + a(-1)^2 - b - 10 = -36$

Alternatively, attempts to divide $f(x)$ algebraically by $(x + 1)$ leading to a quotient of the form $(3x^2 + Px + S)$ with remainder T where P, S and T are functions of a and/or b , followed by setting their remainder T equal to -36 . For reference $P = a - 3, S = b + 3 - a$ and $T = a - b - 13$

A1: Correct unsimplified equation in a and b .

Any indices must be correctly evaluated but terms do not need to be collected.

e.g., $-3 + a - b - 10 = -36$ or $a - b = -23$ o.e.

dM1: Solves simultaneously to find values for a and b . Dependent upon the previous M mark.

Don't be concerned with the process of solving their simultaneous equations provided they are using the given answer to (a) (or a miscopy) and arrive at a solution for a and b .

A1: $a = -10, b = 13$ following award of all previous marks in part (b).

(c)

M1: Full method to find both the quotient and the remainder when their $f(x)$ is divided by $(x - 5)$

By division look for an attempt with a quadratic quotient of the form $(3x^2 + dx + e)$ with $d \neq 0$ and a constant remainder.

A1: For a correct quotient **or** remainder which can be scored within $(x - 5)(3x^2 + 5x + 38) + 180$ or their attempt at algebraic division which may be via a grid method.

A1: **States** quotient is $3x^2 + 5x + 38$ and remainder is 180 but may be seen as e.g. $Q(x) = 3x^2 + 5x + 38$ and $R = 180$ i.e. they must be extracted in some way, not left as e.g. $(x - 5)(3x^2 + 5x + 38) + 180$

SC: Allow SC M1A0A0 for those that **correctly** find the remainder is 180 using

$f(5) = 3(5)^3 - 10(5)^2 + 13(5) - 10 = 180$ even if there is no attempt to find the quotient.

Note that you might see this followed by $f(x) - 180 = 3x^3 - 10x^2 + 13x - 190 = (x - 5)(3x^2 + 5x + 38)$ which scores the first A1 and the final mark is available if they extract the quotient and remainder.

Question Number	Scheme	Marks
5	$4x^{\frac{1}{2}} \rightarrow \dots x^{\frac{1}{2}} \text{ or } k \rightarrow \dots x$ $\left\{ \int \left(\frac{4}{\sqrt{x}} + k \right) dx = \right\} \int \left(4x^{-\frac{1}{2}} + k \right) dx = \frac{4x^{\frac{1}{2}}}{\left(\frac{1}{2}\right)} + kx \{+c\}$ $\left[\frac{4x^{\frac{1}{2}}}{\left(\frac{1}{2}\right)} + kx \right]_2^4 = 30 \Rightarrow (8\sqrt{4} + 4k) - (8\sqrt{2} + 2k) = 30$ $\Rightarrow 2k + 16 - 8\sqrt{2} = 30$ $\Rightarrow k = 7 + 4\sqrt{2}$	M1 A1 dM1 ddM1A1 (5) (5 marks)

Note: Condone spurious inclusion of $\int$ throughout.

M1: Increases the power by one on a correct term. Score for either $4x^{\frac{1}{2}} \rightarrow \dots x^{\frac{1}{2}}$ or $k \rightarrow \dots x$ where ... is a constant and may be unsimplified.

The indices must be evaluated, so do not score for $4x^{\frac{1}{2}} \rightarrow \dots x^{\frac{1}{2}+1}$

Candidates that write e.g. $\frac{4}{\sqrt{x}} = 4x^{\frac{1}{2}} \rightarrow \frac{4}{\left(\frac{3}{2}\right)} x^{\frac{3}{2}}$ or e.g. $\frac{4}{\sqrt{x}} = 4x^{-2} \rightarrow \frac{4}{(-1)} x^{-1}$ will not score this mark (unless they integrate k to ... x).

A1: Correct integration (may be unsimplified) $\frac{4x^{\frac{1}{2}}}{\left(\frac{1}{2}\right)} + kx \{+c\}$ ignoring limits.

The indices must be evaluated, so do not score for $4x^{\frac{1}{2}} \rightarrow \dots x^{\frac{1}{2}+1}$

There is no need for $+c$ in the whole question.

dM1: Substitutes both $x=4$ and $x=2$ into an integrated expression (at least one term must have been integrated), subtracts the correct way round and sets equal to 30.

Condone missing brackets which lead to a sign error, e.g., $8\sqrt{4} + 4k - 8\sqrt{2} + 2k = 30$

It is dependent upon the previous method mark i.e. there must be some clear algebraic integration. If there is no algebraic integration but you think it may be implied then send to review.

ddM1: Dependent upon both previous method marks **and** having correctly integrated k to kx

It is for an attempt to solve the resulting equation in k leading to a value which may be inexact.

Condone slips when solving their equation: do not be concerned about their processing provided they proceed from a linear equation in k to a value for k .

A1: $k = 7 + 4\sqrt{2}$ or any unsimplified exact equivalent, e.g., $k = \frac{14 + 8\sqrt{2}}{2}$ or $k = \frac{30 + 8\sqrt{2} - 16}{2}$

or e.g. $k = 7 + 2^{\frac{5}{2}}$ o.e. and no other solutions.

ISW if they go on to provide a decimal approximation e.g. 12.66.

Question Number	Scheme	Marks
6.(a)	{Mid-point of $XY = \{ (3, 7)$ gradient $XY = \frac{11-3}{6-0} \left\{ = \frac{4}{3} \right\}$ $y - "7" = "-\frac{3}{4}"(x - "3")$ $3x + 4y - 37 = 0$	B1 M1 dM1 A1 (4)
(b)	Substitute $y = 10$ into their line equation to give $x = \dots$ $x = -1$	M1 A1 (2)
(c)	e.g. $r^2 = (" -1" - 0)^2 + (10 - 3)^2$ or $r = \sqrt{(" -1" - 6)^2 + (10 - 11)^2}$ $(x + 1)^2 + (y - 10)^2 = 50$	M1 dM1, A1 (3)
(d)	Full method to find W or e.g. $(\dots, 9)$ or $(" -8", \dots)$ $(-8, 9)$	M1 (B1 on EPEN) A1 (B1 on EPEN) (2)
		(11 marks)

Note: Throughout the question be generous with parts that are mislabelled or not labelled at all, provided it is clear what their intention is.

(a)

B1: Correct coordinates for $\{M = \}$ $(3, 7)$

M1: Correct method for gradient of $XY = \frac{11-3}{6-0} \left\{ = \frac{4}{3} \right\}$

An alternative is to set up and solve an equation e.g. $11 = 6m + 3$ leading to $m = \dots$

dM1: Correct method for the equation of the line through Z and their M (which must not be X or Y).

Look for use of the negative reciprocal of their $\frac{4}{3}$ with their $(3, 7)$, e.g., $y - "7" = "-\frac{3}{4}"(x - "3")$

If using $y = mx + c$ they must proceed as far as $c = \dots$ Dependent on the previous method mark.

A1: $3x + 4y - 37 = 0$ but allow any integer multiple of this and any order of terms.

The $= 0$ must be present. $3x + 4y = 37$ is A0 without also giving an alternative in the required form.

(b)

M1: Substitutes $y = 10$ into their $3x + 4y - 37 = 0$ (or earlier form of this equation) and solves to find a value for x

or Alt uses the fact that $XZ = YZ$ to give $x^2 + 7^2 = (x - 6)^2 + 1^2$ and solves by expanding and then cancelling the x^2 terms to find a value for x

A1: cao $x = -1$ Note: if they use an equation from part (a) it must be correct.

If using **Alt** then you do not need to check their equation in part (a).

(c)

M1: Valid method to find the radius or radius², usually using Pythagoras with $(-1, 10)$ and either X or Y . Alternatively, uses $MZ^2 + MY^2 = r^2$ or $MZ^2 + MX^2 = r^2$

dM1: Correct method for the equation of the circle $(x \pm "-1")^2 + (y \pm 10)^2 = "\sqrt{50}"^2$ using their radius found using a valid method and condoning sign errors. Dependent on the first method mark.

A1: cao $(x+1)^2 + (y-10)^2 = 50$ must be simplified. Do not allow e.g. $(x+1)^2 + (y-10)^2 = \sqrt{50}^2$

This mark is dependent on scoring the A1 in part (b) because we require that $x = -1$ comes from correct working.

ISW after a correct answer is seen e.g. if they go on to attempt to expand the brackets.

Those who fortuitously achieve a correct equation using $x = 1$ will score A0.

(d)

M1: For a full **method** as far as a value for x **or** y which *would* lead to a correct value for either coordinate of W following from their answers to previous parts of the question.

May be implied by one correct coordinate following through on their $x = -1$ using the main scheme, so either $(\dots, 9)$ or $("-8", \dots)$. Follow through on $6 - 2 \times (6 - ("1"))$ for the x coordinate. Allow this mark if they slip and write $(9, -8)$.

Note that there are many ways to find the coordinates of W .

In any of these approaches, condone slips in copying or arithmetic mistakes but the core method must be valid, so any quadratic equation created **must** be solved using an appropriate strategy which may be by calculator. Do not be concerned by how they label any lines e.g. mislabel XW as YW .

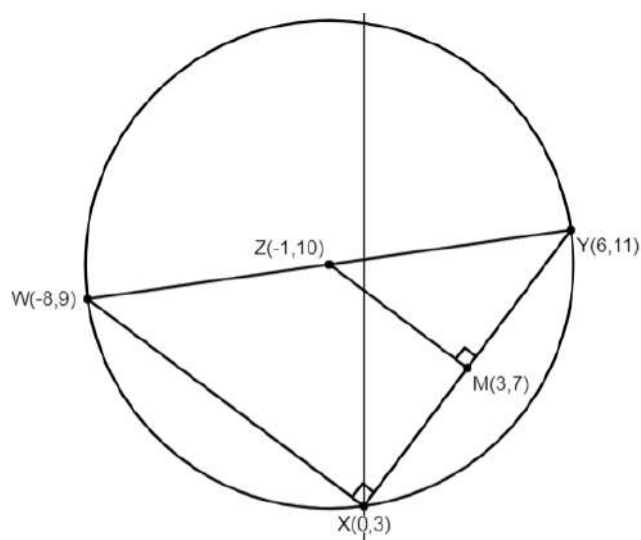
Some examples are:

- Using $\overrightarrow{OY} + 2\overrightarrow{YZ}$ (as in the main scheme).
- Finding the equation of XW $\left(y - 3 = "-\frac{3}{4}"x\right)$ and solving simultaneously with the equation of their circle.
- Finding the equation of YW $\left(y - 11 = "\frac{1}{7}"(x - 6) \text{ or } y - 10 = "\frac{1}{7}"(x - "-1")\right)$ and solving simultaneously with the equation of their circle.
- Finding the equation of XW and the equation of YW (as above) and solving simultaneously.
- Finding $\overrightarrow{OX} + 2\overrightarrow{MZ}$
- Using Pythagoras $XY^2 + XW^2 = (2r)^2$ with $W(a, b)$ lying on any of XW , YW or the circle.

Any of these approaches may let $W(a, b)$ first: e.g. in bullet 2, let $W(a, b)$ then gradient of WX is $\frac{b-3}{a} = "-\frac{3}{4}"$ leading to $a = 4 - \frac{4}{3}b$ which can then be substituted into the equation of the circle or their YW .

A1: cao $(-8, 9)$ and no others seen, i.e., if two possible pairs of coordinates are given then A0.

This mark is dependent on scoring the A1 in part (b) because we require that $x = -1$ comes from correct working.



Question Number	Scheme	Marks
7 (a)	$100 = xy + \frac{1}{2}\pi\left(\frac{x}{2}\right)^2$ $y = \frac{100}{x} - \frac{\pi x}{8}$ $P = 2y + x + \frac{1}{2}\pi x = \frac{200}{x} - \frac{\pi x}{4} + x + \frac{1}{2}\pi x$ $P = \frac{1}{4}x(4 + \pi) + \frac{200}{x} *$	M1 A1 dM1 A1* (4)
(b)	$\left\{\frac{dP}{dx}\right\} = 1 + \frac{\pi}{4} - \frac{200}{x^2}$ $1 + \frac{\pi}{4} - \frac{200}{x^2} = 0 \Rightarrow x^2 = \frac{800}{4 + \pi}$ $\Rightarrow x = \sqrt{\frac{800}{4 + \pi}}$	B1 M1 A1 (3)
(c)	$\frac{d^2P}{dx^2} = \frac{\lambda}{x^3} = \frac{\lambda}{10.6^3} = \dots$ or makes reference to the sign of $\frac{d^2P}{dx^2} = \frac{\lambda}{x^3}$ e.g. $\frac{d^2P}{dx^2} = \frac{400}{x^3}$ so (since $x > 0$) $\frac{d^2P}{dx^2} > 0 \Rightarrow$ minimum	M1 A1 (2)
(d)	Substitutes $x = \sqrt{\frac{800}{4 + \pi}} \approx 10.6$ into $P = \frac{200}{x} + \frac{1}{4}x(4 + \pi) = \dots$ = awrt 37.8 {m}	M1 A1 (2)
		(11 marks)

(a)

M1: Sets $100 = xy + kx^2$ where k is a non-zero constant e.g. $100 = xy + \frac{1}{2}\pi\left(\frac{x}{2}\right)^2$ (may be implied by later work)

A1: Achieves $y = \frac{100}{x} - \frac{\pi x}{8}$ or equivalent correct y in terms of x e.g. $y = 100x^{-1} - \frac{\pi x}{8}$ or $y = \frac{800 - \pi x^2}{8x}$

dM1: Substitutes their y in terms of x into their expression for the perimeter. Don't be concerned about the mechanics of rearranging the subject for this mark.
Dependent on the previous method mark.

A1*: Full proof showing all relevant lines with no errors or omissions.

There is no need to collect terms in x prior to factorisation but there must be evidence of correct substitution of a correct y in terms of x into a correct P in terms of y and x before the given answer. The $P =$ (allow perimeter = or even perimeter:) must be present at some stage but accept if it is first seen in the answer line.

Condone $200x^{-1}$ in place of $\frac{200}{x}$ and allow the terms in any order.

(b) Note: Full marks in (b) can be scored from use of $\frac{dy}{dx}$ or $f'(x)$ in place of $\frac{dP}{dx}$ (or P')

B1: Fully correct derivative $\left\{ \frac{dP}{dx} = \right\} 1 + \frac{\pi}{4} - \frac{200}{x^2}$ o.e e.g. $\left\{ \frac{dP}{dx} = \right\} \frac{4+\pi}{4} - 200x^{-2}$

The indices must be processed, i.e., not $\left\{ \frac{dP}{dx} = \right\} 1 + \frac{\pi}{4} - 200x^{-1-1}$

M1: Sets their $\frac{dP}{dx} = 0$ which must be of the form $A - Bx^{-2}$, $A, B > 0$ **and** proceeds at least to $x^{\pm 2} = C$, $C > 0$ which may be implied by their solution of e.g. $D = Ex^{-2}$, $D \times E > 0$
Alternatively, they may use the quadratic formula. Condone the use of an inequality for this mark.

A1: cao $x = \sqrt{\frac{800}{4+\pi}}$ o.e. such as $\frac{20\sqrt{2}}{\sqrt{4+\pi}}$ or $\frac{20\sqrt{8+2\pi}}{4+\pi}$ and ISW after an acceptable answer.

It must be exact and in a simple form and **not** a decimal 10.58... or embedded fractions e.g.

$\sqrt{\frac{200}{1+\frac{\pi}{4}}}$ or $\frac{10\sqrt{2}}{\sqrt{1+\frac{\pi}{4}}}$ are A0 $\pm \sqrt{\frac{800}{4+\pi}}$ is also A0. Must now be an equality and not e.g.

$$x > \sqrt{\frac{800}{4+\pi}}$$

(c) **Notes: All marks in (c) and (d) can be scored if $x = 10.6$ or better.**

Mark part (c) and part (d) together.

M1: For an attempt to

- Either substitute their answer to part (b) into $\frac{d^2P}{dx^2} = \frac{\lambda}{x^3} = \dots$ and find a value (you may need to check if this is implied)
- Or make reference to the sign of $\frac{d^2P}{dx^2} = \frac{\lambda}{x^3}$
- Alternatively, they may substitute x values either side of their value found in part (b) into their $\frac{dP}{dx}$ to find two values for $\frac{dP}{dx}$

A1: cso Requires a correct $\frac{d^2P}{dx^2} = \frac{400}{x^3}$, a value of 10.6 or better in part (b), a statement and a reason,

e.g. $\frac{d^2P}{dx^2} = \frac{400}{x^3} > 0 \Rightarrow \text{minimum}$

If they calculate the value of the 2nd derivative it must be 0.3 (1sf) or better and they must state > 0

If using the 2nd derivative they must use the notation $\frac{d^2P}{dx^2}$ or P'' for this mark (condone $\frac{d^2P}{d^2x}$)

In the alternative, the two values substituted in must be either side of $\sqrt{\frac{800}{4+\pi}}$, the values of $\frac{dP}{dx}$

must be correct to 1sf, they must use the notation $\frac{dP}{dx}$ (or P') and they must conclude that the gradient changes from negative to positive implying a minimum point (or equivalent).

(d)

M1: Substitutes their $x = \sqrt{\frac{800}{4 + \pi}} \approx 10.6$ into the **given** $P = \frac{1}{4}x(4 + \pi) + \frac{200}{x} = \dots$ or otherwise correct P

You may need to check their answer if they do not show the substitution.

A1: awrt 37.8{m} and must be a decimal.

Note that if **only** awrt 37.8 is given (i.e. no substitution shown) then they must have used calculus to find awrt 10.6 or better in part (b) to score this mark, otherwise score M0A0.

Question Number	Scheme	Marks
8(a)	$\frac{\cos \theta}{2 \sin \theta} = \frac{1 + \sin \theta}{\cos \theta}$ $\cos^2 \theta = 2 \sin \theta (1 + \sin \theta) \Rightarrow 1 - \sin^2 \theta = 2 \sin \theta (1 + \sin \theta)$ $\Rightarrow 1 - \sin^2 \theta = 2 \sin \theta + 2 \sin^2 \theta \Rightarrow 3 \sin^2 \theta + 2 \sin \theta - 1 = 0 \quad *$	M1 dM1 A1* (3)
(b)	$3 \sin^2 \theta + 2 \sin \theta - 1 = 0 \Rightarrow \sin \theta = \frac{1}{3}, \{-1\}$ Uses $\cos^2 \theta \equiv 1 - \sin^2 \theta \Rightarrow \cos^2 \theta = 1 - \left(\frac{1}{3}\right)^2$ $\Rightarrow \{\cos \theta =\} \frac{2\sqrt{2}}{3}$	B1 M1 A1 (3)
(c)	Attempts common ratio $= \frac{\cos \theta}{2 \sin \theta} = \frac{\left(\frac{2\sqrt{2}}{3}\right)}{\left(\frac{2}{3}\right)} = \dots \{\sqrt{2}\}$ Finds $ar^{10} = \frac{2}{3} \times (\sqrt{2})^{10} = \dots$ $\frac{64}{3}$	M1 dM1 A1 (3)
		(9 marks)

(a)

M1: Uses common ratios and forms a correct equation in terms of θ , e.g.,

$$u_1 u_3 = u_2^2 \Rightarrow \cos^2 \theta = 2 \sin \theta (1 + \sin \theta) \text{ or e.g. } 1 + \sin \theta = 2 \sin \theta \left(\frac{\cos \theta}{2 \sin \theta} \right)^2$$

dM1: Cross multiplies (if necessary) and uses $\pm \sin^2 \theta \pm \cos^2 \theta = \pm 1$ to form a quadratic equation in $\sin \theta$
Dependent on the previous method mark.

A1*: Expands the brackets and proceeds correctly to $3 \sin^2 \theta + 2 \sin \theta - 1 = 0$ with no errors.

They must have a correct intermediate line i.e. expanded any brackets before the given answer.
Condone the occasional slip in missing or incorrect arguments or use of e.g. $\sin \theta^2$ but penalise consistent errors in the main body of their work (not their side working). Requires the $= 0$.

(b)

B1: Solves the given equation find $\sin \theta = \frac{1}{3}$ Allow the use of a calculator to solve the 3TQ here.

May be scored in part (a). Ignore any reference to $\sin \theta = -1$ for this mark only.

Not scored for e.g. $x = \sin \theta$ followed by $x = \frac{1}{3}$ unless used later in e.g. $\pm \sin^2 \theta \pm \cos^2 \theta = \pm 1$

M1: Uses $\pm \sin^2 \theta \pm \cos^2 \theta = \pm 1$ to achieve an exact value for $\cos^2 \theta$, i.e., $\cos^2 \theta = 1 - \sin^2 \theta = 1 - \left(\frac{1}{3}\right)^2$ or an exact value for $\cos \theta$ which may come directly from a right-angled triangle with sides that are multiples of 1, $2\sqrt{2}$ (or $\sqrt{8}$) and 3 (or otherwise for their $\sin \theta = \dots$ provided $\sin \theta \neq \pm 1$ or 0)

Condone if they return to $\frac{\cos \theta}{2 \sin \theta} = \frac{1 + \sin \theta}{\cos \theta} \Rightarrow \frac{\cos \theta}{2(\frac{1}{3})} = \frac{1 + (\frac{1}{3})}{\cos \theta} \Rightarrow \cos^2 \theta = \dots$ for this mark.

Alternatively, condone if they find r through e.g. $u_3 = u_1 r^2 \Rightarrow r^2 = \frac{1 + \frac{1}{3}}{2(\frac{1}{3})} = \dots \{2\}$ **and** go on to

find $u_2 = u_1 r = 2\left(\frac{1}{3}\right)\sqrt{2} = \dots$ Note that this approach will also score the first M1 in part (c).

Attempting $\cos\left(\sin^{-1}\left(\frac{1}{3}\right)\right) \{= 0.9428\dots\}$ is not an acceptable method.

A1: $\{\cos \theta = \frac{2\sqrt{2}}{3}$ only (o.e e.g. $\{\cos \theta = \frac{\sqrt{8}}{3}\}$) and ISW after a correct answer.

(c) **No marks can be scored in part (c) from use of $\sin \theta = \pm 1$ as these trivialise the solutions. Similarly, no marks can be scored if their $\sin \theta$ or $\cos \theta$ are inexact.**

M1: Attempts common ratio using either $\frac{\cos \theta}{2 \sin \theta} = \frac{\frac{2\sqrt{2}}{3}}{2\left(\frac{1}{3}\right)} = \dots \{\sqrt{2}\}$ or $\frac{1 + \sin \theta}{\cos \theta} = \frac{1 + \frac{1}{3}}{\frac{2\sqrt{2}}{3}} = \dots \left\{\frac{2}{\sqrt{2}}\right\}$

as far as a value but may be implied. Note this may be seen in (b).

May come from equivalent trigonometric expressions e.g. $\frac{1}{2} \cot \theta = \frac{2\sqrt{2}}{2} \{= \sqrt{2}\}$

Alternatively, attempts r^2 through e.g. $u_3 = u_1 r^2 \Rightarrow r^2 = \frac{1 + \frac{1}{3}}{2(\frac{1}{3})} = \dots \{2\}$ which may be seen in (b).

dM1: Finds $ar^{10} = \frac{2}{3} \times (\sqrt{2})^{10} = \dots$ where a is their $2 \sin \theta$

Dependent on the previous method mark but note that the marks may be scored simultaneously.

You may see $ar^{10} = \frac{2}{3} \times (2)^5 = \dots$ which is also acceptable, as are other correct alternatives.

A1: $\frac{64}{3}$ o.e. e.g. $21\frac{1}{3}$ Do not allow e.g. 21.33 or 21.33... but allow $21.\dot{3}$

Must follow a correct answer in part (b) unless they only use the **alternative** method which does not require a value for $\cos \theta$.

but do **not** allow this mark if they clearly use incorrect e.g. $\cos \theta = -\frac{2\sqrt{2}}{3}$ or $\cos \theta = \text{awrt } 0.943$

Note you may see $ar^{10} = 2 \sin \theta \times \left(\frac{\cos \theta}{2 \sin \theta}\right)^{10} = \frac{64}{3}$ which will score full marks provided it follows a

correct exact answer in part (b).

Do not ISW if they e.g. go on to find the sum of the first 11 terms.

Question Number	Scheme	Marks
9.	Way 1 $\log_4 \frac{a}{b} = 3 \text{ or } \log_4 a = \log_4 64b$ $\frac{a}{b} = 64$ Solves $ab = 25$ with $\frac{a}{b} = k$ and proceeds to $a = \dots$ or $b = \dots$ e.g. $a^2 = 1600 \Rightarrow a = \dots$ $a = 40 \text{ and } b = \frac{5}{8}$	M1 A1 dM1 A1 (4) (4 marks)

Note: Condone the absence of base 4 throughout.

If candidates write $\log_4 a - \log_4 b = 3 \rightarrow \frac{\log_4 a}{\log_4 b} = 3 \rightarrow \frac{a}{b} = 4^3$ allow maximum 1010.

M1: **Correct** use of addition or subtraction law for logs e.g. $\log_4 a - \log_4 b \rightarrow \log_4 \frac{a}{b}$

or $\log_4 a = 3 + \log_4 b = \log_4 p + \log_4 b = \log_4 pb$ (for some constant $p > 0$ with $p \neq 3$)

or (**Way 2**) $\log_4 ab \rightarrow \log_4 a + \log_4 b$

Alternatively, via **Way 3**, achieves a correct $a = 4^{3+\log_4 b}$ or $b = 4^{\log_4 a - 3}$

In **Way 4**, attempts to make a or b the subject of the first equation and substitutes into the second equation.

Not scored for just e.g. $3 = \log_4 64$ or for e.g. $\log_4 a - \log_4 b = 3$ going directly to $\frac{a}{b} = 3$

A1: **Way 1:** Achieves a second correct equation in terms of a and b with logs removed i.e. $\frac{a}{b} = 4^3$ o.e.

Way 2: Achieves a correct equation only in a or only in b which may still have logs.

e.g. $2\log_4 a = 3 + \log_4 25$ or $2\log_4 b = \log_4 25 - 3$

Way 3: Achieves a correct equation only in a or only in b which may still have logs.

e.g. $b \times 4^{3+\log_4 b} = 25$ or $a \times 4^{\log_4 a - 3} = 25$

Way 4: Writes e.g. $a = \frac{25}{b}$ and substitutes into the second equation to achieve a correct equation

only in a or only in b e.g. $\log_4 \frac{25}{b} - \log_4 b = 3$ (proceed to mark as in **Way 2**).

Note that in all approaches they may have already replaced 3 with $\log_4 64$

dM1: Dependent on first M mark.

Way 1: Solves to find a value for a or b using simultaneous equations. Expect to see a method for solving the simultaneous equations but allow slips in rearranging or e.g. transcription errors. If they just write down values then they should be correct for their simultaneous equations.

Ways 2 & 4: Replaces 3 with $\log_4 p$ ($p > 0$ with $p \neq 3$) and otherwise uses logs **correctly** to find a or b .

Way 3: Replaces 4^3 with p ($p > 0$ with $p \neq 3$) and otherwise uses logs **correctly** to find a or b .

There must be a clear method to remove the logs: they cannot proceed directly from e.g. $\log_4 \frac{25}{b^2} = 3$ to $b = \dots$

Some examples:

- **Way 2:** $\log_4 a^2 = \log_4 p + \log_4 25 \Rightarrow \log_4 a^2 = \log_4 (25p) \Rightarrow a^2 = 25p \Rightarrow a = \dots$
- **Way 2:** $\log_4 b^2 = \log_4 25 - \log_4 p \Rightarrow \log_4 b^2 = \log_4 \left(\frac{25}{p} \right) \Rightarrow b^2 = \frac{25}{p} \Rightarrow b = \dots$
- **Way 3:** $a = 4^{3+\log_4 b} \Rightarrow b \times 4^{3+\log_4 b} = 25 \Rightarrow b^2 \times 64 = 25 \Rightarrow b = \dots$
- **Way 3:** $b = 4^{\log_4 a - 3} \Rightarrow a \times 4^{\log_4 a - 3} = 25 \Rightarrow \frac{a^2}{64} = 25 \Rightarrow a = \dots$
- **Way 4:** $a = \frac{25}{b} \Rightarrow \log_4 \frac{25}{b} - \log_4 b = 3 \Rightarrow \log_4 \frac{25}{b^2} = 3 \Rightarrow \frac{25}{b^2} = 64 \Rightarrow b = \dots$
- **Way 4:** $b = \frac{25}{a} \Rightarrow \log_4 a - \log_4 \frac{25}{a} = 3 \Rightarrow \log_4 \frac{a^2}{25} = 3 \Rightarrow \log_4 \frac{a^2}{25} = \log_4 64 \Rightarrow a = \dots$

A1: Both a and b correct and no other solutions. Allow $b = 0.625$ but not a rounded or truncated decimal.

If e.g. $b = -\frac{5}{8}$ is found it must be rejected.

Question Number	Scheme	Marks
10 (a)	Either $kn = 36$ or $\frac{n(n-1)}{2}k^2 = 567$	M1
	Both $kn = 36$ and $\frac{n(n-1)}{2}k^2 = 567$	A1
	$\Rightarrow \frac{n(n-1)}{2} \left(\frac{36}{n} \right)^2 = 567 \Rightarrow n = \dots$ or $\Rightarrow \frac{36}{k} \left(\frac{36}{k} - 1 \right) \times \frac{k^2}{2} = 567 \Rightarrow k = \dots$	dM1
	e.g. $\Rightarrow \frac{648(n-1)}{n} = 567 \Rightarrow 648n - 648 = 567n \Rightarrow n = 8$	A1
	or $\Rightarrow 648 - 18k = 567 \Rightarrow k = \frac{9}{2}$ o.e.	
	$k("8") = 36 \Rightarrow k = \dots$ or $\left(\frac{9}{2} \right) n = 36 \Rightarrow n = \dots$	ddM1
(b)	$n = 8$ and $k = \frac{9}{2}$ o.e.	A1
		(6)
	$\{p=\} \frac{n(n-1)(n-2)}{3!} k^3 = \frac{"8" \times "7" \times "6"}{6} \times \left(\frac{9}{2} \right)^3 = \dots$	M1
	$= 5103$	A1
		(2)
		(8 marks)

Note: Misreading 567 as 576 should lead to $n = 9$ and $k = 4$ and may score maximum
(a) M1A1dM1A0ddM1A0 (b) M1A1 Other misreads of 567 should be treated similarly.

(a)

M1: States either $kn = 36$ or $\frac{n(n-1)}{2}k^2 = 567$ accepting equivalents but see note below.

Condone an incorrect $\frac{n(n-1)}{2}k = 567$ (usually coming from a bracketing error) or use of e.g. 576.

This mark cannot be awarded from e.g. $\binom{n}{1}k = 36$ or ${}^nC_2(kx)^2 = 567x^2$ or with factorials

e.g. $\frac{n!}{(n-2)!}k^2 = 567$ or versions including x terms such as $kx = 36x$ unless followed by a correct

$kn = 36$ or $\frac{n(n-1)}{2}k^2 = 567$

A1: Both $kn = 36$ and $\frac{n(n-1)}{2}k^2 = 567$ correct.

dM1: Forms an equation in one variable and solves leading to a value for k or n .

It is dependent upon having achieved $kn=36$ **and** $\frac{n(n-1)}{2}k^2=567$ condoning slips e.g.

$$\frac{n(n-1)}{2}k=567 \text{ but not just } \frac{n(n-1)}{2}=567$$

The process of forming the equation in one variable must be credible so look for $k = \frac{36}{n}$ being

substituted and not e.g. $k=36-n$ but condone a slip e.g. $\frac{n(n-1)}{2}k^2=567 \rightarrow \frac{n(n-1)}{2}\left(\frac{36}{n}\right)^2=567$

Condone slips in solving their equation in one variable such as poor expansion of brackets.

Note that e.g. $\frac{n}{n-1} = \frac{8}{7} \Rightarrow n=8$ or $1296n^{-1}=162 \Rightarrow n=8$ would both be reasonable equations for candidates to solve by inspection.

A1: For either $n=8$ **or** $k=\frac{9}{2}$ o.e. from correct work and with sufficient working shown. Ignore $n=0$.

Forming a linear equation is sufficient, e.g.,

$$\frac{n(n-1)}{2}\left(\frac{36}{n}\right)^2=567 \Rightarrow \frac{648(n-1)}{n}=567 \Rightarrow 648n-648=567n \Rightarrow n=8$$

$$\text{or } \frac{36}{k}\left(\frac{36}{k}-1\right) \times \frac{k^2}{2}=567 \Rightarrow 648-18k=567 \Rightarrow k=\frac{9}{2}$$

and allow them to solve a quadratic directly by calculator or inspection, e.g.,

$$\frac{n(n-1)}{2}\left(\frac{36}{n}\right)^2=567 \Rightarrow 648n^2-648n=567n^2 \Rightarrow 81n^2-648n=0 \Rightarrow n=8 \quad \{n=0\}$$

ddM1: Uses $k=\frac{36}{n}$ o.e. with their $n="8"$ to find k or their $k=" \frac{9}{2} "$ to find n .

This mark may be implied, so no evidence of the substitution is required.

It is dependent upon **both** previous M marks.

A1: $n=8$ **and** $k=\frac{9}{2}$ o.e. following the award of all previous marks. Ignore any reference to $n=0$.

SC: Solutions that achieve $n=8$ **and** $k=\frac{9}{2}$ o.e. without showing a method for solving the simultaneous equations (e.g. by using trial and error) will score the final A1 but this does not imply any of the previous marks – see examples below:

- $\binom{n}{1}k=36, \binom{n}{2}k^2=567 \Rightarrow n=8, k=\frac{9}{2}$ scores 000001
- $nk=36, \binom{n}{2}k^2=567 \Rightarrow n=8, k=\frac{9}{2}$ scores 100001
- $nk=36, \frac{n(n-1)}{2}k^2=567 \Rightarrow n=8, k=\frac{9}{2}$ scores 110001

(b) **Note: To score any marks in part (b) they must have scored at least one mark in part (a).**

M1: Attempts $\{p=\} \frac{n(n-1)(n-2)}{3!}k^3$ with their values for n and k to find a value $\{\text{for } p\}$.

Alternatively, you may see ${}^8C_3\left(\frac{9}{2}\right)^3=...$ or $\binom{8}{3}\left(\frac{9}{2}\right)^3=...$

Condone e.g. ${}^nC_3 \left(\frac{9}{2}x \right)^3 = \dots x^3$ for this mark.

This can be implied by a 'correct' answer for their values of n and k so you may need to check.
Allow fractional or decimal values for both n and k .

A1: 5103 following correct values for n and k and correct equations in part (a), unless the special case has been applied, in which case this mark is available.
 $5103x^3$ without the 5103 extracted scores A0.
Note if they misread 567 as 576 then they should get $p = 5376$.

Please check the examination details below before entering your candidate information

Candidate surname					Other names				
Centre Number					Candidate Number				

Pearson Edexcel International Advanced Level

Tuesday 13 January 2026

Morning (Time: 1 hour 30 minutes) **Paper reference** **WMA12/01**

Mathematics ▲ ▲

International Advanced Subsidiary/Advanced Level

Pure Mathematics P2

You must have:
Mathematical Formulae and Statistical Tables (Yellow), calculator

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 10 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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1. (a) Find the first 4 terms, in ascending powers of x , of the binomial expansion of

$$(3 + kx)^7$$

where k is a non-zero constant. Give each term in simplest form.

(4)

Given that, in this expansion, the coefficient of x^2 is 3 times the coefficient of x^3

- (b) find, in simplest form, the value of k .

(2)



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Question 1 continued

Lined area for writing answers.

(Total for Question 1 is 6 marks)



2.

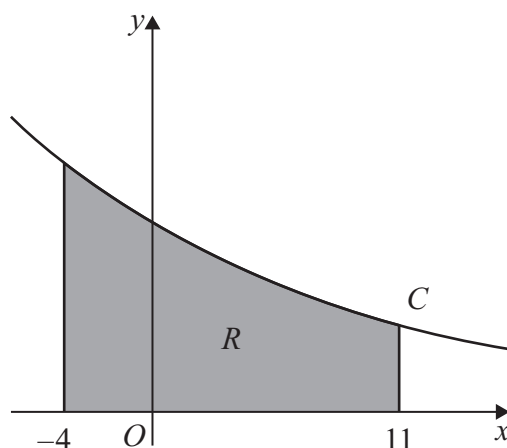


Figure 1

Figure 1 shows a sketch of part of the curve C with equation $y = 2^{-0.1x}$

The table below shows corresponding values of x and y for $y = 2^{-0.1x}$

The y values are given to 4 decimal places.

x	-4	-1	2	5	8	11
y	1.3195	1.0718	0.8706	0.7071	0.5743	0.4665

The region R , shown shaded in Figure 1, is bounded by C , the x -axis and the lines with equations $x = -4$ and $x = 11$

- (a) Use the trapezium rule with all the values of y in the table to find an estimate for the area of R . Give the answer to 2 decimal places.

(3)

- (b) State how you would use the trapezium rule to get a more accurate estimate for the true area of R .

(1)

Using the answer to part (a) and showing your working,

- (c) estimate the value of

$$\int_{-4}^{11} 2^{3-0.1x} dx$$

(2)



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Question 2 continued

Handwriting practice area with horizontal lines.

(Total for Question 2 is 6 marks)



3. (i) Given that

- $f(x) = 4x^3 + 6x + k$, where k is a constant
- $(x + 2)$ is a factor of $f(x)$

find the remainder when $f(x)$ is divided by $(x - 5)$

(4)

(ii) Find the remainder, R , and the quotient, $Q(x)$, when

$$6x^3 - 15x^2 - 21x + 8$$

is divided by $(2x + 3)$

(3)



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Question 3 continued

Handwriting practice area with horizontal lines.

(Total for Question 3 is 7 marks)



4. **In this question you must show all stages of your working.**
Solutions relying entirely on calculator technology are not acceptable.

Given that k is a positive constant and

$$\int_k^{2k} \left(\frac{12}{x^2} + 4 \right) dx = 14$$

find the possible values of k .

(5)



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Question 4 continued

Handwriting practice area with horizontal lines.

(Total for Question 4 is 5 marks)



5. The circle C_1 has equation

$$x^2 + y^2 - 6x + 5y - 41 = 0$$

(a) Find

(i) the coordinates of the centre of C_1

(ii) the radius of C_1

(3)

The circle C_2 has

- centre $(-k, 0)$ where k is a positive constant
- radius 5

Given that circles C_1 and C_2 touch

(b) find the exact value of k .

(3)



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Question 5 continued

(Total for Question 5 is 6 marks)



6. (i) Given that p and q are consecutive odd numbers, where $p > q > 0$, prove that

$$p^2 - q^2$$

is a multiple of 8

(4)

- (ii) The curve C has equation

$$y = x^3 + 12x^2 + 49x + 2$$

Prove that C has no stationary points.

(4)



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Question 6 continued

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Question 6 continued

(Total for Question 6 is 8 marks)



7. In this question you must show all stages of your working. Solutions relying entirely on calculator technology are not acceptable.

(i) Find the exact solution of the equation

$$8^{2x-5} = 20$$

giving the answer in the form $a + b \log_5$ where a and b are rational constants.

(4)

(ii) Using the laws of logarithms, solve the equation

$$\log_3(13 + 2y) + 3 = 2\log_3(4 - y)$$

(5)



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Question 7 continued

(Total for Question 7 is 9 marks)



In this question you must show all stages of your working. Solutions relying entirely on calculator technology are not acceptable.

- giving the answers to one decimal place.

giving the answers, in radians, in the form $k\pi$ where k is a rational constant.

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Question 8 continued

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Question 8 continued

(Total for Question 8 is 10 marks)



9. A company mines lithium.

- in year 1, the company mined 12 400 tonnes of lithium
- in year 15, the company is predicted to mine 7 500 tonnes of lithium

Model *A* assumes that the mass of lithium the company mines will decrease by the same amount each year.

According to model A ,

- (a) find the mass of lithium the company will mine in year 5 (3)
- (b) calculate the **total** mass of lithium the company will mine from year 1 to year 15 inclusive. (2)

Model *B* assumes that the mass of lithium the company mines will decrease by the same percentage each year.

- (c) Find, according to model B , the mass of lithium the company will mine in year 10. Give the answer to the nearest 10 tonnes. (3)

According to model *B*, there is a limit to the **total** mass of lithium that can be mined.

- (d) Calculate the value of this limit. Give the answer to the nearest 100 tonnes. (2)



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Question 9 continued

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Question 9 continued

(Total for Question 9 is 10 marks)



10.

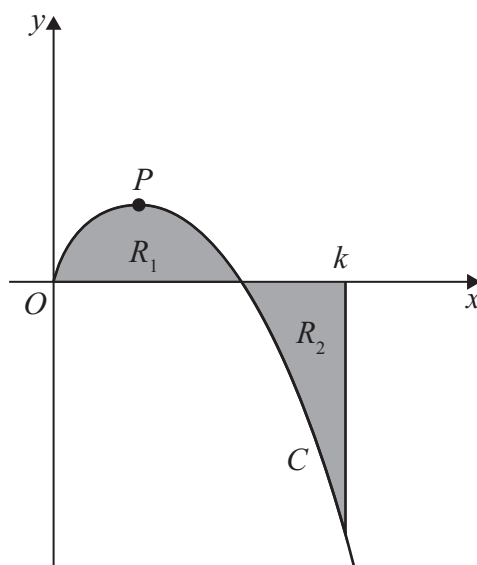


Figure 2

In this question you must show all stages of your working.
Solutions relying entirely on calculator technology are not acceptable.

Figure 2 shows a sketch of the curve C with equation

$$y = \frac{\sqrt{x}(100 - x^2)}{40} \quad x \geq 0$$

The point P is a stationary point on C .

(a) Use algebraic differentiation to find the exact x coordinate of P .

(4)

The region R_1 , shown shaded in Figure 2, is bounded by C and the x -axis.

The region R_2 , also shown shaded in Figure 2, is bounded by C , the x -axis and the line with equation $x = k$, where k is a constant.

Given that the area of R_1 is equal to the area of R_2

(b) use algebraic integration to find the exact value of k .

(4)



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Question 10 continued

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(Total for Question 10 is 8 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (Results)

January 2026

Pearson Edexcel International Advanced Level in
Pure Mathematics P2
WMA12/01

Edexcel and BTEC Qualifications

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January 2026

Question Paper Log Number P84523A

Publication Code WMA12_01_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN:

- bod – benefit of doubt
- ft – follow through
 - the symbol $\checkmark$ will be used for correct ft
- cao – correct answer only
- cso – correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC – special case
- oe – or equivalent (and appropriate)
- d... or dep – dependent
- indep – independent
- dp – decimal places
- sf – significant figures
- * – The answer is printed on the paper or ag- answer given

- $\square$ or d... – The second mark is dependent on gaining the first mark
4. All A marks are 'correct answer only' (cao), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.
 5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. If you are using the annotation facility on ePEN, indicate this action by 'MR' in the body of the script.
 6. If a candidate makes more than one attempt at any question:
 - a) If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - b) If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
 7. Ignore wrong working or incorrect statements following a correct answer.

General Principles for Pure Mathematics Marking

(NB specific mark schemes may sometimes override these general principles)

Method mark for solving 3 term quadratic:

1. Factorisation

$(x^2 + bx + c) = (x + p)(x + q)$, where $|pq| = |c|$ leading to $x = \dots$

$(ax^2 + bx + c) = (mx + p)(nx + q)$, where $|pq| = |c|$ and $|mn| = |a|$ leading to $x = \dots$

2. Formula

Attempt to use correct formula (with values for a, b and c)

3. Completing the square

Solving $x^2 + bx + c = 0$: $(x \pm \frac{b}{2})^2 \pm q \pm c$, $q \neq 0$ leading to $x = \dots$

Method marks for differentiation and integration:

1. Differentiation

Power of at least one term decreased by 1 ($x^n \rightarrow x^{n-1}$)

2. Integration

Power of at least one term increased by 1 ($x^n \rightarrow x^{n+1}$)

Use of a formula

Where a method involves using a formula that has been learnt, the advice given in recent examiners' reports is that the formula should be quoted first.

Normal marking procedure is as follows:

Method mark for quoting a correct formula and attempting to use it, even if there are small mistakes in the substitution of values.

Where the formula is not quoted, the method mark can be gained by implication from correct working with values, but may be lost if there is any mistake in the working.

Exact answers

Examiners' reports have emphasised that where, for example, an exact answer is asked for, or working with surds is clearly required, marks will normally be lost if the candidate resorts to using rounded decimals.

Answers without working

The rubric says that these may not gain full credit. Individual mark schemes will give details of what happens in particular cases. General policy is that if it could be done "in your head", detailed working would not be required. Most candidates do show working, but there are occasional awkward cases and if the mark scheme does not cover this, please contact your team leader for advice.

Question Number	Scheme	Marks
1. (a)	$(3 + kx)^7 = \underline{3^7} + {}^7C_1 3^6 (kx)^1 + {}^7C_2 3^5 (kx)^2 + {}^7C_3 3^4 (kx)^3 + \dots$ $= 2187 + 5103kx + 5103k^2 x^2 + 2835k^3 x^3 + \dots$	<u>B1</u> , M1 A1, A1 (4)
(b)	Sets $5103k^2 = 3 \times 2835k^3 \Rightarrow k = \dots$ $k = \frac{3}{5}$	M1 A1 (2) (6 marks)

(a)

B1: For a first term (constant term) of 3^7 or 2187 or even ${}^7C_0 \times 3^7$

M1: For an attempt at the binomial expansion. Score for a correct attempt at one of terms 2, 3 or 4

Accept sight of ${}^7C_1 3^6 (kx)^1$ or ${}^7C_2 3^5 (kx)^2$ or ${}^7C_3 3^4 (kx)^3$ condoning the Omission of brackets.

Accept any **correct** coefficient appearing from Pascal's triangle.

A1: For any two simplified terms of $2187 + 5103kx + 5103k^2 x^2 + 2835k^3 x^3$

A1: For $2187 + 5103kx + 5103k^2 x^2 + 2835k^3 x^3$ ignoring terms with greater powers. Allow as a list and allow in descending order.

ALT For the first two marks

B1: Takes 3^7 out as a common factor to obtain $3^7 \left(1 + \frac{kx}{3}\right)^7$

M1: For an attempt at the binomial expansion Score for a correct attempt at one of terms 2, 3 or 4 inside the main bracket.

Accept $\dots \left(1 + (7 \times) \left(\frac{kx}{3}\right), \left(\frac{7 \times 6}{2!}\right) \times \left(\frac{kx}{3}\right)^2, \left(\frac{7 \times 6 \times 5}{3!}\right) \times \left(\frac{kx}{3}\right)^3\right)$ condoning

the omission of brackets

(b)

M1: For setting ' $5103k^2 = 3 \times 2835k^3$ ' leading to $k = \dots$ following **correct** processing
M0 if they include x 's, but allow if recovered

A1: For $k = \frac{3}{5}$ or exact equivalent. No other values stated.

Question Number	Scheme	Marks
2 (a)	$\text{Area} \approx \frac{3}{2} \{1.3195 + 0.4665 + 2 \times (1.0718 + 0.8706 + 0.7071 + 0.5743)\}$ $= 12.35$	B1 M1 A1 (3)
(b)	States either 'use more trapezia', or other such as 'make the strip widths narrower'	B1 (1)
(c)	$\int_{-4}^{11} 2^{3-0.1x} dx = 2^3 \times \int_{-4}^{11} 2^{-0.1x} dx = 8 \times '12.35' = 98.8$	M1, A1 (2) (6 marks)

(a)

B1 For $h = 3$ seen anywhere even if it is not later used correctly.

This is implied by sight of $\frac{3}{2}$ in front of the bracket

M1 For a correct content of the bracket within Trapezium Rule, condoning slips.
E.g., missing end bracket(s) or MR on no more than two values

$$\text{FYI: Area } A \approx \left(\frac{3}{2}\right)(1.786 + 2[3.2238]) \Rightarrow \left(\frac{3}{2}\right)(8.2336) = 12.3504$$

A1 awrt 12.35 following the award of M1

Note that the calculator answer for this integral is 12.31

(b)

B1: States any valid method that states or implies thinner strips, more strips, more trapezia, reduce the size of h etc.,

We will also condone for the award of this mark;

Use more y values

Use more x values

Use more x and y values

(c)

M1: Attempts to use the rule $2^{3-0.1x} = 2^3 \times 2^{-0.1x}$ seen anywhere.

A1: awrt 99 following 8×12.35

Note that the calculator answer is 98.4

Question Number	Scheme	Marks
3.(i)	Sets $f(-2) = 0 \Rightarrow 4(-2)^3 + 6(-2) + k = 0 \Rightarrow k = 44$ Attempts $f(5) = 4x^3 + 6x + '44' = 4 \times 5^3 + 6 \times 5 + '44' = 574$	M1, A1 dM1, A1 (4)
(ii)	Sets $6x^3 - 15x^2 - 21x + 8 = (Ax^2 + Bx + C)(2x + 3) + R$ And attempts to find values of A, B, C and R via inspection/ substitution etc Two correct of A, B, C and R $Q(x) = 3x^2 - 12x + \frac{15}{2} \quad R = -\frac{29}{2}$	M1 A1 A1 (3) (7 marks)

(i) M1: Sets $f(\pm 2) = 0 \rightarrow$ leading to a value for k

Uses Polynomial Division:

$$\begin{array}{r} 4x^2 + 8x + 32 \\ x+2 \overline{) 4x^3 + 0x^2 + 6x + k} \end{array} \quad \text{Rem} = k - 44 = 0 \Rightarrow k = 44$$

Allow for $4x^2 + \alpha x + \beta$ with a remainder $k \pm \phi = 0$

A1: $k = 44$ seen or implied

dM1: Attempts $f(\pm 5)$ with their value for k leading to a value for the remainder.

Uses Polynomial division

$$\begin{array}{r} 4x^2 + 20x + 106 \\ x-5 \overline{) 4x^3 + (0x^2) + 6x + '44'} \end{array} \quad \text{Rem} = 574 \text{ or Rem} = 530 + k$$

Allow for $4x^2 + \mu x + \nu$ with a constant remainder

A1: 574

(ii) M1: Full attempt to find both the quotient and remainder.

See main scheme but valid via division. Look for a 3 term quadratic quotient and a constant remainder

Alt - uses polynomial division

Look for a 3-term quadratic quotient and a constant remainder

$$\begin{array}{r} 3x^2 - 12x + \frac{15}{2} \\ 2x+3 \overline{) 6x^3 - 15x^2 - 21x + 8} \end{array} \quad r = -\frac{29}{2}$$

A1: 2 correct terms of the 4 terms in $Q(x) = 3x^2 - 12x + \frac{15}{2}$ and $R = -\frac{29}{2}$

A1: $Q(x) = 3x^2 - 12x + \frac{15}{2}$ and $R = -\frac{29}{2}$ correctly labelled and identified. Allow

Quotient (or even Q) in place of $Q(x)$

Question Number	Scheme	Marks
4.	$\int \left(\frac{12}{x^2} + 4 \right) dx = -\frac{12}{x} + 4x$ $\text{Sets } \int_k^{2k} \left(\frac{12}{x^2} + 4 \right) dx = 14 \Rightarrow \left[-\frac{12}{x} + 4x \right]_k^{2k} = 14$ $\left(-\frac{6}{k} + 8k \right) - \left(-\frac{12}{k} + 4k \right) = 14 \Rightarrow 2k^2 - 7k + 3 = 0 \text{ o.e.}$ $(2k-1)(k-3) = 0 \Rightarrow k = \frac{1}{2}, 3$	M1 dM1, A1 ddM1, A1 (5 marks)

M1: Attempts to integrate with one index correct

dM1: Applies the limits either way around with a subtraction, **and** sets = 14

A1: Forms a correct 3TQ. Terms do not need to be on the same side of the = sign.

Look for $4k^2 + 6 = 14k$ o.e

ddM1: Uses any method of solving a 3TQ including a calculator.

A1: $k = \frac{1}{2}, 3$ following all previous marks.

Question Number	Scheme	Marks
5 (a)	$x^2 + y^2 - 6x + 5y - 41 = 0$ Attempts $(x-3)^2 + \left(y + \frac{5}{2}\right)^2 = \dots$ Correct centre $\left(3, -\frac{5}{2}\right)$ Exact radius $\frac{15}{2}$	M1 A1 A1 (3)
(b)	Sets up appropriate equation $(k+3)^2 + \left(\frac{5}{2}\right)^2 = \left(5 + \frac{15}{2}\right)^2$ $(k+3)^2 = 150 \Rightarrow k+3 = \sqrt{150}$ $\Rightarrow k = 5\sqrt{6} - 3$	M1 dM1 A1 (3) (6 marks)

(a)

M1: Attempts to complete the square for both variables. Look for $(x \pm 3)^2, \left(y \pm \frac{5}{2}\right)^2 = \dots$

This mark can be implied from the coordinates of the centre $\left[3, -\frac{5}{2}\right]$ just written down.

A1: $\left(3, -\frac{5}{2}\right)$

A1: $\frac{15}{2}$ condone $\sqrt{\frac{225}{4}}$ o.e. which may be scored following $(x-3)^2 + \left(y + \frac{5}{2}\right)^2 = \frac{225}{4}$

(b)

M1: Uses Pythagoras' theorem to set up an equation in k

Look for $(k \pm 3)^2 + \left(\frac{5}{2}\right)^2 = \left(5 + \frac{15}{2}\right)^2$ following through on their $\left(3, -\frac{5}{2}\right)$ and $\frac{15}{2}$

Also look for $k^2 + 6k - 141 = 0$ o.e.

dM1: Uses an appropriate method to proceed to a value for k

A1: $k = 5\sqrt{6} - 3$ o.e.

Question Number	Scheme	Marks
6 (i)	Can write p and/or q in an appropriate form. E.g $p = 2n + 1, q = 2n + 3$ $n \in \mathbb{N}$ $p^2 - q^2 = (2n + 1)^2 - (2n - 1)^2$ $= 4n^2 + 4n + 1 - (4n^2 - 4n + 1)$ $= 8n$ which is a multiple of 8, hence proven *	B1 M1 A1 A1* (4)
(ii)	$y = x^3 + 12x^2 + 49x + 2 \Rightarrow \frac{dy}{dx} = 3x^2 + 24x + 49$ $\Rightarrow \frac{dy}{dx} = 3(x + 4)^2 + 1$ Gradient is always ≥ 1 so cannot ever be 0, so no stationary points on C *	M1, dM1, A1 A1* (4) (8 marks)

(i)

B1: Can write p and/or q in an appropriate form. Condone omission of $n \in \mathbb{N}$

Allow any letter to be used in place of n

Allow $(p =) 2n + 3, (q =) 2n + 1$ p and q to be implied

M1: Starts the proof by writing $[p^2 - q^2 =] (2n + 1)^2 - (2n - 1)^2$ o.e

OR, such as $p^2 - q^2 = (2n + 3)^2 - (2n + 1)^2$

NB Must be in one variable only and p and q must be consecutive.

A1: Correct multiplication to an intermediate or fully simplified answer,

Allow $4n^2 + 4n + 1 - (4n^2 - 4n + 1)$

A1*: Reaches a correct answer, E.g. $8n$, gives a valid statement 'which is a multiple of 8' or a minimal conclusion. E.g., 'QED', 'Shown', $\square$, $\#$, etc.,

Note with $p^2 - q^2 = (2n + 3)^2 - (2n + 1)^2$ you will get $8n + 8$

SC Uses $p < q$ Award marks as above, but score B1 M1 A1 A0 for an otherwise fully correct proof.

(ii)

M1: Attempts to differentiate and achieves a 3TQ

An attempt to differentiate is defined in General Guidance.

dM1: And then uses a valid method of showing that $\frac{dy}{dx} \neq 0$

Valid methods could be

1. Attempting to complete the square
2. Attempting the discriminant (Disc = -12)
3. Attempting to solve, with working, ' $3x^2 + 24x + 49 = 0$ '
Accept 'not real roots' following some working but not 'Math Error'

$$\left(\text{Roots are } \frac{-12 \pm \sqrt{3}i}{3} \right)$$

A1: Correct calculations [As above]

A1*: Valid conclusion. E.g.

1. $\frac{dy}{dx} \geq 1$ hence is never 0 **so no stationary points**
2. The Discriminant is negative **so no (real) roots and hence no stationary points**
3. The roots are complex so there are **no (real) solutions and hence no stationary points.**

Accept reference to turning points.

Question Number	Scheme	Marks
7 (i)	$8^{2x-5} = 20$ Take $\log_2$ of <u>both</u> sides and uses power rule $(2x-5)\log_2 8 = \log_2 20$ Uses $\log_2 8 = 3$ or $\log_2 20 = \log_2 4 + \log_2 5$ $3(2x-5) = 2 + \log_2 5$ $x = \frac{17}{6} + \frac{1}{6}\log_2 5$	M1 dM1 A1 A1 (4)
(ii)	$\log_3 (13+2y) + 3 = 2\log_3 (4-y)$ One correct log law $2\log_3 (4-y) \rightarrow \log_3 (4-y)^2$ or $3 \rightarrow \log_3 27$ Correct attempt to combine two terms Correct equation (not involving logs) E.g. $(4-y)^2 = 27(13+2y)$ $y^2 - 62y - 335 = 0$ $(y+5)(y-67) = 0$ $y = -5 \text{ only}$	B1 M1 A1 dM1 A1 (5) (9 marks)

(i)

M1: Take $\log_2$ of both sides and uses power rule $(2x-5)\log_2 8 = \log_2 20$

Allow this mark for log work with any or no base: E.g. $(2x-5)\log 8 = \log 20$

dM1: Uses $\log_2 8 = 3$ or $\log_2 20 = \log_2 4 + \log_2 5$ **correctly** to obtain an equation in x involving just $\log_2 5$

A1: A **correct** intermediate equation in x involving just $\log_2 5$

A1: $x = \frac{17}{6} + \frac{1}{6}\log_2 5$

There are several ways of solving part (i). These are the General Principles for marking this. Allow numerical slips only, index and log work must be correct.

M1: Deal with the index and take logs of both sides

dM1: Simplify logs/use the addition law **correctly** to obtain an equation involving x , $\log_2 5$ and constant(s) only. If candidates change from base 8 to base 2 it must be correct throughout.

A1: For a **correct** equation involving x and $\log_2 5$ (no other logs) and constant(s)

A1: For $x = \frac{17}{6} + \frac{1}{6}\log_2 5$

(ii)

B1: One correct log law $2\log_3(4-y) \rightarrow \log_3(4-y)^2$ or $3 \rightarrow \log_3 27$

M1: Correct attempt to **combine** two terms

$$\log_3(13+2y) + 3 = \log_3 27(13+2y) \text{ or}$$

$$2\log_3(4-y) - \log_3(13+2y) = \log_3 \frac{(4-y)^2}{(13+2y)}$$

Do not award this mark for an equation from incorrect log work when **combining** the terms, for example:

$$2\log_3(4-y) - \log_3(13+2y) = \frac{\log_3(4-y)^2}{\log_3(13+2y)} \Rightarrow \log_3 \frac{(4-y)^2}{(13+2y)}$$

A1: Correct equation (not involving logs) E.g. $(4-y)^2 = 27(13+2y)$

dM1: Correct method of solving 3TQ in y . Allow for either 67 or -5 seen.

Dependent upon previous M

A1: A1: $y = -5$ **only** If $y = 67$ is not rejected then award A0

Question Number	Scheme	Marks
8 (i)	$4 \tan^2 (2\theta - 30)^\circ + 1 = 49$ $\tan (2\theta - 30)^\circ = (\pm) \sqrt{12}$ $(2\theta - 30) = \text{any of awrt } 74, 106, 254, 286$ Correct method to find θ E.g. $\theta = \text{awrt } \frac{74+30}{2}$ Two of $\theta = \text{awrt } 51.9, 68.1, 141.9, 158.1$ All four of $\theta = \text{awrt } 51.9, 68.1, 141.9, 158.1$	M1 A1 dM1 A1 A1 (5)
(ii)	Uses $\tan x = \frac{\sin x}{\cos x} \Rightarrow 2 \times \frac{\sin x}{\cos x} \sin x + 3 = 0$ $2 \sin^2 x + 3 \cos x = 0 \Rightarrow 2(1 - \cos^2 x) + 3 \cos x = 0$ $\Rightarrow 2 \cos^2 x - 3 \cos x - 2 = 0$ $\Rightarrow (2 \cos x + 1)(\cos x - 2) = 0 \Rightarrow \cos x = -\frac{1}{2}$ $\Rightarrow x = \frac{2}{3}\pi, \frac{4}{3}\pi$	M1 dM1 A1 ddM1 A1 (5) (10 marks)

(i)

M1: **Either:** Attempts to make $\tan(2\theta - 30)^\circ$ the subject. Allow $\tan \alpha^\circ = 3.46$

An attempt is defined as a numerical slip in finding '12'

Allow the use of a substitution here e.g., let $2\theta - 30 = x \Rightarrow \tan x^\circ = (\pm) \sqrt{12}$

OR: Uses the sin/cos and Pythagorean identities as follows:

$$\tan^2 \alpha = 12 \Rightarrow \frac{\sin^2 \alpha}{\cos^2 \alpha} = 12 \Rightarrow 1 - \cos^2 \alpha = 12 \cos^2 \alpha$$

$$\cos^2 \alpha = \frac{1}{13} \Rightarrow \cos \alpha = (\pm) \sqrt{\frac{1}{13}} \quad \text{o.e.}$$

$$\text{OR} \quad \sin \alpha = (\pm) \sqrt{\frac{12}{13}} \quad \text{o.e.}$$

Award this mark for obtaining a value for either sin or cos allowing for numerical slips only.

A1: Achieves $(2\theta - 30) = \text{any of one of awrt } 74, 106, 254, 286$

Allow a substitution, so achieves any one of $x = \text{awrt } 74, 106, \dots$

dM1: Dependent upon the previous M mark. It is for attempting to find θ . Score for $\frac{\arctan k \pm 30}{2}$

A1: For two of $\theta = \text{awrt } 51.9, 68.1, 141.9, 158.1$

A1: All four of $\theta = \text{awrt } 51.9, 68.1, 141.9, 158.1$ and no other values in the range
Ignore values outside of range.

(ii)

M1: Uses $\tan x = \frac{\sin x}{\cos x} \Rightarrow 2 \times \frac{\sin x}{\cos x} \sin x + 3 = 0$

dM1: Uses $\sin^2 x = 1 - \cos^2 x$ and multiplies by $\cos x$ and attempts to form a 3TQ in $\cos x$

A1: Correct simplified 3 term quadratic $2\cos^2 x - 3\cos x - 2 = 0$ in any form.

ddM1: Solves a 3TQ using any valid method [including calculators] in $\cos x$ leading to at least one value for $\cos x$

A1: $x = \frac{2}{3}\pi, \frac{4}{3}\pi$ and no other values in the range Ignore values outside of range

Question Number	Scheme	Marks
9.(a)	Attempts to use $7\,500 = 12\,400 + 14d$ to find ' d ' Finds $d = (-350)$ and uses this in $12\,400 + 4d$ Lithium mined in Year 5 is 11 000	M1 M1 A1 (3)
(b)	Attempts $\frac{15}{2}(12400 + 7500)$ or $\frac{15}{2}\{2 \times 12400 + 14 \times -350\} = 149\,250$	M1, A1 (2)
(c)	Attempts to use $7\,500 = 12\,400r^{14}$ to find ' r ' Finds $r = (0.9647)$ and uses this in $12\,400 \times r^9$ Lithium mined in Year 10 $8580 \leq L \leq 9000$	M1 M1 A1 (3)
(d)	Limit = $\frac{12400}{1 - '0.9647'} = 351\,300$ Accept $310\,000 \leq S_{\infty} \leq 351\,600$	M1, A1 (2)
		(10 marks)

] (a)

M1: Attempts to use the AP formula in an attempt to find ' d '

Accept an attempt at $7\,500 = 12\,400 + 14d$ resulting in a value for d .

Accept the calculation $\frac{7500 - 12400}{14}$ condoning slips on the 7500 and 12400

M1: A correct attempt, using $12\,400 + 4d$, to find the mass of lithium mined in year 5.

You may award this following an "incorrect" AP formula with $15d$ being used instead of $14d$

Eg $7\,500 = 12\,400 + 15d$ or more likely $\frac{7500 - 12400}{15}$ usually leading to an answer of awrt 11093

A1: Lithium mined in Year 5 is 11 000

(b)

M1: Any correct method to find the sum of the AP .

Look for $\frac{15}{2}\{2 \times 12400 + 14 \times -350\} = \dots$ following through on their ' d '

OR $\frac{15}{2}(12400 + 7500) = \dots$ using first + last formula

A1: 149 250

(c)

M1: Attempts to use the GP n th term formula in an attempt to find ' r '

Accept an attempt at $7\,500 = 12\,400r^{14} \Rightarrow r^{14} = \frac{7500}{12400} \Rightarrow r = \dots$ condoning numerical slips on the values.

Accept the calculation $\sqrt[14]{\frac{7500}{12400}}$

M1: A correct attempt, using $12\,400 \times r^9$, to find the 10th term ft their positive r

You may award this following an "incorrect" GP formula with 15 being used instead of 14

Eg following $7\,500 = 12\,400r^{15}$. or $r = \sqrt[15]{\frac{7500}{12400}}$.

A1: Accept awrt in the range $8580 \leq \mathbb{L} \leq 9000$

(d)

M1: A correct method for the sum to infinity of a GP.

Look for an attempt at $\frac{12400}{1 - '0.9647'}$ following through on their 0.9647

Allow this mark only if their $|r| < 1$

A1: Accept awrt in the range $310\,000 \leq S_{\infty} \leq 351\,600$

Question Number	Scheme	Marks
10.(a)	$y = \frac{\sqrt{x}(100 - x^2)}{40} = \frac{5}{2}x^{\frac{1}{2}} - \frac{1}{40}x^{\frac{5}{2}}$ $\frac{dy}{dx} = \frac{5}{4}x^{-\frac{1}{2}} - \frac{1}{16}x^{\frac{3}{2}}$ Stationary point $\frac{5}{4}x^{-\frac{1}{2}} - \frac{1}{16}x^{\frac{3}{2}} = 0 \Rightarrow x^2 = 20$ $x = 2\sqrt{5}$	M1, A1 dM1 A1 (4)
(b)	$\int \left(\frac{5}{2}x^{\frac{1}{2}} - \frac{1}{40}x^{\frac{5}{2}} \right) dx = \frac{5}{3}x^{\frac{3}{2}} - \frac{1}{140}x^{\frac{7}{2}}$ $\frac{5}{3}k^{\frac{3}{2}} - \frac{1}{140}k^{\frac{7}{2}} = 0 \Rightarrow k^2 = \frac{140 \times 5}{3} = \frac{700}{3}$ $\Rightarrow k = \sqrt{\frac{700}{3}} \text{ or } \frac{10}{3}\sqrt{21}$	M1, A1 dM1 A1 (4) (8 marks)

(a)

M1: An attempt to differentiate.

Writes as a sum of two terms and reduces the power of at least one term by 1

A1: $\frac{dy}{dx} = \frac{5}{4}x^{-\frac{1}{2}} - \frac{1}{16}x^{\frac{3}{2}}$ which may be left unsimplified

dM1: Sets $\frac{dy}{dx} = 0$ **and** proceeds to find a value for x^2 or kx^2

A1: $x = 2\sqrt{5}$ or exact equivalent

(b)

M1: An attempt to integrate.

Writes as a sum of two terms and increases the power of at least one term by 1

A1: $\frac{5}{3}x^{\frac{3}{2}} - \frac{1}{140}x^{\frac{7}{2}}$ which may be left unsimplified. Ignore $+ C$

dM1: Substitutes $x = k$ in their $\frac{5}{3}x^{\frac{3}{2}} - \frac{1}{140}x^{\frac{7}{2}} = 0$ with only two terms in k [and any constant terms eliminated by cancelling] **and** solves for k^2

A1: $k = \frac{10}{3}\sqrt{21}$ or exact equivalent

Pearson Edexcel International Advanced Level

Monday 19 January 2026

Morning (Time: 1 hour 30 minutes)

Paper

reference

WMA13/01A

Mathematics

International Advanced Level

Pure Mathematics P3

Question paper

You must have:

Answer book (sent separately).

Do not return this question paper with the answer book.

Turn over ►

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1.

**In this question you must show all stages of your working.
Solutions relying on calculator technology are not acceptable.**

The curve C has equation

$$y = \frac{3x - 2}{(x - 2)^2} \quad x \neq 2$$

The point P on C has x coordinate 4

Find an equation of the normal to C at the point P in the form $ax + by + c = 0$, where a , b and c are integers.

(6)

(Total for Question 1 is 6 marks)

2. Given that

$$f(x) = \frac{4}{3x+5} \quad x > 0$$

$$g(x) = \frac{1}{x} \quad x > 0$$

(a) state the range of f ,

(2)

(b) find f^{-1}

(3)

(c) find $fg(x)$.

(1)

(d) Show that the equation $fg(x) = gf(x)$ has no real solutions.

(4)

(Total for Question 2 is 10 marks)



3.

**In this question you must show all stages of your working.
Solutions relying on calculator technology are not acceptable.**

(i) (a) Divide $(x^2 - 3x + 6)$ by $(x + 2)$ (2)

(b) Hence find $\int \frac{x^2 - 3x + 6}{x + 2} dx$ (3)

(ii) Using algebraic integration, find the exact value of

$$\int_0^{\frac{\pi}{6}} (\cos \theta - \sin \theta)^2 d\theta$$
(5)

(Total for Question 3 is 10 marks)

4. Given that

$$y = 8 \tan(2x) \quad -\frac{\pi}{4} < x < \frac{\pi}{4}$$

show that

$$\frac{dx}{dy} = \frac{A}{B + y^2}$$

where A and B are integers to be found. (4)

(Total for Question 4 is 4 marks)

5.

**In this question you must show all stages of your working.
Solutions relying entirely on calculator technology are not acceptable.**

(a) Show that

$$\frac{\cot^2 x}{1 + \cot^2 x} \equiv \cos^2 x \quad (3)$$

(b) Hence solve, for $0 \leq x < 360^\circ$

$$\frac{\cot^2 x}{1 + \cot^2 x} = 8 \cos 2x + 2 \cos x$$

Give each solution in degrees to one decimal place.

(5)

(Total for Question 5 is 8 marks)



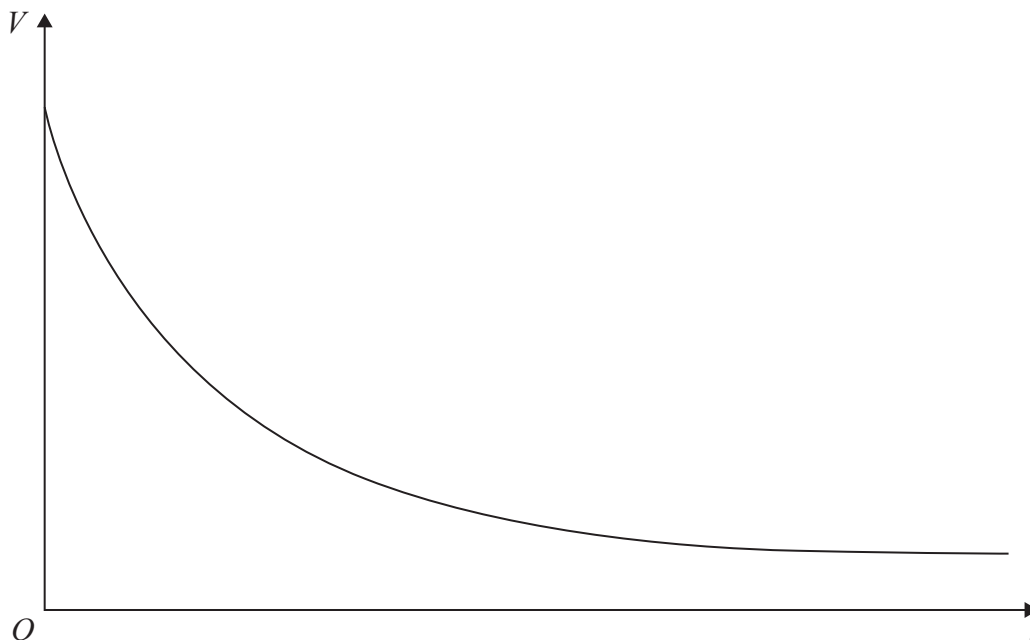


Figure 1

**In this question you must show all stages of your working.
Solutions relying entirely on calculator technology are not acceptable.**

The value of a particular car is modelled by the formula

$$V = 18\,000e^{-0.2t} + 4000e^{-0.1t} + 1000 \quad t \geq 0$$

where the value of the car is V pounds when the age of the car is t years.

A sketch of t against V is shown in Figure 1.

- (a) State the range of V . (2)

According to this model,

- (b) find the rate at which the value of the car is decreasing when $t = 10$
Give your answer in pounds per year. (3)
- (c) Calculate the exact value of t when $V = 15\,000$ giving the answer in its simplest form. (4)

(Total for Question 6 is 9 marks)

7.

**In this question you must show all stages of your working.
Solutions relying entirely on calculator technology are not acceptable.**

- (a) Express $\sqrt{5} \cos \theta - 2 \sin \theta$ in the form $R \cos(\theta + \alpha)$, where $R > 0$ and $0 < \alpha < \frac{\pi}{2}$

State the value of R and give the value of α to 4 significant figures.

(3)

- (b) Solve, for $-\pi < \theta < \pi$,

$$\sqrt{5} \cos \theta - 2 \sin \theta = 0.5$$

giving your answers to 3 significant figures.

(4)

$$f(x) = A(\sqrt{5} \cos \theta - 2 \sin \theta) + B \quad \theta \in \mathbb{R}$$

where A and B are constants.

Given that the range of f is

$$-15 \leq f(x) \leq 33$$

- (c) find the value of B and the possible values of A .

(4)

(Total for Question 7 is 11 marks)



8. Given that a is a positive constant,

(a) on **separate** diagrams, sketch the graph with equation

(i) $y = a - |x|$

(ii) $y = |3x - 2a|$

Show on each sketch the coordinates, in terms of a , of each point at which the graph crosses or meets the axes.

(4)

(b) Find, in terms of a , the values of x for which

$$a - |x| = |3x - 2a|$$

(4)

(Total for Question 8 is 8 marks)

9. (a) Given that $-\frac{\pi}{2} < g(x) < \frac{\pi}{2}$, sketch the graph of $y = g(x)$ where

$$g(x) = \arctan x \quad x \in \mathbb{R}$$

(2)

(b) Find the exact value of x for which

$$3g(x+1) - \pi = 0$$

(2)

The equation $\arctan x - 4 + \frac{1}{2}x = 0$ has a positive root at $x = \alpha$ radians.

(c) Show that $5 < \alpha < 6$

(2)

The iteration formula

$$x_{n+1} = 8 - 2 \arctan x_n$$

can be used to find an approximation for α

(d) Taking $x_0 = 5$, use this formula to find x_1 and α , giving each answer to 4 decimal places.

(3)

(Total for Question 9 is 9 marks)

TOTAL FOR PAPER IS 75 MARKS

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Please check the examination details below before entering your candidate information

Candidate surname					Other names				
Centre Number					Candidate Number				

Pearson Edexcel International Advanced Level

Monday 19 January 2026

Morning (Time: 1 hour 30 minutes) **Paper reference** **WMA13/01A**

Mathematics
International Advanced Level
Pure Mathematics P3
Answer Book

You must have:
 Question paper (sent separately).
 Mathematical Formulae and Statistical Tables (Yellow), calculator.

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 9 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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Question 1

Write the answer to Question 1 on these 2 pages

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(Total for Question 1 is 6 marks)



Question 2

Write the answer to Question 2 on these 4 pages

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Question 2 continued

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(Total for Question 2 is 10 marks)



Question 3

Write the answer to Question 3 on these 4 pages

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Question 3 continued

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(Total for Question 3 is 10 marks)



Question 4

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(Total for Question 4 is 4 marks)



Question 5

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(Total for Question 5 is 8 marks)



Question 6

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Question 6 continued

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(Total for Question 6 is 9 marks)



Question 7

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Question 7 continued

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Question 8

Write the answer to Question 8 on these 2 pages

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(Total for Question 8 is 8 marks)



Question 9

Write the answer to Question 9 on these 3 pages

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Question 9 continued

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(Total for Question 9 is 9 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (Results)

January 2026

Pearson Edexcel International Advanced Level in
Pure Mathematics P3
WMA13/01A

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January 2026

Question Paper Log Number P87594A

Publication Code WMA13_01A_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN:

- bod – benefit of doubt
- ft – follow through
 - the symbol $\surd$ will be used for correct ft
- cao – correct answer only
- cso – correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC – special case
- oe – or equivalent (and appropriate)
- d... or dep – dependent
- indep – independent
- dp – decimal places
- sf – significant figures
- * – The answer is printed on the paper or ag- answer given

- $\square$ or d... – The second mark is dependent on gaining the first mark
4. All A marks are 'correct answer only' (cao), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.
 5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. If you are using the annotation facility on ePEN, indicate this action by 'MR' in the body of the script.
 6. If a candidate makes more than one attempt at any question:
 - a) If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - b) If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
 7. Ignore wrong working or incorrect statements following a correct answer.

General Principles for Pure Mathematics Marking

(NB specific mark schemes may sometimes override these general principles)

Method mark for solving 3 term quadratic:

1. Factorisation

$(x^2 + bx + c) = (x + p)(x + q)$, where $|pq| = |c|$ leading to $x = \dots$

$(ax^2 + bx + c) = (mx + p)(nx + q)$, where $|pq| = |c|$ and $|mn| = |a|$ leading to $x = \dots$

2. Formula

Attempt to use correct formula (with values for a, b and c)

3. Completing the square

Solving $x^2 + bx + c = 0$: $(x \pm \frac{b}{2})^2 \pm q \pm c$, $q \neq 0$ leading to $x = \dots$

Method marks for differentiation and integration:

1. Differentiation

Power of at least one term decreased by 1 ($x^n \rightarrow x^{n-1}$)

2. Integration

Power of at least one term increased by 1 ($x^n \rightarrow x^{n+1}$)

Use of a formula

Where a method involves using a formula that has been learnt, the advice given in recent examiners' reports is that the formula should be quoted first.

Normal marking procedure is as follows:

Method mark for quoting a correct formula and attempting to use it, even if there are small mistakes in the substitution of values.

Where the formula is not quoted, the method mark can be gained by implication from correct working with values, but may be lost if there is any mistake in the working.

Exact answers

Examiners' reports have emphasised that where, for example, an exact answer is asked for, or working with surds is clearly required, marks will normally be lost if the candidate resorts to using rounded decimals.

Answers without working

The rubric says that these may not gain full credit. Individual mark schemes will give details of what happens in particular cases. General policy is that if it could be done "in your head", detailed working would not be required. Most candidates do show working, but there are occasional awkward cases and if the mark scheme does not cover this, please contact your team leader for advice.

Question Number	Scheme	Marks
1	$y = \frac{5}{2}$ at point P	B1
	$y = \frac{3x-2}{(x-2)^2} \Rightarrow \frac{dy}{dx} = \frac{(x-2)^2 \times 3 - (3x-2) \times 2(x-2)}{(x-2)^4}$	M1A1
	Sub $x = 4$ into $\frac{dy}{dx} = \left(-\frac{7}{4}\right)$	M1
	$\frac{4}{7} = \frac{y - \frac{5}{2}}{x - 4} \Rightarrow 8x - 14y + 3 = 0$	M1,A1
		(6 marks)

Notes

B1: Correct coordinate $y = \frac{5}{2}$ at P stated or used.

M1: Attempts to differentiate using the Quotient rule or Product rule to achieve an expression of the correct form.

Look for $\frac{(x-2)^2 \times A - (3x-2) \times B(x-2)}{((x-2)^2)^2}$ or $A(x-2)^{-2} + (3x-2) \times -B(x-2)^{-3}$ where $A, B > 0$

You may condone missing brackets for the M mark, but they must have been recovered (possibly implied by working) for the A mark.

Partial fractions may be used. Look for

$y = \frac{3x-2}{(x-2)^2} \Rightarrow y = \frac{P}{(x-2)} + \frac{Q}{(x-2)^2}$ ($P = 3, Q = 4$) $\Rightarrow \frac{dy}{dx} = \pm \frac{R}{(x-2)^2} \pm \frac{S}{(x-2)^3}$ with appropriate signs for their P and Q .

A1: Any correct (unsimplified) form of the derivative. Accept from the product rule versions equivalent to $\frac{dy}{dx} = 3(x-2)^{-2} - 2(3x-2)(x-2)^{-3}$ or from partial fractions $\frac{dy}{dx} = -3(x-2)^{-2} - 8(x-2)^{-3}$

FYI: Correct simplified expressions are $\frac{dy}{dx} = \frac{-3x^2 + 4x + 4}{(x-2)^4}$ or $\frac{-3x-2}{(x-2)^3}$

M1: Substitutes $x = 4$ into their derivative (any changed function) to find a numerical value of $\frac{dy}{dx}$.

M1: Uses $x = 4$ and their numerical value of y at $x = 4$ with their numerical $-\frac{dx}{dy}$ to form an equation of a normal. If the form $y = mx + c$ is used then it must be a full method reaching a value for c .

A1: Accept $\pm A(8x - 14y + 3) = 0$ where A is a non-zero integer coming from correct work. Terms may be in a different order but must be on one side and the “= 0” must be given. Watch for correct answers coming from incorrect versions of $\frac{dy}{dx}$ with eg. $(x-2)^2$ on the denominator, which will lose both A marks.

Question Number	Scheme	Marks
2. (a)	$0 < f(x) < \frac{4}{5}$	M1A1
		(2)
(b)	$y = \frac{4}{3x+5} \Rightarrow (3x+5)y = 4 \Rightarrow x = h(y)$	M1
	$\Rightarrow x = \frac{4-5y}{3y}$ or $\Rightarrow y = \frac{4-5x}{3x}$ o.e.	A1
	$f^{-1}(x) = \frac{4-5x}{3x} \quad 0 < x < \frac{4}{5}$	A1ft
		(3)
(c)	$fg(x) = \frac{4}{\frac{3}{x} + 5}$	B1
		(1)
(d)	$\frac{3x+5}{4} = \frac{4}{\frac{3}{x} + 5} \rightarrow ax^2 + bx + c = 0$	M1
	$15x^2 + 18x + 15 = 0$ or $5x^2 + 6x + 5 = 0$ oe	A1
	E.g. Uses $18^2 - 4 \times 15 \times 15$ or completing square, or applies formula.	dM1
	E.g. Discriminant < 0 hence there are no real solutions.	A1
		(4)
		(10 marks)

Notes

(a)

M1: One end correct, condoning $\leq$ instead of $<$. Accept alternative forms, e.g. interval notation. Condone use of x for this mark.

A1: Completely correct. Accept with $f(x)$, f or y or Range, but A0 with x used. If interval notation is used, brackets must be correct for this mark, ie $\left(0, \frac{4}{5}\right)$.

(b)

M1: Sets $y = f(x)$, multiplies both sides by denominator and reaches x as a function of y . Condone slips in expanding or in signs when rearranging after cross multiplying. Alternatively swaps x any y and proceeds to y as a function of x .

A1: Correct expression for x in terms of y , or if swapping first, y in terms of x . E.g. $y = \frac{4-5x}{3x}$,

$$y = \frac{4}{3x} - \frac{5}{3} \text{ or } x = \frac{\frac{4}{y} - 5}{3}$$

A1ft: A fully correct definition for f^{-1} with the correct rule and a correct domain or follow through domain for their (a). Must be in terms of x but accept with “ $y =$ ”

$$\text{E.g. } f^{-1}(x) = \frac{1}{3} \left(\frac{4}{x} - 5 \right) \quad 0 < x < \frac{4}{5} \quad \text{Accept equivalent forms for the rule as long as it is}$$

unambiguous e.g. $\frac{\frac{4}{x} - 5}{3}$ is acceptable. You may isw after an acceptable answer has been seen.

(c)

B1: $fg(x) = \frac{4}{\frac{3}{x} + 5}$ - allow any correct form then isw.

(d)

M1: Sets their $fg(x)$ from (c) equal to their attempt at $1/f(x)$ (condone a slip if intent is clear), and attempt at simplification to give a quadratic. Alternatively, sets $g^{-1}fg(x) = f(x)$ or $gfg^{-1}(x) = f(x)$ with $g^{-1}(x) = \frac{1}{x}$ and attempts the simplification to a quadratic, e.g. $\frac{3+5x}{4x} = \frac{4}{3x+5}$ or $\frac{3\left(\frac{1}{x}\right) + 5}{4} = \frac{4}{3x+5}$ leading to a quadratic in x .

A1: Correct 3TQ formed (any multiple). The “=0” may be implied.

dM1: Uses discriminant or completes the square to e.g. $5(x+b)^2 - c + "15"$ or $(\sqrt{5}x+b)^2 - c + "15"$ or attempts formula on their quadratic. There must be some working or indication of what they are doing to show the result, not just a value or solutions stated.

For example, stating the value -576 (or $-576 < 0$) with no context is dM0 but writing “Discriminant = -576 ” is sufficient for dM1 as they have said what the -576 is. Similarly, if they state “Discriminant = ...” for an incorrect quadratic without “ $b^2 - 4ac$ ” the value would need to be correct for their quadratic to imply correct method but just a value with no context will be dM0 even if correct.

Simply stating the complex roots with no working is dM0, as is going direct to a factorisation

$$\left(x - \frac{-3+4i}{5}\right)\left(x - \frac{-3-4i}{5}\right) = 0.$$

A1: Completely correct work with reason and conclusion. Accept for the reason

- Correct discriminant < 0 ($-576 < 0$ or $-64 < 0$ for the quadratic shown in scheme) oe
- Correct completed square > 0 for all x
- Correct formula with correct complex (hence not real) roots stated with reference to “complex” or “not real” or contradiction due to square root of negative.

The conclusion may be minimal, e.g. // or QED.

Question Number	Scheme		Marks
3.(i)(a)	$ \begin{array}{r} x-5 \\ x+2 \overline{) x^2 - 3x + 6} \\ \underline{x^2 + 2x} \\ -5x + 6 \\ \underline{-5x - 10} \\ 16 \end{array} $	$ \begin{aligned} \frac{x^2 - 3x + 6}{x + 2} &= Ax + B + \frac{C}{x + 2} \\ \Rightarrow x^2 - 3x + 6 &= (Ax + B)(x + 2) + C \\ \Rightarrow 1 &= A, -3 = 2A + B, 6 = 2B + C \\ \Rightarrow A &= \dots, B = \dots, C = \dots \end{aligned} $	M1
	Quotient = $x - 5$ and Remainder = 16		A1
			(2)
(b)	$\int \frac{x^2 - 3x + 6}{x + 2} dx = \int x - 5 + \frac{16}{x + 2} dx = \frac{1}{2}x^2 - 5x + 16 \ln(x + 2) + c$		M1, B1ft, A1
			(3)
(ii)	$\int_0^{\frac{\pi}{6}} (\cos\theta - \sin\theta)^2 d\theta = \int_0^{\frac{\pi}{6}} (\cos^2\theta - 2\sin\theta\cos\theta + \sin^2\theta) d\theta$ and one of $\int \sin^2\theta + \cos^2\theta d\theta = \int 1 d\theta \rightarrow \theta$ or $\int 2\sin\theta\cos\theta d\theta = \int \sin 2\theta d\theta \rightarrow k\cos 2\theta$ or other valid integration approaches for one of these		M1
	E.g. $\rightarrow \int 1 - \sin 2\theta d\theta \rightarrow \theta + k\cos 2\theta$ (oe)		dM1
	$\int_0^{\frac{\pi}{6}} (\cos\theta - \sin\theta)^2 d\theta = \left[\theta + \frac{1}{2}\cos 2\theta \right]_0^{\frac{\pi}{6}} \text{ oe}$		A1
	$= \left(\frac{\pi}{6} + \frac{1}{2} \times \frac{1}{2} \right) - \left(0 + \frac{1}{2} \right) = \frac{\pi}{6} - \frac{1}{4}$		ddM1 A1
			(5)
			(10 marks)

Notes

(i)(a)

M1: Full method to find the quotient and remainder. May use long division to produce a linear quotient and a constant remainder or use a partial fraction method to set up correct form and find the constants.

A1: Correct quotient and remainder seen anywhere – even in the division. If using partial fractions with correct form shown allow for the correct constants found.

(b)

M1: $\int \frac{K}{x+2} dx \rightarrow A \ln(x+2)$ (A constant) condoning a missing bracket.

B1ft: Correct integration of their linear quotient. Note $(x-5) \rightarrow \frac{1}{2}(x-5)^2$ is an equivalent correct expression.

A1: Fully correct answer including the constant. Note $\ln|x+2|$ is fine.

(ii)

Note: $d\theta$ need not be seen, and condone use of dx in the integrals.

M1: Attempts to multiply out (correct form for terms – at least three terms) and attempts a correct integration method on either the $\cos^2\theta + \sin^2\theta$ or the $\sin\theta\cos\theta$. Must use correct trig identities – but allow benefit of doubt throughout if e.g. $\cos^2\theta$ and $\sin^2\theta$ double angle identities are two correct identities but may have changed order.

There are a variety of methods that can be used:

$$\cos^2\theta + \sin^2\theta = 1 \rightarrow \theta \text{ is the most common on these terms but also possible is}$$
$$\cos^2\theta + \sin^2\theta = \frac{1}{2}(1 + \cos 2\theta) + \frac{1}{2}(1 - \cos 2\theta) \rightarrow \frac{\theta}{2} + A\sin 2\theta + \frac{\theta}{2} - A\sin 2\theta$$

For the other term $2\sin\theta\cos\theta = \sin 2\theta \rightarrow K\cos 2\theta$ is most common, but you may also see $2\sin\theta\cos\theta \rightarrow K\cos^2\theta$ or $K\sin^2\theta$ (or possibly attempts at integration by parts, but they would need to be complete attempts).

dM1: Multiplies out and applies correct integration technique to all terms of the integral.

A1: Fully correct integral, unsimplified. Possible forms are

$$\theta + \frac{1}{2}\cos 2\theta, \quad \frac{\theta}{2} + \frac{1}{4}\sin 2\theta + \cos^2\theta + \frac{\theta}{2} - \frac{1}{4}\sin 2\theta, \quad \theta - \sin^2\theta \text{ etc.}$$

Condone a mix of x 's and θ 's as long as they are recovered by substitution of the limits, but A0 if they do not attempt the substitution.

ddM1: Applies the limits to their full attempt at the integral and evaluates trig expressions– depends on both previous Ms. Both limits must be applied, do not accept just “– 0” for the lower limit if it is not 0

A1: $\frac{\pi}{6} - \frac{1}{4}$ or simplified expression, e.g. $\frac{2\pi - 3}{12}$

Question Number	Scheme		Marks
4	Differentiates wrt x $\frac{dy}{dx} = 16 \sec^2(2x)$	Gives $x = \frac{1}{2} \arctan\left(\frac{y}{8}\right)$	M1
	Inverts to get $\frac{dx}{dy} = \frac{1}{16 \sec^2 2x} = \frac{1}{16(1 + \tan^2 2x)}$ Or $\frac{dy}{dx} = 16(1 + \tan^2 2x) = 16 \times \left(1 + \left(\frac{y}{8}\right)^2\right)$	$\frac{dx}{dy} = K \times \frac{1}{\left(1 + \left(\frac{y}{8}\right)^2\right)}$	dM1
	$\frac{dx}{dy} = \frac{A}{B + y^2}$	$\frac{dx}{dy} = \frac{1}{2} \cdot \frac{1/8}{\left(1 + \left(\frac{y}{8}\right)^2\right)} = \frac{A}{B + y^2}$	ddM1
	$= \frac{4}{64 + y^2}$		A1
			(4)
			(4 marks)

Notes

Way 1:

M1: Achieves $\left(\frac{dy}{dx}\right) = \lambda \sec^2(2x)$ or $1 = \lambda \sec^2(2x) \frac{dx}{dy}$ (oe) In the second case the $\frac{dx}{dy}$ must be present, but for this mark allow if just “ $= \lambda \sec^2 2x$ ” is given – but the $\frac{dy}{dx}$ must be present for further marks to be scored.

If they change $\tan 2x$ to $\frac{\sin 2x}{\cos 2x}$ they can score this mark for $\frac{dy}{dx} = \frac{a \cos 2x \cos 2x \pm b \sin 2x \sin 2x}{(\cos 2x)^2}$

If other identities are seen progress is unlikely and must reach a derivative in terms of trig terms in $2x$.

For instance, use of $y = \frac{16 \tan x}{1 - \tan^2 x}$ will not like make suitable progress as they will be working in $\tan x$. Only if suitable identities to get in to $2x$ terms is made will they become eligible for this mark. Review any cases you feel worthy of merit and do not know how to score.

dM1: Either

- finds reciprocal of their function (or makes $\frac{dx}{dy}$ the subject) **and** uses $1 + \tan^2 2x = \sec^2 2x$
- OR

- uses $1 + \tan^2 2x = \sec^2 2x$ **and** replaces $\tan 2x$ by $y/8$ to get an expression in y only

ddM1: Full process (all three steps noted in the dM mark) to make $\frac{dx}{dy}$ the subject in terms of y and

eliminate fractions to reach the correct form. Note, correct replacement of $\tan 2x$ by $y/8$ is required but there may be algebraic slips following that in simplifying to the correct form.

A1: cao and depends on all previous marks.

Way 2:

M1: Expresses x as $x = \lambda \arctan\left(\frac{y}{8}\right)$

dM1: Differentiates to achieve a form $K \times \frac{1}{\left(1 + \left(\frac{y}{8}\right)^2\right)}$

ddM1: Differentiates their x **correctly using the chain rule** **and** eliminates fractions correctly to achieve the correct form.

A1: cao and depends on all previous marks.

Question Number	Scheme	Marks
5 (a)	Way 1: $\frac{\cot^2 x}{1 + \cot^2 x} \equiv \frac{\cos^2 x / \sin^2 x}{\operatorname{cosec}^2 x} \equiv \frac{\cos^2 x / \sin^2 x}{1 / \sin^2 x} \equiv \cos^2 x$	M1, M1, A1
	Way 2: $\frac{\cot^2 x}{1 + \cot^2 x} \equiv \frac{\cos^2 x}{\sin^2 x + \cos^2 x} \equiv \frac{\cos^2 x}{1} \equiv \cos^2 x$	M1, M1 A1
	Way 3: Consider $\cos^2 x(1 + \cot^2 x) = \cos^2 x \operatorname{cosec}^2 x = \frac{\cos^2 x}{\sin^2 x} = \cot^2 x$ Hence $\frac{\cot^2 x}{1 + \cot^2 x} \equiv \cos^2 x$	M1 M1 A1
	Way 4: Consider $\cos^2 x(1 + \cot^2 x) = \cos^2 x(1 + \frac{\cos^2 x}{\sin^2 x}) = \frac{\cos^2 x(\sin^2 x + \cos^2 x)}{\sin^2 x} = \frac{\cos^2 x}{\sin^2 x} = \cot^2 x$ Hence $\frac{\cot^2 x}{1 + \cot^2 x} \equiv \cos^2 x$	M1 M1 A1
		(3)
(b)	$\cos^2 x = 8(2 \cos^2 x - 1) + 2 \cos x$	M1
	$15 \cos^2 x + 2 \cos x - 8 = 0$	A1
	So $\cos x = 2/3$ or $-4/5$ leading to at least one value for x	dM1
	$\Rightarrow x = 48.2^\circ$ or 143.1° or 216.9° or 311.8°	A1, A1
		(5)
		(8 marks)

Notes

(a)

Way 1 and Way 3:

M1: See one of $1 + \cot^2 x = \operatorname{cosec}^2 x$, $\cot^2 x = \frac{\cos^2 x}{\sin^2 x}$ used.

M1: See two of $1 + \cot^2 x = \operatorname{cosec}^2 x$, $\cot^2 x = \frac{\cos^2 x}{\sin^2 x}$, $\operatorname{cosec}^2 x = \frac{1}{\sin^2 x}$ used.

A1: See all three of $1 + \cot^2 x = \operatorname{cosec}^2 x$, $\cot^2 x = \frac{\cos^2 x}{\sin^2 x}$, $\operatorname{cosec}^2 x = \frac{1}{\sin^2 x}$ used and **conclusion reached** – which may be reaching $\cos^2 x$ if working from LHS to RHS.

Way 2:

M1: See one of $\sin^2 x(1 + \cot^2 x) = \sin^2 x + \cos^2 x$, $\cot^2 x \sin^2 x = \cos^2 x$ used **or implied**

M1: See two of $\sin^2 x(1 + \cot^2 x) = \sin^2 x + \cos^2 x$, $\cot^2 x \sin^2 x = \cos^2 x$, $\sin^2 x + \cos^2 x = 1$ used **or implied**

A1: See all three of $\sin^2 x(1 + \cot^2 x) = \sin^2 x + \cos^2 x$, $\cot^2 x \sin^2 x = \cos^2 x$, $\sin^2 x + \cos^2 x = 1$ used **or implied** and **conclusion reached**. In this method multiplication of numerator and denominator may be implied and $\sin^2 x(1 + \cot^2 x) = \sin^2 x + \cos^2 x$ **may not be explicit**.

Way 4:

M1: See $\cot^2 x = \frac{\cos^2 x}{\sin^2 x}$ used

M1: See both $\cot^2 x = \frac{\cos^2 x}{\sin^2 x}$ and $(1 + \frac{\cos^2 x}{\sin^2 x}) = \frac{(\sin^2 x + \cos^2 x)}{\sin^2 x}$ used

A1: See all three of $\cot^2 x = \frac{\cos^2 x}{\sin^2 x}$, $(1 + \frac{\cos^2 x}{\sin^2 x}) = \frac{(\sin^2 x + \cos^2 x)}{\sin^2 x}$ and $\sin^2 x + \cos^2 x = 1$ used and **conclusion reached**.

Note: for conclusions, if working from one side direct to the other, accept successfully reaching the other side as the conclusion. If multiplying or not starting directly from one side some concluding statement will be required (e.g. “hence proved”).

There will be some combinations of these methods or variations on these. **A complete method with no errors scores M1M1A1**

In general score M1 for one valid and appropriate identity used (possibly implied), M1 for two valid and appropriate (different) identities applied within a single proof and A1 for a complete process using all necessary identities and if not proving from one side to the other directly a conclusion will also be needed.

E.g. $\frac{\cot^2 x}{1 + \cot^2 x} = \frac{\cos^2 x / \sin^2 x}{\operatorname{cosec}^2 x} = \frac{\cos^2 x}{\sin^2 x \operatorname{cosec}^2 x} = \cos^2 x$ scores M1 for use of $\cot^2 x = \frac{\cos^2 x}{\sin^2 x}$, M1 for use of $1 + \cot^2 x = \operatorname{cosec}^2 x$ (or vice versa) and A for the complete proof with all appropriate identities used.

Note: Condone poor notation for the M marks, but for the final A the notation should be correct throughout the proof, allowing a single notational slip if recovered.

(b)

M1: Uses part (a) to replace left hand side and uses double angle formula for $\cos 2x$ on right hand side to get an equation in $\cos x$ only.

Condone $\cos 2x = \pm 2 \cos^2 x \pm 1$ for the double angle identity. If $\cos 2x = \cos^2 x - \sin^2 x$ is used this mark is not scored until the $\sin^2 x$ is replaced by $1 - \cos^2 x$. Condone a slip or an omission on either of the coefficients 8 and 2.

A1: Correct three term quadratic reached. Terms should all be gathered on one side unless an appropriate completing the square method is shown to solve to imply it. The $= 0$ may be implied.

dM1: Solves their 3TQ in $\cos x$ by any method – factorising, formula or completion of square or just writing down answers (must be correct for their quadratic if no method shown – you may need to check - an invalid solutions for $\cos x$ may be omitted). You must see a value for $\cos x$ (or e.g. value for a if as substitution $a = \cos x$ has been used) appearing before sight of a value for x . No value for $\cos x$ seen will be dM0A0A0 (even if correct answer appear).

A1: Two correct answers in the range. Must be in degrees.

A1: All four answers in the range, $x = \text{awrt } 48.2^\circ$ or 143.1° or 216.9° or 311.8°

Any extra solutions in the range withhold the last A mark.

Ignore any solutions outside the range $0 \leq x \leq 360^\circ$

Question Number	Scheme	Marks
6 (a)	$1000 < V \leq 23000$	B1,B1
		(2)
(b)	$\frac{dV}{dt} = 18000 \times -0.2e^{-0.2t} + 4000 \times -0.1e^{-0.1t}$	M1
	$\left. \frac{dV}{dt} \right _{t=10} = 18000 \times -0.2e^{-2} + 4000 \times -0.1e^{-1} = (-)634 \text{ (awrt)}$	dM1A1
		(3)
(c)	$(15000 = 18000e^{-0.2t} + 4000e^{-0.1t} + 1000 \Rightarrow 0 = 9e^{-0.2t} + 2e^{-0.1t} - 7)$	
	$0 = (9e^{-0.1t} - 7)(e^{-0.1t} + 1)$	M1A1
	$9e^{-0.1t} = 7 \Rightarrow t = 10 \ln\left(\frac{9}{7}\right) \text{ oe}$	dM1A1
		(4)
		(9 marks)

Notes

(a)

B1: Achieves the value of one end, either 23000 or 1000 associated to the correct end. Condone for this mark the incorrect omission or inclusion of the boundary. Eg $V < 23000$ but do not condone $V \geq 23000$ or just 23000 with no inequality (or similar with the 1000).

B1: Completely correct solution. Accept $1000 < V \leq 23000$, $1000 < \text{Range} \leq 23000$, $(1000, 23000]$. The inequalities must be correct, $1000 < V < 23000$ is B0.

(b)

M1: Differentiates to form $\frac{dV}{dt} = Ae^{-0.2t} + Be^{-0.1t} + (0)$ where $A \neq 18000$, $B \neq 4000$

dM1: Substitutes $t = 10$ into their $\frac{dV}{dt}$. It is dependent upon having scored the previous M1.

A1: Correct solution only. Accept awrt ± 634 following a correct $\frac{dV}{dt} = -3600e^{-0.2t} - 400e^{-0.1t}$. Do not isw if they change to 6.34 as their final answer.

Watch for students who substitute $t = 10$ into their V first and then differentiate. This is M0dM0A0.

Watch for students who achieve +634 following $\frac{dV}{dt} = 3600e^{-0.2t} + 400e^{-0.1t}$. This is M1dM1A0

(c)

M1: Sets up a 3TQ in $e^{\pm 0.1t}$ from the information **AND** makes a valid attempt to factorise or solve the quadratic. May be implied by reaching $e^{\pm 0.1t} = \frac{7}{9}$ or $\frac{9}{7}$ or root of their quadratic either way up. May use a substitution and solve a quadratic in their variable.

A1: Correct factors $(9e^{-0.1t} - 7)(e^{-0.1t} + 1)$ or $(7e^{0.1t} - 9)(e^{0.1t} + 1)$ or correct solutions associated to the correct exponential terms, though they may omit the negative solution.

dM1: Dependent upon the previous M1. Proceeds via correct ln work to find the exact value for t

E.g. This is scored for setting the $ae^{\pm 0.1t} - b = 0$ and proceeding 'correctly' to $t = \dots$ or if quadratic solved by other means it is for proceeding from $e^{\pm 0.1t} = K$ correctly to achieve a value for t .

A1: $t = 10 \ln\left(\frac{9}{7}\right)$. Accept other simplest form alternatives such as $-10 \ln\left(\frac{7}{9}\right)$ or $\ln\left(\frac{9}{7}\right)^{10}$ and withhold

if any extra solutions are given. ISW a correct answer as long as no extra solutions are given.

NB Answers only will score no marks in part (c).

Question Number	Scheme	Marks
7.	$\sqrt{5}\cos\theta - 2\sin\theta \equiv R\cos(\theta + \alpha)$	
(a)	$R = 3$	B1
	$\tan\alpha = \frac{2}{\sqrt{5}}, \Rightarrow \alpha = \text{awrt } 0.7297 \text{ (4 sf)}$	M1, A1
		(3)
(b)	$3\cos(\theta + 0.7297) = 0.5 \Rightarrow \cos(\theta + 0.7297) = \frac{0.5}{3}$	M1
	$\Rightarrow \theta_1 = 0.674 \text{ (3 sf)}$	A1
	$\theta_2 + "0.7297" = "-1.4033" \Rightarrow \theta_2 = \dots$	dM1
	$\Rightarrow \theta_2 = -2.13 \text{ (3 sf)}$	A1
		(4)
(c)	E.g. $3A + B = 33$ or $3A + B = -15$ or $B = \frac{33-15}{2} = \dots$ $-3A + B = -15$ or $-3A + B = 33$ or $B = \dots$ $\Rightarrow A = \dots$ or $B = \dots$	M1
	$A = 8, B = 9$ and $A = -8, B = 9$	A1A1A1
		(4)
		(11 marks)

Notes

(a)

B1: For $R = 3$ stated or seen in their expression. $\sqrt{9}$ is B0. ± 3 is B0.

M1: $\tan\alpha = \pm \frac{2}{\sqrt{5}}, \tan\alpha = \pm \frac{\sqrt{5}}{2} \Rightarrow \alpha = \dots$

Also allow $\cos\alpha = \pm \frac{\sqrt{5}}{3}$ or $\pm \frac{2}{3}$, $\sin\alpha = \pm \frac{2}{3}$ or $\pm \frac{\sqrt{5}}{3} \Rightarrow \alpha = \dots$, where “3” is their R

Note the M may be scored if they find α in degrees (41.8°).

A1: $\alpha = \text{awrt } 0.7297 \text{ (4 sf)}$. No need to state the full expression for this mark.

(b)

M1: Uses part (a) and proceeds to $\cos(\theta + "0.7297") = \frac{0.5}{3}$. Must see some working, but may be

implied by $\theta \pm "0.7297" = 1.4033$ or $\theta \pm "0.7297" = \cos^{-1}\left(\frac{0.5}{\text{their } 3}\right)$

A1: Achieves a correct value for θ of awrt 0.674

dM1: Correct method for a second angle, usually given for $\theta_2 + \text{their } 0.7297 = -\text{their } 1.4033 \Rightarrow \theta_2 = \dots$

May be implied but the previous M must have been gained. If working in degrees as long as they are consistently in degrees.

A1: $\Rightarrow \theta_2 = \text{awrt } -2.13 \text{ (3 sf)}$ but withhold if there are extra solutions in the range and first A scored.

For candidates who work consistently in degrees in (a) and (b) allow awrt 38.6° for the first A in (b) or awrt -122° for the second A mark if the first A was lost due to error (i.e. max one A mark).

(c)

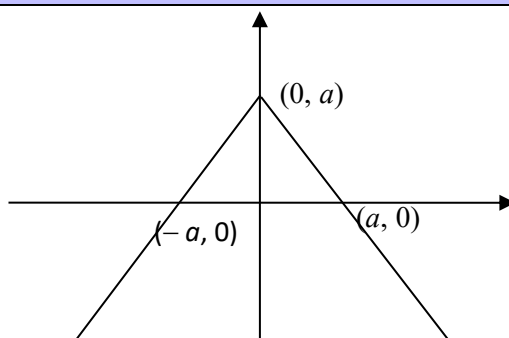
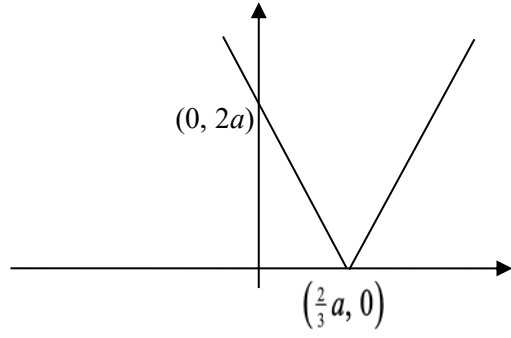
M1: Correct method to find at least one value. E.g. writes down at least one pair of simultaneous equations (or in-equations) of form $-15 = kA + B$, $33 = -kA + B$ or uses B is mean value of end points other suitable working or equation and finds at least one of $A = \dots$ or $B = \dots$

Note correct value for A or B implies M1A1 (with no incorrect working for it)

A1: At least one of $A = 8, B = 9$ or $A = -8$

A1: At least two of $A = 8, B = 9$ or $A = -8$

A1: For all three of $A = 8, B = 9$ and $A = -8$ and no other values.

Question Number	Scheme		Marks
8(a) (i)		Correct ^ shape, any position	B1
		Correct diagram with intercepts correctly placed	B1
(ii)		Correct v shape, any position	B1
		Correct diagram with intercepts correctly placed	B1
(b)	$a - x = 3x - 2a \Rightarrow x = \dots$ or $a - x = -3x + 2a \Rightarrow x = \dots$		M1
	$x = \frac{3}{4}a$ or $x = \frac{1}{2}a$		A1
	$a - x = 3x - 2a \Rightarrow x = \dots$ and $a - x = -3x + 2a \Rightarrow x = \dots$		dM1
	$x = \frac{3}{4}a$ and $x = \frac{1}{2}a$		A1
			(4)
			(8 marks)

Notes

(a)(i)

B1: For a correct ^ shape in any position. Condone if not quite symmetric.

B1: Fully correct sketch, and must continue below the x axis, with correct intercepts in terms of a either marked on the graph or correctly stated. No need for the 0 coordinate if labelled on the graph.

Condone coordinates the wrong way round (eg $(a,0)$ instead of $(0, a)$) only if they are in the correct positions on the graph. Condone if not quite symmetric.

(ii)

B1: For a correct v shape in any position, condone if it does not cross the y axis. Condone if not quite symmetric. Condone a Y shape as benefit of doubt as an attempt to form the graph.

B1: Fully correct sketch, must continue into second quadrant with same conditions for intercepts as above. Condone if not quite symmetric.

If multiple graphs are drawn on the same axes in (a), if they are labelled score for the graph labelled with correct function/part number. If there is no labelling you may apply bod for the first B only.

(b)

M1: Attempts to solve either correct equation. Must come from correct modulus work (bod if no incorrect work is seen). Watch out for

$a - |x| = |3x - 2a| \Rightarrow a - |x| = 3|x| - 2|a| \Rightarrow 3a = 4x \Rightarrow x = \frac{3}{4}a$ which obtains a correct answer from incorrect work.

A1: One correct value from a correct equation.

dM1: Attempt to solve both correct equations, which may be amidst other work – again both must come from correct work.

A1: Both values correct and no other values. Any other values must have been rejected.

NB: Attempts via squaring may be seen. This will work since both solutions are positive (can be deduced from the sketch) and so $x > 0$ gives $|x| = x$. Score as follows

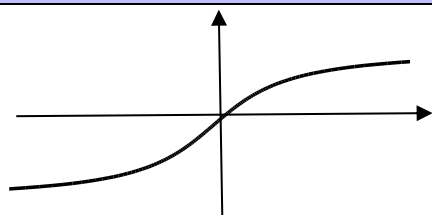
M1: Attempts to square producing a correct equation.

$$x > 0 \Rightarrow |x| = x \Rightarrow (a - |x|)^2 = (3x - 2a)^2 \Rightarrow a^2 - 2ax + x^2 = 9x^2 - 12ax + 4a^2$$

A1: Solves to produce at least one correct solution $\Rightarrow 8x^2 - 10ax + 3a^2 \Rightarrow x = \frac{3}{4}a$ or $x = \frac{1}{2}a$

dM1: Attempts to solve their correct equation (look for factorisation or formula attempts, though may contain errors simplifying an initially correct equation).

A1: $x = \frac{3}{4}a$ **and** $x = \frac{1}{2}a$ and no other x values. Ignore any y values found for these coordinates.

Question Number	Scheme		Marks
9 (a)		Curve thro (0,0) in quad 1 and 3 and is increasing	M1
		Gradient $\rightarrow 0$ as $x \rightarrow \pm \infty$	A1
(b)	$3 \arctan(x+1) - \pi = 0 \Rightarrow \arctan(x+1) = \frac{\pi}{3} \Rightarrow x+1 = \tan\left(\frac{\pi}{3}\right)$		M1
	$\Rightarrow (x+1) = \tan\left(\frac{\pi}{3}\right) \Rightarrow x = \tan\left(\frac{\pi}{3}\right) - 1 = \sqrt{3} - 1$		A1
(c)	$f(x) = \pm \left(\arctan x - 4 + \frac{1}{2}x \right) \Rightarrow f(5) = \mp 0.126..., f(6) = \pm 0.405...$		M1
	Since $f(x)$ is continuous and changes sign over the interval (5,6), so there is a root in this interval [so $5 < \alpha < 6$]		A1
(d)	$x_1 = 8 - 2 \arctan 5$		M1
	$x_1 = \text{cao } 5.2532, \alpha = \text{awrt } 5.2358$		A1, A1
	(9 marks)		

Notes

(a)

M1: Any mostly increasing curve (allowing tolerance of slight curvature at the ends) through (0,0) and that lies entirely in quadrants 1 and 3 with no clear vertical asymptote(s).

A1: Fully correct sketch with the correct curvature. Asymptotes need not be drawn but the curve must be flattening out at either end. Do not allow for curves that clearly turn back on themselves.

(b)

M1: Proceeds to $\arctan(x+1) = \frac{\pi}{3}$ codoning sign/coefficient slip rearranging and attempts to take tan of both sides. Accept seeing $\pm\sqrt{3}$ or $\pm\frac{1}{\sqrt{3}}$ (awrt 1.73 or 0.577) as evidence if method not shown.

A1: $\sqrt{3} - 1$ only. A0 if other solutions are given.

(c)

M1: Substitutes $x = 5$ and $x = 6$ into $\pm \left(\arctan x - 4 + \frac{1}{2}x \right)$ and achieves one value correct to at least 1 sf rounded or truncated (evidence of clearly incorrect values that happen to round to 1s.f. is M0). A tighter range may be used, but must include the root.

A1: For achieving

- both values correct (to at least one s.f. as per the M)
- a correct reason e.g. change of sign (accept <0 , >0 shown) **and** reference to being a continuous function (condone poor spelling)
- a minimal conclusion, e.g. root, or so $5 < \alpha < 6$

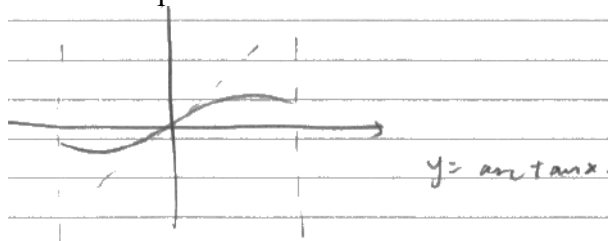
(d)

M1: Applies the iteration formula once to achieve a correct expression for x_1 or awrt 5.3 or awrt 5.2 before finding the root.

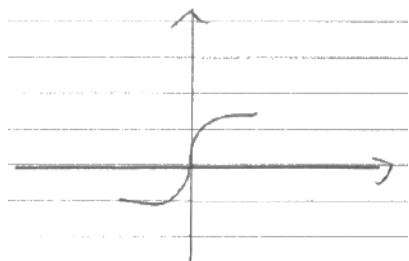
A1: 5.2532 cao

A1: awrt 5.2358 provided the M is scored.

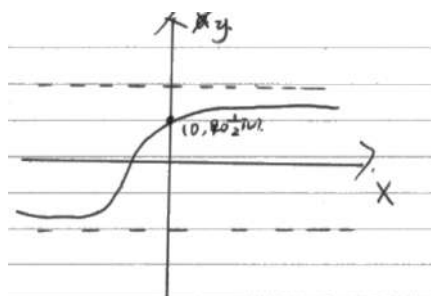
Some examples of sketches and how to score.



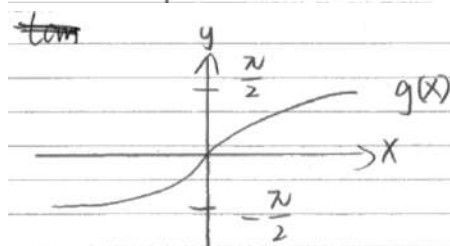
Scores M1A0 for the attempt, allowing tolerance at the ends for the curvature for the M mark, but it is clearly turning back on itself (at both ends) so A0.



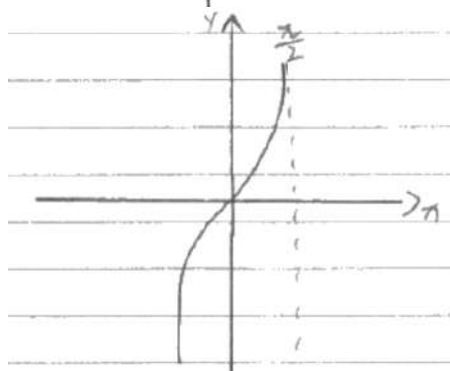
M1 A1 Mostly increasing curve in quadrants 1 and 3 only with no vertical asymptotes and this is a borderline case on the A mark with benefit of doubt applied to the “levelling off” on the left hand end. There is a slight curving back on itself but could be consider as pen slip.



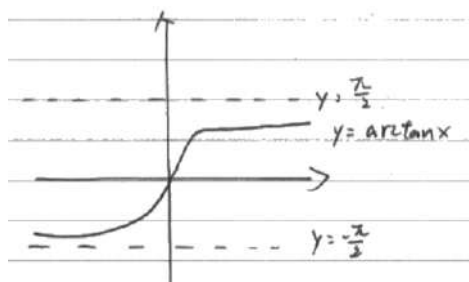
M0A0 Does not pass through (0,0)



M1A1 Suitable sketch showing all the necessary features with ends levelling sufficiently as x tends to infinity.



M0A0 There is a clear vertical asymptote



M1A0 Mostly increasing curve in quadrants 1 and 3 only with no vertical asymptotes, tolerable curvature for the M1, but a clear sudden change in gradient is no suitable for the A1.

Please check the examination details below before entering your candidate information

Candidate surname					Other names				
Centre Number					Candidate Number				

Pearson Edexcel International Advanced Level

Monday 19 January 2026

Morning (Time: 1 hour 30 minutes) **Paper reference** **WMA13/01**

Mathematics
International Advanced Level
Pure Mathematics P3

You must have:
 Mathematical Formulae and Statistical Tables (Yellow), calculator

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 10 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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1.

$$g(x) = 3x - 5 + 5 \sin(x^2)$$

where x is measured in radians.

(a) Show that $g(x) = 0$ has a root α in the interval $[0.7, 0.8]$ (2)

(b) Show that the equation $g(x) = 0$ can be written in the form

$$x = [\arcsin(1 - px)]^{\frac{1}{2}}$$

where p is a constant to be found. (1)

Using the iteration formula

$$x_{n+1} = [\arcsin(1 - px_n)]^{\frac{1}{2}}$$

with the value of p found in part (b) and starting with $x_1 = 0.7$

(c) (i) find, to 4 decimal places, the value of x_2
 (ii) find, by repeated iteration, the value of α , giving your answer to 4 decimal places. (3)



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Question 1 continued

Handwriting practice area with horizontal lines.

(Total for Question 1 is 6 marks)



2. (i) Given $y = x^2 \ln 2x$, find in simplest form, $\frac{dy}{dx}$ (2)

(ii) Given

$$f(x) = \frac{e^{2x}}{(4x+3)^2} \quad x > -\frac{3}{4}$$

show that

$$f'(x) = \frac{2e^{2x}(ax+b)}{(4x+3)^3}$$

where a and b are constants to be found.

(4)



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Question 2 continued

Handwriting practice area with horizontal lines.

(Total for Question 2 is 6 marks)



3. (i) Find, in simplest form,

$$\int 2(3x+5)^7 dx \quad (2)$$

(ii) $f(x) = \frac{4x^3 + x^2 - 7x + 14}{(x-1)(x+2)} \quad x > 1$

- (a) Write $f(x)$ in the form

$$ax + b + \frac{c}{x-1}$$

where a , b and c are constants to be found.

(4)

- (b) Hence, using algebraic integration, find

$$\int_3^9 f(x) dx$$

writing the answer in simplest form.

(4)



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Question 3 continued

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Question 3 continued

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(Total for Question 3 is 10 marks)



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Question 4 continued

Handwriting practice area with horizontal lines.

(Total for Question 4 is 6 marks)



5. The function f is defined by

$$f : x \rightarrow \frac{2x+16}{x-4} \quad x \neq 4$$

(a) Find $ff(x)$, giving your answer as a single fraction in its simplest form.

(3)

(b) Find $f^{-1}(12)$

(2)

The function g is defined by

$$g : x \rightarrow \ln x \quad x > 0 \quad x \neq e^4$$

(c) Find the exact values of a such that

$$fg(a) = g(a)$$

(3)



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Question 5 continued

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Question 5 continued

(Total for Question 5 is 8 marks)



6. In this question you must show all stages of your working. Solutions relying entirely on calculator technology are not acceptable.

(a) Show that the equation

$$2 \cos(\theta - 60^\circ) = 3 \sin \theta$$

can be written in the form

$$\tan \theta = \frac{1}{6}(3 + \sqrt{3}) \quad (4)$$

(b) Hence solve, for $0 \leq x < 180^\circ$, the equation

$$2 \cos(2x - 70^\circ) = 3 \sin(2x - 10^\circ)$$

giving your solutions to one decimal place. (3)

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P 7 8 9 1 0 A 0 1 7 3 2

Question 6 continued

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Question 6 continued

(Total for Question 6 is 7 marks)



7.

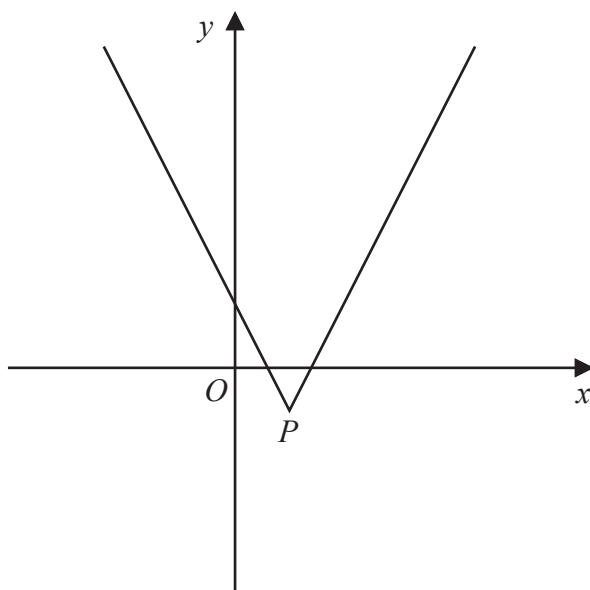
**Figure 1**

Figure 1 shows a sketch of part of the graph with equation $y = f(x)$, where

$$f(x) = |3x - 11| - 4$$

The vertex of the graph is at the point P , as shown in Figure 1.

(a) State the coordinates of P .

(2)

(b) Solve the equation $f(x) = 8$

(3)

The line l has equation $y = mx$, where m is a constant.

Given that l intersects the graph of $y = f(x)$ at exactly one point,

(c) find the possible values of m .

(3)

The graph with equation $y = f(x)$ is transformed onto the graph with equation $y = af(x - b)$, where a and b are constants.

Given that the vertex of the graph with equation $y = af(x - b)$ is $(5, 16)$

(d) find the value of a and the value of b .

(2)



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Question 7 continued

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Question 7 continued

(Total for Question 7 is 10 marks)



8. A curve has equation

$$x = e^{2 \tan y} \quad -\frac{\pi}{2} < y < \frac{\pi}{2}$$

Show that

$$\frac{dy}{dx} = \frac{a}{x(b + (\ln x)^n)}$$

where a , b and n are integers to be found.

(4)



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Question 8 continued

(Total for Question 8 is 4 marks)



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Question 9 continued

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Question 9 continued

(Total for Question 9 is 9 marks)



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Question 10 continued

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(Total for Question 10 is 9 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (Results)

January 2026

Pearson Edexcel International Advanced Level in
Pure Mathematics P3
WMA13/01

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January 2026

Question Paper Log Number P78910A

Publication Code WMA13_01_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN:

- bod – benefit of doubt
- ft – follow through
 - the symbol $\checkmark$ will be used for correct ft
- cao – correct answer only
- cso – correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC – special case
- oe – or equivalent (and appropriate)
- d... or dep – dependent
- indep – independent
- dp – decimal places
- sf – significant figures
- * – The answer is printed on the paper or ag- answer given

- $\square$ or d... – The second mark is dependent on gaining the first mark
4. All A marks are 'correct answer only' (cao), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.
 5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. If you are using the annotation facility on ePEN, indicate this action by 'MR' in the body of the script.
 6. If a candidate makes more than one attempt at any question:
 - a) If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - b) If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
 7. Ignore wrong working or incorrect statements following a correct answer.

General Principles for Pure Mathematics Marking

(NB specific mark schemes may sometimes override these general principles)

Method mark for solving 3 term quadratic:

1. Factorisation

$(x^2 + bx + c) = (x + p)(x + q)$, where $|pq| = |c|$ leading to $x = \dots$

$(ax^2 + bx + c) = (mx + p)(nx + q)$, where $|pq| = |c|$ and $|mn| = |a|$ leading to $x = \dots$

2. Formula

Attempt to use correct formula (with values for a, b and c)

3. Completing the square

Solving $x^2 + bx + c = 0$: $(x \pm \frac{b}{2})^2 \pm q \pm c$, $q \neq 0$ leading to $x = \dots$

Method marks for differentiation and integration:

1. Differentiation

Power of at least one term decreased by 1 ($x^n \rightarrow x^{n-1}$)

2. Integration

Power of at least one term increased by 1 ($x^n \rightarrow x^{n+1}$)

Use of a formula

Where a method involves using a formula that has been learnt, the advice given in recent examiners' reports is that the formula should be quoted first.

Normal marking procedure is as follows:

Method mark for quoting a correct formula and attempting to use it, even if there are small mistakes in the substitution of values.

Where the formula is not quoted, the method mark can be gained by implication from correct working with values, but may be lost if there is any mistake in the working.

Exact answers

Examiners' reports have emphasised that where, for example, an exact answer is asked for, or working with surds is clearly required, marks will normally be lost if the candidate resorts to using rounded decimals.

Answers without working

The rubric says that these may not gain full credit. Individual mark schemes will give details of what happens in particular cases. General policy is that if it could be done "in your head", detailed working would not be required. Most candidates do show working, but there are occasional awkward cases and if the mark scheme does not cover this, please contact your team leader for advice.

Question Number	Scheme	Marks
1 (a)	$g(x) = 3x - 5 + 5 \sin(x^2)$ $g(0.7) = -0.55, \quad g(0.8) = 0.39$ Change of sign and continuous function, hence root in $[0.7, 0.8]$	M1 A1 (2)
(b)	$0 = 3x - 5 + 5 \sin(x^2) \Rightarrow x = [\arcsin(1 - 0.6x)]^{\frac{1}{2}}$	B1 (1)
(ci)	$x_2 = [\arcsin(1 - 0.6 \times 0.7)]^{\frac{1}{2}} = \text{awrt } 0.7866$	M1, A1
(cii)	$\alpha = 0.7589$	A1
		(3)
		(6 marks)

- (a)
- M1 Attempts the value of g at 0.7 and 0.8 with one correct (to 1 s.f. rounded or truncated). Use of a narrower range is possible, providing the lower x value gives a negative function value and the higher one gives a positive function value. You may need to check these function values.
- A1 Requires
- Both values correct to 1 s.f., rounded or truncated.
 - Reason: sign change (or $g(0.7) < 0, g(0.8) > 0$ or $g(0.7)g(0.8) < 0$, etc) and “continuous function” (or “continuous graph/curve”, or just “continuity” etc.)
 - Minimal conclusion, e.g. “root”, “root in interval”, “root in $[0.7, 0.8]$ ”, “ α lies in interval”, etc). Do not condone the incorrect statement “Change of sign hence continuous function and root in interval” etc.
- (b)
- B1 Correct value of p stated or implied. May be embedded in formula. If embedded, allow e.g. $-\frac{3x}{5}$ in place of $-0.6x$. Condone slips in the formula if the correct value of p is clearly seen. If an incorrect p value is seen in (b) it is B0, regardless of what the candidate uses in (c). If there is no obvious attempt at (b), then you can mark any formula used in (c). Apply isw if, for example, a correct formula is given, followed by $p = -0.6$.
- (ci)
- M1 Attempts to substitute $x_1 = 0.7$ into the correct formula with their $\pm p$ to reach a value. Do not be concerned about the labelling of this second approximation, e.g. it may be labelled x_1 or x_3 . This mark is available for candidates working in degrees, in which case, if a correct formula is used, they will get $x_2 = 5.954$. For an incorrect formula and no working, you may have to check their answer, whether working in radians or degrees.
Can be implied by 0.786... following $p = 0.6$
- A1 awrt 0.7866. Condone incorrect labelling.
- (cii)
- A1 cao $\alpha = 0.7589$. Accept $x = 0.7589$ or e.g. $x_{11} = 0.7589$ if it is clear this is their final answer.

Question Number	Scheme	Marks
2 (i)	$y = x^2 \ln 2x \Rightarrow \left(\frac{dy}{dx} = \right) 2x \ln 2x + x$ o.e.	M1 A1
(ii)	$(f'(x) =) \frac{2(4x+3)^2 e^{2x} - 8(4x+3)e^{2x}}{(4x+3)^4} \text{ or } 2e^{2x}(4x+3)^{-2} - 8e^{2x}(4x+3)^{-3}$ $= \frac{\cancel{(4x+3)}e^{2x}[2(4x+3)-8]}{(4x+3)^{\cancel{4}^3}} \text{ or } e^{2x}(4x+3)^{-3}[2(4x+3)-8]$ $= \frac{2e^{2x}(4x-1)}{(4x+3)^3}$	M1 A1 dM1 A1 (6 marks)

(i)
M1 Attempts the product rule to achieve $Ax \ln 2x + Bx$ o.e. with $A, B \neq 0$ which may be unsimplified.

A1 $\left(\frac{dy}{dx} = \right) 2x \ln 2x + x$. Condone $\ln 2x(2x) + x$. isw after a correct answer.

(ii)
M1 Attempts the quotient rule to achieve $\frac{P(4x+3)^2 e^{2x} - Q(4x+3)e^{2x}}{(4x+3)^4}$ with $P, Q > 0$. Allow $-Q(4x+3)e^{2x}$ to be expanded, i.e. if correct $-(32x+24)e^{2x}$ or $-32xe^{2x} - 24e^{2x}$.

Alternatively, attempts the product rule. Look for $Pe^{2x}(4x+3)^{-2} - Qe^{2x}(4x+3)^{-3}$ with $P, Q > 0$.

In either case, Q may be written as the product of two integers.

Condone miscopying slips on $(4x+3)$, e.g. $(3x+4)$

A1 Using quotient rule: $(f'(x) =) \frac{2(4x+3)^2 e^{2x} - 8(4x+3)e^{2x}}{(4x+3)^4}$ o.e.

Using product rule: $(f'(x) =) 2e^{2x}(4x+3)^{-2} - 8e^{2x}(4x+3)^{-3}$ o.e.

In either case, allow 8 to be written as $(2)(4)$.

dM1 Dependent on previous M1. Correctly takes out a common factor of $(4x+3)e^{2x}$ from their numerator and cancels $(4x+3)$. If using product rule, must take out a common factor of $(4x+3)^{-3}e^{2x}$. They may also take out a factor of 2 at this stage, but this is not required for dM1.

A1 Achieves $\frac{2e^{2x}(4x-1)}{(4x+3)^3}$. Do not allow $2e^{2x}(4x-1)(4x+3)^{-3}$. Allow recovery of invisible brackets at any stage.

Question Number	Scheme	Marks
3 (i)	$\int 2(3x+5)^7 dx = \frac{(3x+5)^8}{12} (+c)$	M1 A1 (2)
(ii) (a)	By division $x^2 + x - 2 \overline{) 4x^3 + x^2 - 7x + 14}$ Remainder = $4x + 8$ $\frac{4x+8}{x^2+x-2} = \frac{4(x+2)}{(x+2)(x-1)}$ $\frac{4x^3+x^2-7x+14}{(x-1)(x+2)} \equiv 4x-3 + \frac{4}{x-1}$	M1 A1 M1 A1 (4)
(b)	$\int_3^9 f(x) dx = [2x^2 - 3x + 4 \ln(x-1)]_3^9$ $= 126 + 4 \ln 8 - 4 \ln 2 = 126 + 8 \ln 2$	M1 A1ft dM1 A1 (4) (10 marks)

(i)

M1 Integrates and achieves $k(3x+5)^8$ where k is a constant. Any attempt that involves expanding $(3x+5)^7$ is unlikely to reach an answer in its simplest form, so probably scores M0A0, but if you think there is a meaningful attempt to factorise the answer into the required form, send to review. If a substitution is used, they must revert to x and reach $k(3x+5)^8$

A1 $\frac{(3x+5)^8}{12}$ with or without $+c$

(ii) (a)

By division

M1 Divides the cubic by $x^2 + x - 2$ and achieves a linear quotient $4x \pm \dots$. Watch out for different ways to present the division, e.g. grid method. They may divide first by $(x+2)$ and then by $(x-1)$ or vice versa. See exemplification below. Do not allow misreads for the quadratic divisor; or if dividing by the two linear factors separately, these must be correct.

A1 Achieves the linear quotient $4x - 3$. This mark can be given even if slips in the division lead to an incorrect remainder.

M1 See one of the following 3 cases below for award of this mark. All 3 cases depend on a valid attempt at division and $Q(x)$ is their linear quotient after division.

- 1) If the candidate has divided the cubic by $x^2 + x - 2$, achieving a remainder $px + q$, this mark can be awarded for reaching $Q(x) + \frac{px+q}{x^2+x-2}$ or $Q(x) + \frac{px+q}{(x+2)(x-1)}$
- 2) If they have divided by $(x+2)$ and then $(x-1)$, they should reach an expression of the form $Q(x) + \frac{c}{x-1}$, where c is an integer. If there are slips in the division by $(x+2)$ leading to a non-zero remainder, award for reaching $Q(x) + \frac{px+q}{x^2+x-2}$ or $Q(x) + \frac{px+q}{(x+2)(x-1)}$
- 3) If they have divided by $(x-1)$ and then $(x+2)$, this mark can be awarded for reaching $Q(x) + \frac{px+q}{x^2+x-2}$ or $Q(x) + \frac{px+q}{(x+2)(x-1)}$

In Cases (2) and (3) there must be a correct method for combining the two remainders into a single fraction.

A1 $4x - 3 + \frac{4}{x-1}$ which may be seen in (ii) (b)

Division by the two linear factors separately – exemplification

$$\frac{4x^3 + x^2 - 7x + 14}{x+2} = 4x^2 - 7x + 7; \text{ followed by } \frac{4x^2 - 7x + 7}{x-1} = 4x - 3 + \frac{4}{x-1} \quad (\text{M1A1M1A1})$$

Or $\frac{4x^3 + x^2 - 7x + 14}{x-1} = 4x^2 + 5x - 2 + \frac{12}{x-1}$; followed by $\frac{4x^2 + 5x - 2}{x+2} = 4x - 3 + \frac{4}{x+2}$ (M1A1 here for correct quotient). Then $\frac{12}{(x-1)(x+2)} + \frac{4}{x+2} = \frac{4}{x-1} \Rightarrow f(x) = 4x - 3 + \frac{4}{x-1}$ (M1A1)

Alt: By comparing terms / using an identity. This must be of the correct form but condone slips (say in signs).
 $4x^3 + x^2 - 7x + 14 = (ax+b)(x+2)(x-1) + c(x+2)$

M1 Correct method to find two constants, e.g. $x = 1 \Rightarrow 12 = 3c \Rightarrow c = 4$, compare terms in $x^3 \Rightarrow 4 = a$

A1 Two correct constants

M1 Correct method to find all three constants

A1 $4x - 3 + \frac{4}{x-1}$ which may be seen in (ii) (b)

(ii) (b)

M1 Achieves a correct $c \ln(x-1)$ AND one of the other two terms: $\frac{1}{2}ax^2$ or bx for their a, b and c .

Condone invisible brackets in the log term as long as there is a recovery when substituting limits.

A1ft $\int ax + b + \frac{c}{x-1} dx = \frac{1}{2}ax^2 + bx + c \ln(x-1)$. Follow through on their a, b and c . Condone a spurious integration symbol and dx after integration.

dM1 Dependent on the first M1. Substitutes in both limits and subtracts. Condone missing brackets around the expression involving the lower limit.

A1 $126 + 4 \ln 4$ or $126 + 8 \ln 2$ or any equivalent involving a single log term. Withhold this mark if a spurious integration symbol or dx features in their final answer. Isw after a correct expression.

Question Number	Scheme	Marks
4	$\log_{10} h = 2.4 - 0.25 \log_{10} m$	
(a)	$\log_{10} h = 2.4 - 0.25 \log_{10} 3 \Rightarrow h = 10^{2.4 - 0.25 \log_{10} 3}$ $\Rightarrow h = 191$	M1 A1 (2)
(b)	Example: One correct law $\log_{10} h = 2.4 + \log_{10} m^{-0.25}$ Full method in forming an equation linking h and m, e.g. $h = 10^{2.4} \times m^{-0.25}$ $\Rightarrow h = \frac{251}{m^{0.25}}$	M1 dM1 A1 (3)
(c)	The resting heart rate (in beats per minute) for (a mammal of mass) 1 kg	B1 (1) (6 marks)

- (a)
- M1 Substitutes $m = 3$ into the given equation and uses the correct order of operations to find h . Can be implied by a correct value for h .
- A1 awrt 191
- (b)
- M1 Makes a first step towards achieving an answer. Sight of a correct rule or law used. Will usually be awarded for one of:
- Application of a power rule e.g. $-0.25 \log_{10} m \rightarrow \log_{10} m^{-0.25}$
 - An attempt to make h the subject. E.g. $\log_{10} h = 2.4 - 0.25 \log_{10} m \rightarrow h = 10^{2.4 - 0.25 \log_{10} m}$
 - Both of the above applied at once, e.g. $\log_{10} h = 2.4 - 0.25 \log_{10} m \rightarrow h = \frac{10^{2.4}}{m^{0.25}}$ or $10^{2.4} \times m^{-0.25}$
- In this case, M1 dM1 are scored together.
- dM1 Dependent on the first M1. Full and complete method to make h the subject, with logs being correctly removed, e.g. $\log_{10} h = 2.4 + \log_{10} m^{-0.25} \Rightarrow h = 10^{2.4} \times m^{-0.25}$
- A1 Achieves $h = \frac{251}{m^{0.25}}$ with at least one intermediate step (see M1) between the given equation and the final answer. Accept $\frac{1}{4}$ or 0.250 in place of 0.25 and allow awrt 251. Do not accept $p = 251, q = 0.25$ for this mark without seeing the full equation.
- Note:** It is possible to score 000 in (b) despite a numerator of 251 if an incorrect method is used.
- Note:** Allow full marks for part (b) if full working is shown correctly in (a).
- SC:** Award SC110 for use of $m = 3$ in part (a), and making h the subject, reaching $h = \frac{10^{2.4}}{3^{1/4}}$ and then writing down $p = 251, q = 0.25$ in part (b).
- (c)
- B1 “The (resting) heart rate (in beats per minute) for (a mammal of mass) 1 kg”. Also accept “The beats per minute for (a mammal of mass) 1 kg.”

Question Number	Scheme	Marks
5 (a)	$ff(x) = \frac{2 \times \left(\frac{2x+16}{x-4} \right) + 16}{\left(\frac{2x+16}{x-4} \right) - 4}, \frac{2 \times (2x+16) + 16(x-4)}{(2x+16) - 4(x-4)}, = \frac{10x-16}{-x+16}$	M1, dM1, A1 (3)
(b)	$\frac{2x+16}{x-4} = 12 \Rightarrow 10x = 64 \Rightarrow x = 6.4$	M1 A1 (2)
(c)	$\frac{2 \ln a + 16}{\ln a - 4} = \ln a \Rightarrow (\ln a)^2 - 6 \ln a - 16 = 0$ $\Rightarrow (\ln a - 8)(\ln a + 2) = 0 \Rightarrow \ln a = 8, -2$ $\Rightarrow a = e^{-2}, e^8$	M1 dM1 A1 (3) 8 marks

(a)

M1 Attempts to fully substitute $f(x)$ for x in $\frac{2x+16}{x-4}$. Condone **one** slip as long as the intention is clear and there are two substitutions of $f(x)$ for x .

dM1 Dependent on the first M1. Correct attempt to form a single fraction (see scheme) by multiplying two terms in the numerator and two terms in the denominator by $(x-4)$

A1 $\frac{10x-16}{-x+16}$ or exact simplified equivalent

(b)

M1 Attempts to solve $f(x) = 12$ using correct order of operations (multiplying by $x-4$ and grouping terms in x).

Alternatively, reaches $f^{-1}(x) = \frac{ax+b}{cx+d}$ using correct order of operations and attempts to substitute

$x = 12$. Note: $f^{-1}(x) = \frac{4x+16}{x-2}$

A1 6.4 o.e.

(c) **Note:** If correct answers appear without a 3TQ, send to review.

M1 Sets up a 3TQ in $\ln a$. Must have three terms, but not necessarily on one side of the equation. Condone a four term quadratic with all terms on one side if it is followed by a correct attempt to solve. Condone missing “=0”.

dM1 Dependent on the first M1. Full attempt to solve a 3TQ in $\ln a$, using any valid method (including calculator), reaching two values, which do not necessarily have to be labelled $\ln a$. Allow a substitution, e.g. $x = \ln a$ or even $a = \ln a$.

A1 $a = e^8, e^{-2}$ (or $\frac{1}{e^2}$) and no others. Accept answers labelled as x or unlabelled. Apply isw (e.g. if exact answers are followed by decimals). Must follow M1 dM1.

Question Number	Scheme	Marks
7 (a)	$\left(\frac{11}{3}, -4\right)$	B1 B1 (2)
(b)	Attempts $3x - 11 - 4 = 8$ and $-3x + 11 - 4 = 8$ $x = -\frac{1}{3}, \frac{23}{3}$	M1, dM1 A1 (3)
(c)	$m \geq 3, \quad m = -\frac{12}{11}, \quad m < -3$	M1, A1, A1 (3)
(d)	$a = -4, \quad b = \frac{4}{3}$	B1ft, B1ft (2) (10 marks)

Note: Check working near to the question text or written on the diagram.

- (a)
B1 For one correct coordinate
B1 For $\left(\frac{11}{3}, -4\right)$. Allow missing brackets, or $x = \frac{11}{3}, y = -4$. Accept equivalent fractions for $\frac{11}{3}$
- (b)
M1 For a full attempt at either $3x - 11 - 4 = 8$ or $-3x + 11 - 4 = 8$. Must lead to a value for x .
dM1 Dependent on the first M1. For a full attempt at both $3x - 11 - 4 = 8$ and $-3x + 11 - 4 = 8$ leading to values for x .
A1 $x = -\frac{1}{3}, \frac{23}{3}$ only. If one of these has clearly been selected as a final answer and the other rejected, withhold this mark.
Alt
M1 Reaches $|3x - 11| = 12$, squares both sides and solves a quadratic equation. Must lead to a value for x .
dM1 Reaches two values for x following a valid method for solving their quadratic equation.
A1 $x = -\frac{1}{3}, \frac{23}{3}$. If one of these has clearly been selected as a final answer and the other rejected, withhold this mark.
- (c)
M1 Finds any of the three critical values for m . This need not be presented as an inequality.
A1 Two of $m \geq 3, \quad m = -\frac{12}{11}, \quad m < -3$. Do not give this mark if there are contradictions, e.g.
 $m = -\frac{12}{11}, m > -\frac{12}{11}$ unless the correct answer is clearly indicated. Accept set notation.
A1 All three of $m \geq 3, \quad m = -\frac{12}{11}, \quad m < -3$ with no contradictions (see above). Accept set notation.
- (d) **Note: If $a=...$ and $b=...$ are not stated, they could be embedded in $y = af(x-b)$. The stated values take precedence.**

B1ft Either $a = -4$ or $b = \frac{4}{3}$ but follow through on their vertex, so allow $a = \frac{16}{-4}$ or $b = 5 - \frac{11}{3}$

B1ft Both $a = -4$ and $b = \frac{4}{3}$ but follow through on their vertex, so allow $a = \frac{16}{-4}$ and $b = 5 - \frac{11}{3}$

Question Number	Scheme	Marks
8	$x = e^{2 \tan y} \Rightarrow \frac{dx}{dy} = e^{2 \tan y} \times 2 \sec^2 y$ $\Rightarrow \frac{dx}{dy} = 2x \left(1 + \tan^2 y \right) = 2x \left(1 + \left(\frac{\ln x}{2} \right)^2 \right)$ $\Rightarrow \frac{dy}{dx} = \frac{4}{2x \left(4 + (\ln x)^2 \right)}$ $\Rightarrow \frac{dy}{dx} = \frac{2}{x \left(4 + (\ln x)^2 \right)}$	B1 M1 M1 A1 (4) (4 marks)

Note: Condone incorrect notations for $(\ln x)^2$ such as $\ln x^2$ and $\ln^2 x$ in working, but not in the final answer.

B1 Correct expression for $\frac{dx}{dy}$ as in scheme or in an equivalent form

The following two M marks require their $\frac{dx}{dy}$ to be in the form $k e^{2 \tan y} \sec^2 y$.

M1 Either:

- Attempts the reciprocal of their $\frac{dx}{dy}$ to form an expression for $\frac{dy}{dx}$; OR
- Uses $\sec^2 y = 1 + \tan^2 y$ to get $\frac{dx}{dy}$ in terms of x .

M1 Both:

- Attempts the reciprocal of their $\frac{dx}{dy}$ to form an expression for $\frac{dy}{dx}$; AND
- Uses $\sec^2 y = 1 + \tan^2 y$ to get $\frac{dy}{dx}$ in terms of x .

A1 $\frac{dy}{dx} = \frac{2}{x \left(4 + (\ln x)^2 \right)}$. Condone missing $\frac{dy}{dx}$ on LHS as long as it appears somewhere in working and it is clear that it refers to their final answer.

Alt for the two M marks using cos

The following two M marks require their $\frac{dx}{dy}$ to be in the form $\frac{k e^{2 \tan y}}{\cos^2 y}$.

M1 Either:

- Attempts the reciprocal of their $\frac{dx}{dy}$ to form an expression for $\frac{dy}{dx}$; OR
- Forms an expression for $\cos^2 y$ using a valid method and gets $\frac{dx}{dy}$ in terms of x .

M1 Both:

- Attempts the reciprocal of their $\frac{dx}{dy}$ to form an expression for $\frac{dy}{dx}$; AND
- Forms an expression for $\cos^2 y$ using a valid method and gets $\frac{dy}{dx}$ in terms of x .

Alt using arctan. Note that B1 M1 M0 A0 is not possible via this route

$$\text{B1} \quad x = e^{2 \tan y} \Rightarrow y = \arctan\left(\frac{1}{2} \ln x\right) \Rightarrow \frac{dy}{dx} = \frac{1}{1 + \left(\frac{1}{2} \ln x\right)^2} \times \dots \text{ where } \dots \text{ could be } 1.$$

$$\text{M2} \quad \frac{dy}{dx} = \frac{1}{1 + \left(\frac{1}{2} \ln x\right)^2} \times \frac{1}{2x}$$

$$\text{A1} \quad \frac{dy}{dx} = \frac{2}{x \left(4 + (\ln x)^2\right)}$$

Alt using implicit differentiation

$$\text{B1} \quad x = e^{2 \tan y} \Rightarrow \ln x = 2 \tan y \Rightarrow \frac{1}{x} \frac{dx}{dy} = 2 \sec^2 y \quad \text{OR} \quad x = e^{2 \tan y} \Rightarrow \ln x = 2 \tan y \Rightarrow \frac{1}{x} = 2 \sec^2 y \frac{dy}{dx}$$

Other variations are possible. Then as main method

And compares coefficients of $\sin x \cos x$ and $\sin^2 x$ to reach two equations in R and α . In some cases, the two equations may not be explicitly stated, but implied by further work.

- A1 $R \cos \alpha = \frac{3}{2}$ and $R \sin \alpha = 3$ or equivalent equations. Note that a value of R may be embedded if it has already been calculated by inspection of coefficients or construction of a triangle. In some cases, the two equations may not be explicitly stated, but implied by further work.

The following two M marks are both dependent on the first two M marks, i.e. we require a correct method leading to $R \cos \alpha = \frac{3}{2}$ and $R \sin \alpha = 3$.

- ddM1 $R^2 = \left(\frac{3}{2}\right)^2 + 3^2 \Rightarrow R = \dots$ May be implied by their R value, even if R is inexact.

- ddM1 $\tan \alpha = \frac{3}{\frac{3}{2}} \Rightarrow \alpha = \dots$ but condone $\tan \alpha = \frac{\left(\frac{3}{2}\right)}{3} \Rightarrow \alpha = \dots$ Alternatively α can be found using $\sin \alpha = \frac{3}{R}$ or $\cos \alpha = \frac{3/2}{R}$ with their R .

- A1 $(h(x) = 5 + \frac{3}{2}\sqrt{5} \sin(2x + 1.107))$. A full expression must be given for $h(x)$, not just values of P , R and α . This expression must be seen in part (a).

(b) **Note: this mark can be scored following incorrect working in part (a).**

- B1ft $5 - \frac{3}{2}\sqrt{5} \leq h(x) \leq 5 + \frac{3}{2}\sqrt{5}$ o.e. allowing follow through on their P and R
 $\left[5 - \frac{3\sqrt{5}}{2}, 5 + \frac{3\sqrt{5}}{2}\right]$ and $\left\{h(x) : 5 - \frac{3\sqrt{5}}{2} \leq h(x) \leq 5 + \frac{3\sqrt{5}}{2}\right\}$ are suitable alternatives.

Condone y or h in place of $h(x)$ but not $f(x)$ or x .

(c) **Note: full marks can be scored in part (c) following incorrect working in part (a).**

- M1 Attempts to solve $2x + 1.107 = \frac{7\pi}{2}$ using the correct order of operations, leading to a value for x .
 Alternatively solves $\sin(2x + 1.107) = -1$ using the correct order of operations, and selects the second positive value of x .

Or differentiates to reach $2 \cos(2x + 1.107) = 0$ and solves to find the fourth positive solution.

- A1 $x = \text{awrt } 4.94$

Question Number	Scheme	Marks
10 (a)	$\left(\frac{dN_A}{dt}\right) = 900 \times 0.2e^{0.2 \times 5} = \text{awrt } 489 \text{ or } 180e$	M1, A1 (2)
(b)	States or implies that $P = 2\,000$ $11570 = 8000 + 2000e^{k \times 4} \Rightarrow 2000e^{4k} = 3570$ $\Rightarrow k = \text{awrt } 0.145$	B1 M1 dM1, A1 (4)
(c)	$8000 + 900e^{0.2T} = 8000 + "2000"e^{0.145T}$ $e^{(0.2 - "0.145")T} = \frac{"2000"}{900} \quad \text{or} \quad \ln(900e^{0.2T}) = \ln("2000"e^{0.145T})$ $\ln 900 + 0.2T = \ln "2000" + 0.145T$ $T = \frac{1}{(0.2 - "0.145")} \ln\left(\frac{"2000"}{900}\right)$ $T = 14.5$	M1 dM1 A1 (3) (9 marks)

(a) **Note: if a correct answer is seen without any working, please send to review.**

M1 $\frac{dN_A}{dt} = Ce^{0.2 \times 5} = \dots$ where $C \neq 900$. Withhold this mark if they substitute $t = 5$ before differentiation.
A1 awrt 489 or exact 180e. isw

(b)
B1 States or implies that $P = 2\,000$
M1 Proceeds to $Ae^{4k} = B$ where $A \times B > 0$
dM1 Dependent on previous M1. Correct attempt to solve using ln, following the correct order of operations. Proceeding from $Ae^{4k} = B$ to a value for k with no ln work is dM0 A0.
A1 $k = \text{awrt } 0.145$. Exact answer only is A0.

(c) **Condone use of t in place of T throughout this part.**

M1 Cancels 8000 on each side, then **either**:

- uses correct index work to achieve an equation in $e^{(0.2 - "0.145")T}$ that could be rearranged to the form $e^{(0.2 - "0.145")T} = K$ where $K > 0$; **or**
- takes ln of both sides and uses the log addition law on both sides, giving an equation involving two terms in T and at least one constant term.

dM1 Dependent on previous M1. Correct ln work leading to a positive value or positive exact expression for T . Proceeding from $e^{(0.2 - "0.145")T} = K$ to a value for T with no ln work is dM0 A0.
A1 $T = \text{awrt } 14.5$. Exact answer only is A0.

Pearson Edexcel International Advanced Level

Thursday 22 January 2026

Morning (Time: 1 hour 30 minutes)

Paper

reference

WMA14/01A

Mathematics

International Advanced Level

Pure Mathematics P4

Question paper

You must have:

Answer book (sent separately).

Do not return this question paper with the answer book.

Turn over ►

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Pearson

1.

$$f(x) = \frac{27}{(3-5x)^2} \quad |x| < \frac{3}{5}$$

- (a) Find the series expansion of $f(x)$, in ascending powers of x , up to and including the term in x^3

Give each coefficient in its simplest form.

(4)

Using your answer to part (a), find the series expansion in ascending powers of x , up to and including the term in x^3 , of

(b) $g(x) = \frac{27}{(3+5x)^2} \quad |x| < \frac{3}{5}$ (1)

(c) $h(x) = \frac{27}{(3-x)^2} \quad |x| < 3$ (2)

(Total for Question 1 is 7 marks)

2.

In this question you must show all stages of your working.
Solutions relying on calculator technology are not acceptable.

A curve has equation

$$4x^2 - y^2 + 2xy + 5 = 0$$

Given that

- points P and Q lie on the curve
- $\frac{dy}{dx} = 2$ at P and at Q

find the coordinates of P and Q .

(7)

(Total for Question 2 is 7 marks)



3. The height, h metres, of a shrub, t years after it was planted, is modelled by the differential equation

$$\frac{dh}{dt} = \frac{2h^{\frac{3}{2}}}{5t^2} \quad t > 0$$

Given that $h = 1$ when $t = 1$

- (a) solve the differential equation to show that

$$h = \frac{at^2}{(1 + bt)^2}$$

where a and b are constants to be found.

(6)

- (b) Hence find, according to the model, the limit of the height of the shrub.

(2)

(Total for Question 3 is 8 marks)

4. **In this question you must show all stages of your working.
Solutions relying on calculator technology are not acceptable.**

Find

$$\int_1^3 \frac{3x^2 + 8}{x^2 - 4x} dx$$

giving the answer in the form $a + b \ln 3$ where a and b are constants.

(7)

(Total for Question 4 is 7 marks)

5. With respect to a fixed origin O , the lines l_1 and l_2 are given by the equations

$$l_1 : \mathbf{r} = \begin{pmatrix} 2 \\ 1 \\ 3 \end{pmatrix} + \lambda \begin{pmatrix} -2 \\ 1 \\ 4 \end{pmatrix}$$

$$l_2 : \mathbf{r} = \begin{pmatrix} 10 \\ c \\ 3 \end{pmatrix} + \mu \begin{pmatrix} a \\ b \\ -2 \end{pmatrix}$$

where a , b and c are constants and λ and μ are scalar parameters.

Given that

- l_1 and l_2 meet when $\lambda = -2$
- l_1 and l_2 are perpendicular

find the value of a , the value of b and the value of c .

(6)

(Total for Question 5 is 6 marks)

6.

**In this question you must show all stages of your working.
Solutions relying on calculator technology are not acceptable.**

(a) Use algebraic integration and the substitution $u = 2x - 1$ to show that

$$\int_2^5 \frac{(3x + 2)^2}{2x - 1} dx = 72 + \frac{49}{8} \ln 3$$

(6)

The curve C has equation

$$y = \frac{3x + 2}{2\sqrt{2x - 1}} \quad x > 1$$

The finite region R is bounded by C , the x -axis and the lines with equations $x = 2$ and $x = 5$

The region R is rotated through 2π radians about the x -axis to form a solid of revolution.

(b) Using the result from part (a), find the exact value of the volume of the solid generated.

(2)

(Total for Question 6 is 8 marks)



7.

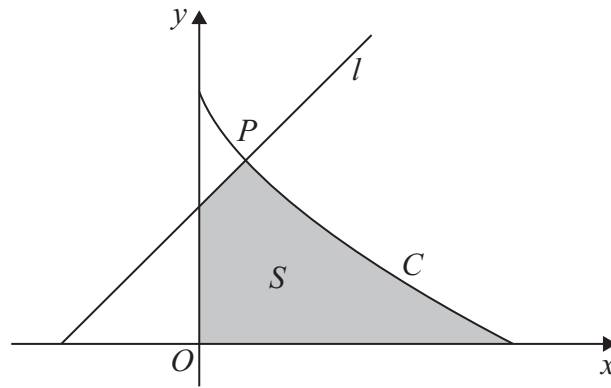


Figure 1

**In this question you must show all stages of your working.
Solutions relying on calculator technology are not acceptable.**

Figure 1 shows a sketch of the curve C with parametric equations

$$x = 8 \cos^3 \theta \quad y = 6 \sin^2 \theta \quad 0 \leq \theta \leq \frac{\pi}{2}$$

Given that the point P lies on C and has parameter $\theta = \frac{\pi}{3}$

(a) find the coordinates of P .

(2)

The line l is the normal to C at P .

(b) Find an equation for l in the form $y = mx + c$, where m and c are constants.

(5)

The finite region S , shown shaded in Figure 1, is bounded by the curve C , the line l , the y -axis and the x -axis.

(c) Show that the area of S is given by

$$4 + 144 \int_0^{\frac{\pi}{3}} (\sin \theta \cos^2 \theta - \sin \theta \cos^4 \theta) d\theta$$

(6)

(d) Hence, using algebraic integration, find the exact area of S .

(3)

(Total for Question 7 is 16 marks)

8. (a) Factorise $4p^2 - q^2$ (1)

(b) Hence, prove by contradiction, that there are no positive integers p and q such that

$$4p^2 - q^2 = 46$$

(4)

(Total for Question 8 is 5 marks)

9. $ABCD$ is a parallelogram with AB parallel to DC and AD parallel to BC .
The position vectors of A , B , C and D relative to a fixed origin O are
 $\mathbf{a}$, $\mathbf{b}$, $\mathbf{c}$ and $\mathbf{d}$ respectively.

Given that

$$\mathbf{a} = \mathbf{i} + \mathbf{j} - 2\mathbf{k} \quad \mathbf{b} = 3\mathbf{i} - \mathbf{j} + 6\mathbf{k} \quad \mathbf{c} = -\mathbf{i} + 3\mathbf{j} + 6\mathbf{k}$$

(a) find the position vector $\mathbf{d}$, (3)

(b) find the angle between the sides AB and BC of the parallelogram, (4)

(c) find the area of the parallelogram $ABCD$. (2)

The point E lies on the line through the points C and D , so that D is the midpoint of CE .

(d) Use your answer to part (c) to find the area of the trapezium $ABCE$. (2)

(Total for Question 9 is 11 marks)

TOTAL FOR PAPER IS 75 MARKS



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Please check the examination details below before entering your candidate information

Candidate surname		Other names	
Centre Number		Candidate Number	

Pearson Edexcel International Advanced Level

Thursday 22 January 2026

Morning (Time: 1 hour 30 minutes)

Paper reference **WMA14/01A**

Mathematics

International Advanced Level

Pure Mathematics P4

Answer Book

You must have:
 Question paper (sent separately).
 Mathematical Formulae and Statistical Tables (Yellow), calculator.

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 9 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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Question 1

Write the answer to Question 1 on these 2 pages

DO NOT WRITE IN THIS AREA

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DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA

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(Total for Question 1 is 7 marks)



Question 2

Write the answer to Question 2 on these 2 pages

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(Total for Question 2 is 7 marks)



Question 3

Write the answer to Question 3 on these 4 pages

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Question 3 continued

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Question 4

Write the answer to Question 4 on these 4 pages

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Question 4 continued

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Question 5

Write the answer to Question 5 on these 2 pages

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DO NOT WRITE IN THIS AREA

(Total for Question 5 is 6 marks)



Question 6

Write the answer to Question 6 on these 4 pages

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Question 6 continued

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(Total for Question 6 is 8 marks)



Question 7

Write the answer to Question 7 on these 4 pages

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Question 7 continued

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(Total for Question 7 is 16 marks)



Question 8

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(Total for Question 8 is 5 marks)



Question 9

Write the answer to Question 9 on these 3 pages

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DO NOT WRITE IN THIS AREA



Question 9 continued

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DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(Total for Question 9 is 11 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (Results)

January 2026

Pearson Edexcel International Advanced Level in
Pure Mathematics P4
WMA14/01A

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January 2026

Question Paper Log Number P87595A

Publication Code WMA14_01_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN:

- bod – benefit of doubt
- ft – follow through
 - the symbol $\surd$ will be used for correct ft
- cao – correct answer only
- cso – correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC – special case
- oe – or equivalent (and appropriate)
- d... or dep – dependent
- indep – independent
- dp – decimal places
- sf – significant figures
- * – The answer is printed on the paper or ag- answer given

- $\square$ or d... – The second mark is dependent on gaining the first mark
4. All A marks are 'correct answer only' (cao), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.
 5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. If you are using the annotation facility on ePEN, indicate this action by 'MR' in the body of the script.
 6. If a candidate makes more than one attempt at any question:
 - a) If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - b) If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
 7. Ignore wrong working or incorrect statements following a correct answer.

General Principles for Pure Mathematics Marking

(NB specific mark schemes may sometimes override these general principles)

Method mark for solving 3 term quadratic:

1. Factorisation

$(x^2 + bx + c) = (x + p)(x + q)$, where $|pq| = |c|$ leading to $x = \dots$

$(ax^2 + bx + c) = (mx + p)(nx + q)$, where $|pq| = |c|$ and $|mn| = |a|$ leading to $x = \dots$

2. Formula

Attempt to use correct formula (with values for a, b and c)

3. Completing the square

Solving $x^2 + bx + c = 0$: $(x \pm \frac{b}{2})^2 \pm q \pm c$, $q \neq 0$ leading to $x = \dots$

Method marks for differentiation and integration:

1. Differentiation

Power of at least one term decreased by 1 ($x^n \rightarrow x^{n-1}$)

2. Integration

Power of at least one term increased by 1 ($x^n \rightarrow x^{n+1}$)

Use of a formula

Where a method involves using a formula that has been learnt, the advice given in recent examiners' reports is that the formula should be quoted first.

Normal marking procedure is as follows:

Method mark for quoting a correct formula and attempting to use it, even if there are small mistakes in the substitution of values.

Where the formula is not quoted, the method mark can be gained by implication from correct working with values, but may be lost if there is any mistake in the working.

Exact answers

Examiners' reports have emphasised that where, for example, an exact answer is asked for, or working with surds is clearly required, marks will normally be lost if the candidate resorts to using rounded decimals.

Answers without working

The rubric says that these may not gain full credit. Individual mark schemes will give details of what happens in particular cases. General policy is that if it could be done "in your head", detailed working would not be required. Most candidates do show working, but there are occasional awkward cases and if the mark scheme does not cover this, please contact your team leader for advice.

Question Number	Scheme	Marks
1(a)	$27(3-5x)^{-2} = 27 \times \frac{1}{9} \left(1 - \frac{5}{3}x\right)^{-2} \text{ o.e. } 3 \times \left(1 - \frac{5}{3}x\right)^{-2}$ $= (3) \left(1 + (-2) \left(-\frac{5}{3}x\right) + \frac{(-2)(-3)}{2!} \left(-\frac{5}{3}x\right)^2 + \frac{(-2)(-3)(-4)}{3!} \left(-\frac{5}{3}x\right)^3 + \dots \right)$ $= 3 + 10x + 25x^2 + \frac{500}{9}x^3 + \dots$	B1 M1, A1 A1 (4)
(b)	$27(3+5x)^{-2} = 27(3+5x)^{-2} = 3 - 10x + 25x^2 - \frac{500}{9}x^3 + \dots$	B1ft (1)
(c)	$27(3-x)^{-2} = 3 + \frac{10}{5}x + \frac{25}{5^2}x^2 + \frac{500}{9 \times 5^3}x^3 = 3 + 2x + x^2 + \frac{4}{9}x^3 + \dots$	M1A1 (2)
Alt(a)	$27(3-5x)^{-2} = 27 \left(3^{-2} + (-2) \times 3^{-3} \times (-5x) + \frac{(-2)(-3)}{2} \times 3^{-4} \times (-5x)^2 + \frac{(-2)(-3)(-4)}{3!} (3)^{-5} (-5x)^3 \right)$ $= 27 \left(\frac{1}{9} + \frac{10x}{27} + \frac{25x^2}{27} + \frac{500x^3}{243} + \dots \right)$ $= 3 + 10x + 25x^2 + \frac{500}{9}x^3 + \dots$	B1 M1 A1 A1 (7 marks)

(a)

B1: Correctly takes out a factor and proceeds to $3 \times \left(1 - \frac{5}{3}x\right)^{-2}$ which may be unsimplified. May be implied

M1: Expands $(1+kx)^{-2}$ $k \neq \pm 1$ to give the correct structure for 3rd or 4th term

$$\frac{(-2)(-3)}{2}(kx)^2 \text{ or } \frac{(-2)(-3)(-4)}{3!}(kx)^3 \text{ with or without the brackets around } kx$$

A1: A correct simplified or unsimplified form of the expansion of $\left(1 - \frac{5}{3}x\right)^{-2}$ May be implied by their final answer. Allow terms to be listed, which may be on different lines for this mark.

A1: Fully correct simplified expansion $= 3 + 10x + 25x^2 + \frac{500}{9}x^3$ with all terms written on one line. Do not isw if they e.g. multiply through by 9

Alt(a)

B1: For the first term $27(3^{-2} + \dots$

M1: For correct structure for 3rd or 4th terms $\frac{(-2)(-3)}{2} \times 3^{-4} \times (-5x)^2$ or $\frac{(-2)(-3)(-4)}{3!} (3)^{-5} (-5x)^3$ with or without the brackets around $-5x$

A1A1: See main scheme notes

In both parts ignore earlier workings if it is a restart and just mark their final answer

(b)

B1ft: $3 - 10x + 25x^2 - \frac{500}{9}x^3$ or if (a) was incorrect either score for a correct answer or follow through on their part (a) i.e. $A + Bx + Cx^2 + Dx^3 \rightarrow A - Bx + Cx^2 - Dx^3$

(c)

M1: Comparing their final answer line in (c) to their answer to part (a) of the form $A + Bx + Cx^2 + Dx^3$ look for at least two of $B \rightarrow \frac{B}{5}$ or $C \rightarrow \frac{C}{25}$ or $D \rightarrow \frac{D}{125}$

A1: $3 + 2x + x^2 + \frac{4}{9}x^3$ **which can only be scored following full marks in (a)**

Question Number	Scheme	Marks
2.	$\cancel{\left(\frac{dy}{dx}\right)} = 8x - 2y \frac{dy}{dx} + 2x \frac{dy}{dx} + 2y = 0$ Sets $\frac{dy}{dx} = 2, \Rightarrow 8x - 4y + 4x + 2y = 0 \Rightarrow y - 6x = 0$ Sub "$y = 6x$" into $4x^2 - y^2 + 2xy + 5 = 0$ $\Rightarrow 4x^2 - 36x^2 + 12x^2 + 5 = 0 \Rightarrow x^2 = \frac{1}{4} \Rightarrow x = \pm \frac{1}{2}$ $\left(\frac{1}{2}, 3\right) \quad \left(-\frac{1}{2}, -3\right)$	<u>M1</u> <u>B1</u> A1 M1 dM1, A1 A1 (7 marks) (7)

M1: Differentiates $4x^2 - y^2 + 5$ wrt x to obtain $Ax + By \frac{dy}{dx}$ (inc. $5 \rightarrow 0$) Condone $\frac{dy}{dx} = \dots$ at start

B1: Sight of $\frac{d}{dx}(2xy) = 2x \frac{dy}{dx} + 2y$ oe e.g. $2\left(y + x \frac{dy}{dx}\right)$

A1: $8x - 2y \frac{dy}{dx} + 2x \frac{dy}{dx} + 2y = 0$ oe e.g. $\frac{dy}{dx} = \frac{-8x - 2y}{2x - 2y}$ oe The $=0$ may be implied by further work

M1: Sets $\frac{dy}{dx} = 2$ in their differentiated function in x and y and proceeds to a linear equation in x and y .

Brackets do not need to be multiplied out. Condone arithmetical slips in their rearrangement.

There must have been some attempt at implicit differentiation so look for at least a $\dots y \frac{dy}{dx}$ or $\dots x \frac{dy}{dx}$

term in their differentiated function – not just e.g. $\frac{dy}{dx} = 8x - 2y + 2$

Note: $\frac{dy}{dx} = 0 \Rightarrow y = -4x \Rightarrow 20x^2 = 5 \Rightarrow x = \pm \frac{1}{2}$ scores M0dM0A0A0

dM1: Dependent on the previous method mark only. For this mark:

- substitutes their $y = 6x$ or $x = \frac{y}{6}$ into the equation of curve C to form an equation in one variable
- reaches a **two-term quadratic** $Ax^2 = B$ oe or $Ay^2 = B$ oe for any values of A or B where $A \times B > 0$:

e.g. $(4x^2 - 36x^2 + 12x^2 + 5 = 0 \Rightarrow) \quad 20x^2 = 5$

e.g. $\left(4\left(\frac{y}{6}\right)^2 - y^2 + \frac{y^2}{3} + 5 = 0 \Rightarrow\right) \quad \frac{5}{9}y^2 = 5$

but condone slips in the working. Also allow if both terms are on one side of an equation. The $= 0$ may be implied by further work.

- solves their **two term quadratic** to find a value for x or y (you do not need to be check this)

It cannot be implied by a correct value for x or y .

A1: Either **one correct pair** of coordinates **or both x or both y values**. It must follow evidence of a two term quadratic. If it is a pair of coordinates, condone the omission of brackets.

A1: **Both** $\left(\frac{1}{2}, 3\right)$ and $\left(-\frac{1}{2}, -3\right)$ (two answers correct following a correct quadratic in x or y only can score dM1A1A1) Any extra solutions (obtained by substituting the variable found first into the quadratic, instead of the linear equation for example) result in A0.

Unsimplified answers lose the final A mark e.g. $\left(\frac{\sqrt{5}}{\sqrt{20}}, 3\right)$ and $\left(-\frac{\sqrt{5}}{\sqrt{20}}, -3\right)$

Allow $(0.5, 3)$ and $(-0.5, -3)$ and condone without brackets.

Coordinates may be written separately if pairing is clear but a wrong pairing or just stating the x coordinates together and the y coordinates together is A0.

i.e. $x = \frac{1}{2}, y = 3$ and $x = -\frac{1}{2}, y = -3$ is acceptable but $x = \pm \frac{1}{2}, y = \pm 3$ is not sufficient

Question Number	Scheme	Marks
3	$\frac{dh}{dt} = \frac{2h^{\frac{3}{2}}}{5t^2}$	
(a)	$\int \frac{1}{2h^{\frac{3}{2}}} dh = \int \frac{1}{5t^2} dt$ $-h^{-\frac{1}{2}} = -\frac{1}{5}t^{-1} (+c) \text{ oe}$ $-(1)^{-\frac{1}{2}} = -\frac{1}{5}(1)^{-1} + c \Rightarrow c = \dots \left(\text{e.g.} = -\frac{4}{5} \right)$ e.g. $-h^{-\frac{1}{2}} = -\frac{1}{5}t^{-1} - \frac{4}{5} \Rightarrow \frac{1}{\sqrt{h}} = \frac{1}{5t} + \frac{4}{5} = \frac{1+4t}{5t} \Rightarrow \sqrt{h} = \frac{5t}{1+4t} \Rightarrow h = \dots$ or $\frac{1}{\sqrt{h}} = \frac{1}{5t} + \frac{4}{5} \Rightarrow 5t = \sqrt{h}(1+4t) \Rightarrow h = \dots$ $h = \frac{25t^2}{(1+4t)^2} \quad (a = 25, b = 4)$	B1 M1, A1 M1 M1 A1
		(6)
(b)	Max $h = \frac{25}{16}$ or 1.5625 (m)	M1, A1ft
		(2)
		Total 8

(a)

B1: Correct separation of variables (allow equivalent forms) There is no need to see the integral signs but the dh and dt must be present and in the correct positions or may be implied by further work.

M1: Reaches $\alpha h^{-\frac{1}{2}} = \beta t^{-1} (+c)$ oe

A1: Correct integration with or without $+c$ Accept other correct equivalent forms of $-h^{-\frac{1}{2}} = -\frac{1}{5}t^{-1} (+c)$

e.g. $-10h^{-\frac{1}{2}} = -2t^{-1} (+c)$

Note that if they do not have a constant of integration then no further marks can be scored

M1: Uses given conditions at an appropriate point in their integrated form (however poor) to find a constant of integration for their equation in h and t . Alternatively uses $\left[-h^{-\frac{1}{2}} \right]_1^h = \left[-\frac{1}{5}t^{-1} + c \right]_1^t$

Allow stating $h = 1, t = 1 \Rightarrow c = \dots$ or equivalent but if a value for c is stated without any method seen then you will need to check this on your calculator.

M1: Uses correct algebra starting from their integrated expression of the form $\alpha h^{-\frac{1}{2}} = \beta t^{-1} + c$ oe to make h the subject . Look for an attempt that has

- a single fraction being formed before “inverting” oe. Do not allow attempts where the candidate inverts each term. Alternatively they may multiply throughout and factorise. Condone sign slips only in their manipulation
- a correct attempt to square i.e. each side is squared rather than each term. Condone the slip e.g. $5t^2$ instead of $25t^2$

A1: cao $h = \frac{25t^2}{(1+4t)^2} \quad (a = 25, b = 4)$

(b)

M1: Max $h = \frac{\text{Their } a}{\text{Their } b^2}$ from an answer to (a) in the form $h = \frac{at^2}{(c+bt)^2} \quad a > 0$ or allow from an equation of the required form stated in this part.

Implied by 1.56 (i.e. answer to 3sf)

A1ft: $\frac{25}{16}$ (m) or exact equivalent e.g. or 1.5625 (m) following through on their $h = \frac{"25"t^2}{(1+"4"t)^2}$ oe $a > 0$

Condone e.g. $h \leq \frac{25}{16}$ or $0 < h < \frac{25}{16}$ or any other correct notation including interval notation

e.g. $\left(0, \frac{25}{16}\right), \left[0, \frac{25}{16}\right]$ Units not required but if given they must be correct.

Question number	Scheme	Marks
4	For fractions $\frac{A}{x} + \frac{B}{x-4} = -\frac{2}{x} + \frac{14}{x-4}$ $\frac{3x^2+8}{x^2-4x} = 3 - \frac{2}{x} + \frac{14}{x-4}$ $\int_1^3 \frac{3x^2+8}{x^2-4x} dx = \int_1^3 3 - \frac{2}{x} + \frac{14}{x-4} dx = \left[3x - 2 \ln x + 14 \ln x-4 \right]_{(x=1)}^{(x=3)}$ $= 9 - 2 \ln 3 - 3 - 14 \ln 3$ $= 6 - 16 \ln 3$	M1 A1 B1ft M1 A1ft dM1 A1 (7) [7 marks]

M1: Attempts to write in partial fractions form and finds values A **and** B for $\frac{A}{x} + \frac{B}{x-4}$ $A, B \neq 0$ Note this may be scored without the "3". They cannot just state values for A and B for this mark – it must be written in partial fraction form.

A1: $-\frac{2}{x} + \frac{14}{x-4}$ oe

B1ft: Correct partial fraction form $\frac{3x^2+8}{x^2-4x} = 3 - \frac{2}{x} + \frac{14}{x-4}$ oe such as $3 - \frac{2}{x} - \frac{14}{4-x}$ **ft on their non-zero values for A and B .** Condone e.g. $\frac{3x^2+8}{x^2-4x} = 3 + -\frac{2}{x} + \frac{14}{x-4}$

Allow use of the letters " A " and " B " instead of numerical values i.e. $3 + \frac{A}{x} + \frac{B}{4-x}$

Also allow this mark to be scored for $3 + \frac{12x+8}{x^2-4x}$ or ft on their remainder $Cx + D$ both non-zero.

M1: For $\int \frac{1}{x} dx \rightarrow \ln x$ **and** $\int \frac{1}{x-4} dx \rightarrow \ln|x-4|$ but allowing $\ln(x-4)$ and $-\ln(4-x)$. Condone invisible brackets for this mark.

A1ft For $\int 3 - \frac{2}{x} + \frac{14}{x-4} dx \rightarrow 3x - 2 \ln|x| + 14 \ln|x-4|$ oe following through on their non-zero coefficients. $x-4$ requires modulus signs and/or brackets unless implied by later work (condone not around x)

E.g. allow $\int 3 - \frac{2}{x} - \frac{14}{4-x} dx \rightarrow 3x - 2 \ln x + 14 \ln(4-x)$

dM1: Uses both limits 3 and 1, subtracts either way round and proceeds to the expression $P + Q \ln 3$ where P and Q are rational and non-zero. Must have simplified to this form.

It cannot be implied by $6 - 16 \ln 3$ on its own. We must see some evidence of limits being used which as a minimum is the limits substituted in the integrand.

It is dependent on the previous method mark.

A1: $6 - 16 \ln 3$ **following all previous marks scored**

Special Case:

Some candidates know to use PF but fail to see it is an improper fraction.

Note that use of $3x^2 + 8 \equiv A(x-4) + Bx$ would result in $A = -2, B = 14$ via substitution. The solution may appear as:

$$\begin{aligned}\frac{3x^2 + 8}{x^2 - 4x} &= \frac{14}{x-4} - \frac{2}{x} \\ \int_1^3 \frac{3x^2 + 8}{x^2 - 4x} dx &= \int_1^3 \frac{14}{x-4} - \frac{2}{x} dx = \left[14 \ln|x-4| - 2 \ln|x| \right]_{(x=1)}^{(x=3)} \\ &= 14 \ln 1 - 2 \ln 3 - (14 \ln 3 - 2 \ln 1) = -16 \ln 3\end{aligned}$$

This potentially will score M1A1B0M1A0dM0A0 for 3 out of 7

However, a candidate who correctly adds 3 to their partial fraction can potentially score full marks using the main scheme – send to review if unsure.

Question Number	Scheme	Marks
5	Point of intersection is $(6, -1, -5)$ or the value of $\mu = 4$ Uses their μ and i components $10 + \mu a = "6"$ to find a $a = -1$ Uses perpendicular vectors $\Rightarrow \begin{pmatrix} -2 \\ 1 \\ 4 \end{pmatrix} \cdot \begin{pmatrix} a \\ b \\ -2 \end{pmatrix} = 0 \Rightarrow -2a + b - 8 = 0 \Rightarrow b = (6)$ Uses j component "$c + \mu b$" = "-1" $\Rightarrow c + 24 = -1 \Rightarrow c = (-25)$ $b = 6, c = -25$	B1 M1 A1 dM1 ddM1 A1 (6) [6 marks]

B1: States or uses the point of intersection as $(6, -1, -5)$ or the value of $\mu = 4$ Allow values or vectors seen or used or implied. These values are sometimes embedded within the work e.g. $2 - 2(-2)$, $1 - 2$ and $3 + 4(-2)$

M1: A full method to find " a ". This involves

- using the **k** component of l_2 to find μ
- followed by the **i** component to find a

A1: $a = -1$ May be seen or implied by further work.

dM1: A full method of finding " b ".

This involves using the fact that $\begin{pmatrix} -2 \\ 1 \\ 4 \end{pmatrix} \cdot \begin{pmatrix} a \\ b \\ -2 \end{pmatrix} = 0$ and using their value of a . Look for at least 2 correct products or implied by a correct value for b .

Condone arithmetical slips. It is dependent on the previous method mark.

ddM1: A full method of finding " c " using the **j** component. For using their values for a , b and μ and proceeding from " $c + \mu b$ " = "-1" to a value for c . If just a value for c is stated you may have to check using their values for a , b and μ . It is dependent on the previous two method marks.

A1: $b = 6, c = -25$

(Note a common misread is $\lambda = 2$ and will lead to a point of intersection $(-2, 3, 11)$ of values of $\mu = -4$, $a = 3$, $b = 14$, $c = 59$ apply the misread rule in situations like this so max score will be B0M1A0dM1ddM1A1 – send to review if unsure)

If they attempt to find c before b then send to review (unless fully correct and scores full marks)

Question Number	Scheme	Marks
6(a)	$\frac{du}{dx} = 2 \text{ or } \frac{dx}{du} = \frac{1}{2}$	B1
	$\int \frac{(3x+2)^2}{2x-1} dx = \int \frac{\left(3\frac{u+1}{2} + 2\right)^2}{u} \frac{1}{2} du$	M1
	$= \frac{1}{8} \int \left(9u + 42 + \frac{49}{u}\right) du$	dM1
	$= \frac{1}{8} \left[\frac{9u^2}{2} + 42u + 49 \ln u \right]$	A1
	$= \frac{1}{8} \left[\frac{9(9)^2}{2} + 42(9) + 49 \ln(9) - \left(\frac{9(3)^2}{2} + 42(3) + 49 \ln(3) \right) \right]$	M1
	$72 + \frac{49}{8} \ln 3^*$	A1*
		(6)
(b)	$V = \pi \int \left(\frac{3x+2}{2\sqrt{2x-1}} \right)^2 dx = \frac{\pi}{4} \int \frac{(3x+2)^2}{2x-1} dx$	M1
	$= \pi \left(18 + \frac{49}{32} \ln 3 \right)$	A1
		(2)
		Total 8

(a) Note if no algebraic integration is seen then max score B1M1dM1A0M0A0*

Correct answer with no working scores 0 marks

You may see other credit-worthy methods e.g. partial fractions followed by substitution – send to review

B1: $\frac{du}{dx} = 2$ o.e such as $\frac{dx}{du} = \frac{1}{2}$ or $du = 2dx$

M1: An attempt at a complete substitution in terms of u Look for $A \int \frac{(\text{linear expression in } u)^2}{u} (du)$ $A \neq 0$

Condone slips. The du may be implied by further work.

dM1: Proceeds to the form $\int \left(\alpha u + \beta + \frac{\gamma}{u} \right) (du)$ oe which may be unsimplified $\alpha, \beta, \gamma \neq 0$. It is dependent on the previous method mark.

A1: $\frac{1}{8} \left[\frac{9u^2}{2} + 42u + 49 \ln u \right]$ oe (note may see e.g. $\frac{49}{8} \ln 8u$ for $\frac{49}{8} \ln u$) May be unsimplified

M1: Correct use of changed limits (3 and 9) within their integrand in ' u ' of the form $pu^2 + qu + r \ln ku$ or $x = 2$ and $x = 5$ within the integral of this form where ' u ' has been changed back to $2x - 1$

It cannot be for proceeding directly to the given answer which is M0 – must see some evidence of the use of limits.

A1*: Obtains the given answer with no errors seen and all previous marks scored. Condone invisible brackets to be recovered provided it is before the final answer. Do not penalise incorrect limits on the integral in their working, provided the correct values were substituted in to their integrand.

$$\text{Note} = \frac{1}{8} \left[\frac{9u^2}{2} + 42u + 49 \ln u \right]_3^9 = \text{given answer then M0A0*}$$

(b)

M1: $V = K\pi \times \text{answer to (a)}$. Condone $K = 1$ Implied by $K\pi \times \left(72 + \frac{49}{8} \ln 3 \right)$

A1: Correct exact answer (allow equivalent exact forms) e.g. $\frac{\pi}{4} \left(72 + \frac{49}{8} \ln 3 \right)$ isw

Question Number	Scheme	Marks
7 (a)	(1, 4.5)	B1B1 (2)
(b)	Attempts $\frac{dy}{dx} = \frac{dy/d\theta}{dx/d\theta} = \frac{12 \sin \theta \cos \theta}{-24 \cos^2 \theta \sin \theta} = \left(-\frac{1}{2 \cos \theta}\right)$ Subs $\theta = \frac{\pi}{3}$ into $\frac{dy}{dx} \Rightarrow \frac{dy}{dx} = \dots (= -1)$ Uses gradient of normal with (1, 4.5) $\Rightarrow (y - 4.5) = 1(x - 1)$ $y = x + 3.5$	M1A1 dM1 ddM1 A1 (5)
(c)	Attempts $\int y \frac{dx}{d\theta} d\theta = \int 6 \sin^2 \theta \times -24 \cos^2 \theta \sin \theta d\theta$ Uses $\sin^2 \theta = 1 - \cos^2 \theta \Rightarrow \int y \frac{dx}{d\theta} d\theta = \int A(\cos^2 \theta \sin \theta - \cos^4 \theta \sin \theta) d\theta$ Area of trapezium = $\frac{1}{2}(3.5 + 4.5) = 4$ Attempts trapezium + area under curve = $\frac{1}{2}(3.5 + 4.5) - 144 \int_{\frac{\pi}{3}}^0 \sin^3 \theta \cos^2 \theta d\theta$ $\text{Area} = 4 + 144 \int_0^{\frac{\pi}{3}} (\sin \theta \cos^2 \theta - \sin \theta \cos^4 \theta) d\theta *$	M1A1 dM1 B1ft dM1 A1* (6)
(d)	$\text{Area} = 4 + 144 \left[-\frac{\cos^3 \theta}{3} + \frac{\cos^5 \theta}{5} \right]_0^{\frac{\pi}{3}} = 4 + 144 \left(\left(-\frac{1}{24} + \frac{1}{160} \right) - \left(-\frac{1}{3} + \frac{1}{5} \right) \right) = \frac{181}{10}$	M1A1A1 (3) (16 marks)

(a)

B1: Either of (1, 4.5) Accept any exact equivalent for 4.5 (May be seen on a diagram) May be written separately e.g. $x = 1, y = 4.5$ Condone coordinates without brackets

B1: Both (1, 4.5) Accept any exact equivalent for 4.5 (May be seen on a diagram) May be written separately e.g. $x = 1, y = 4.5$ Condone coordinates without brackets. isw once a correct pair is seen

Note for parts (b), (c) and (d) do not penalise incorrect notation provided the intention is clear or notation is recovered. E.g. $\sin \theta^2$ for $\sin^2 \theta$.

(b)

M1: Attempts $\left(\frac{dy}{dx} = \right) \frac{dy/d\theta}{dx/d\theta}$ Allow e.g. " $12 \sin \theta \cos \theta$ " $\times \frac{1}{-24 \cos^2 \theta \sin \theta}$ or

e.g. " $6 \sin 2\theta$ " $\times \frac{1}{-12 \sin 2\theta \cos \theta}$ Condone poor differentiation on y and/or x provided the functions are both

"changed". If the attempts at $\frac{dy}{d\theta}$ and $\frac{dx}{d\theta}$ are not seen separately then look for the formula stated or a

numerator of the form $p \sin \theta \cos \theta$ or a denominator of the form $q \cos^2 \theta \sin \theta$. May be seen as an attempt to directly find $-\frac{dx}{dy}$

A1: $\left(\frac{dy}{dx} = \right) -\frac{12 \sin \theta \cos \theta}{24 \cos^2 \theta \sin \theta} = \left(-\frac{1}{2 \cos \theta}\right)$ oe May be unsimplified and may be implied by further work

dM1: Substitutes $\theta = \frac{\pi}{3}$ into their $\frac{dy}{dx}$ to achieve a value. If just a value is stated then you may need to check this on your calculator. Condone slips provided the intention is clear. Dep. on 1st M. May be implied by their gradient in the equation of a normal.

ddM1: Attempts to find the normal by using the negative reciprocal of their $\frac{dy}{dx}$ with their $(1, 4.5)$ to produce an equation of a normal $\Rightarrow (y - 4.5) = 1(x - 1)$ If using $y = mx + c$ then $\Rightarrow c = \dots$ Dep on both previous Ms

A1: $y = x + 3.5$ o.e. in the required form

Alt(b) Finding the cartesian equation and differentiating

M1: Finds the cartesian equation $y = A \pm Bx^{\frac{2}{3}}$ and attempts to differentiate proceeding to the form $\left(\frac{dy}{dx} = \right) Cx^{\frac{1}{3}}$ May be unsimplified and index does not need to be processed

A1: $\left(\frac{dy}{dx} = \right) -x^{-\frac{1}{3}}$ May be unsimplified but index processed

dM1: Substitutes $x = 1$ into their $\frac{dy}{dx} = (-1)$ to achieve a value. If just a value is stated then you may need to check this on your calculator. Condone slips provided the intention is clear. Dep. on 1st M. May be implied by their gradient in the equation of a normal.

ddM1: Attempts to find the normal by using the negative reciprocal of their $\frac{dy}{dx}$ with their $(1, 4.5)$ to produce an equation of a normal $\Rightarrow (y - 4.5) = 1(x - 1)$ If using $y = mx + c$ then $\Rightarrow c = \dots$ Dep on both previous Ms

A1: $y = x + 3.5$ o.e. in the required form

(c) Note: Do not be concerned with the order of the limits on the integral and being consistent with 144 until the final mark.

M1: Attempts $\int y \frac{dx}{d\theta} d\theta$ (Allow omission of $d\theta$ and allow unsimplified). Condone poor attempts at $\frac{dx}{d\theta}$

A1: $\int 6 \sin^2 \theta \times -24 \cos^2 \theta \sin \theta (d\theta)$

dM1: Uses the identity $\sin^2 \theta = 1 - \cos^2 \theta$ to proceed from $\int A \sin^3 \theta \cos^2 \theta d\theta$ to produce an expression in an 'integrable form'. Dep. on 1st M

$\int A \sin^3 \theta \cos^2 \theta d\theta = \int A \sin \theta (1 - \cos^2 \theta) \cos^2 \theta d\theta = A \int (\sin \theta \cos^2 \theta - \sin \theta \cos^4 \theta) d\theta$ Condone sign slips only for this mark.

B1ft: Area of trapezium = $\frac{1}{2} ("3.5" + "4.5")$ or alternatively $\int_0^1 ("x + 3.5") dx = \left[\frac{x^2}{2} + 3.5x \right]_0^1 (= 0.5 + 3.5) = 4$

Where integration is used you must see the integrated expression but they can proceed directly to the answer from this point. You may need to check this on your calculator.

Must see any correct calculation to find the area. Just stating area of trapezium = "4" is B0ft

dM1: Attempts trapezium + area under curve. Look for $= \frac{1}{2} (3.5 + 4.5) \pm A \int_0^{\frac{\pi}{3}} \sin^3 \theta \cos^2 \theta (d\theta)$

OR alternatively $= \frac{1}{2} (3.5 + 4.5) \pm A \int_0^{\frac{\pi}{3}} (\sin \theta \cos^2 \theta - \sin \theta \cos^4 \theta) (d\theta)$ There must be an attempt to use the correct limits either way around and add a trapezium. Dep on 1st M

A1*: Achieves the given answer including $d\theta$ provided all previous marks have been awarded. **Must be seen in (c) so do not condone at the start of (d).** Withhold this mark if the limits written on the integral are not consistent with ± 144 oe on any line of their solution but do not be concerned with the positions of 8 and 1 on the integral before they are replaced. Do not condone sign slips but allow invisible brackets to be recovered before the final answer.

Alt(c) – finding the cartesian equation first

M1: Finds the cartesian equation and proceeds to the form $\int A \pm Bx^{\frac{2}{3}} dx$ oe (ignore limits)

A1: $\int 6 - \frac{3}{2} x^{\frac{2}{3}} (dx) \left(= \frac{3}{2} \int 4 - x^{\frac{2}{3}} dx \right)$ oe

dM1: $\frac{3}{2} \int \left(4 - (8 \cos^3 \theta)^{\frac{2}{3}} \right) (-24 \cos^2 \theta \sin \theta) \Rightarrow$ integrable form as in main scheme notes

B1ftdM1A1*: Main scheme notes

(d)

M1: $\int \sin \theta \cos^n \theta = \pm \frac{\cos^{n+1} \theta}{n+1}$ in either term. This cannot be implied by a correct answer. May use substitution e.g. $u = \cos \theta$

A1: Any correct (unsimplified) answer following a correct integrated expression. Trigonometric expressions should be evaluated.

A1: 18.1 or exact equivalent cso

Question Number	Scheme	Marks
8 (a)	$4p^2 - q^2 = (2p + q)(2p - q)$	B1
		(1)
(b)	Makes one valid statement :Either $2p + q = 46$ or $2p + q = 23$ $2p - q = 1$ or $2p - q = 2$	M1
	Solves correctly one of the pairs (see notes): e.g. $2p + q = 46, 2p - q = 1 \Rightarrow p = 11.75, (q = 22.5)$ oe or e.g. $2p + q = 23, 2p - q = 2 \Rightarrow p = 6.25, (q = 10.5)$ oe	A1
	States and attempts to solve both equations (see above)	dM1
	Fully correct proof by contradiction requiring (1) correct set up, (2) correct solution of both equations and (3) correct conclusion *	A1*
		(4)
		Total 5

(a)

B1: Correct factorisation

Note on open this is B1M1A1A1* but we are marking this M1A1dM1A1*

Mark the attempts at valid pairs of equations in the order which scores the most marks

(b) If you see any other proofs which appear to be credit worthy then send to review

M1: Deduces either of the valid pairs of equations. There is no requirement to justify that $2p + q$ must be greater than $2p - q$ and therefore solve the other possible equations. Ignore these attempts at these pairs of equations.

A1: Correctly solves one of the two valid pairs of equations. No working is required, just the correct solution. Note that it is acceptable to only go as far as finding either one of p or q as that is a non-integer. However, if they find the other one of p or q then they must both be correct. Beware that the correct solving may be their second valid pair.

Note if they only proceed to e.g. $4p = 25$ **they must explain the contradiction** that e.g. p cannot be an integer **because** 25 is not divisible by 4 or LHS=even, RHS=odd or LHS=multiple of 4, RHS=not a multiple of 4

dM1: States and attempts to solve **both** valid pairs of equations. Condone proceeding as far as e.g. $4p = 47$ for this mark. It is dependent on the previous method mark.

A1*: Full proof by contradiction. This must follow M1A1dM1

Look for

- a correct set up with words such as “assume there is” or “let there be” with “integers p and q ”
- correct solution of **both** valid pairs of equations (and explanations where required e.g. if only proceeding as far as $4p = 25$) If p and q are both found for both valid pairs then they must be correct.
- a (minimal) conclusion

Minimal proof for 4 marks:

Assume that there are integers p and q such that $4p^2 - q^2 = 46$

(So) $2p + q = 46$, $2p - q = 1 \Rightarrow p = 11.75$ not an integer

(and) $2p + q = 23$, $2p - q = 2 \Rightarrow p = 6.25$ not an integer

Hence, (we have a contradiction), so statement is proven

Alt(b) – using odd and even factor argument example

M1: Identifies that $46 = 1 \times 46$, 2×23 **and** considers either the case when q is odd OR when q is even

- when q is odd then $(2p + q)$ is odd and $(2p - q)$ is odd OR
- when q is even then $(2p + q)$ is even and $(2p - q)$ is even

A1: Deduces correctly for the case when q is odd that 46 cannot be the product of two odd numbers OR deduces correctly for the case when q is even that 46 cannot be the product of two even numbers

dM1: Considers both cases (see first M1). It is dependent on the previous method mark

A1*: Full proof by contradiction. This must follow M1A1dM1

Look for

- a correct set up with words such as “assume there is” or “let there be” with “integers p and q ”
 - correct deductions for both odd and even cases
 - a (minimal) conclusion
-

Alt(b) – condone using even property example

M1: e.g. $4p^2 - q^2 = 46 \left(\Rightarrow q^2 = 4p^2 - 46 \right)$ and deduces q^2 (or q) is even.

A1: **States** q^2 is even (then q is even) and writes in the form $q = 2m$

dM1: Attempts $(2m)^2 = 4p^2 - 46$ and rearranges to a form where a contradiction can be deduced It is dependent on the previous method mark. e.g. $4m^2 = 4p^2 - 46 \Rightarrow m^2 = p^2 - \frac{46}{4}$ (which means m^2 and hence m cannot be an integer so there is a contradiction)

A1*: Full proof by contradiction. This must follow M1A1dM1

Look for

- a correct set up with words such as “assume there is” or “let there be” with “integers p and q ”
- correct deductions
- a (minimal) conclusion

Question Number	Scheme	Marks
9 (a)	$\mathbf{a} = \mathbf{i} + \mathbf{j} - 2\mathbf{k} \quad \mathbf{b} = 3\mathbf{i} - \mathbf{j} + 6\mathbf{k} \quad \mathbf{c} = -\mathbf{i} + 3\mathbf{j} + 6\mathbf{k}$ e.g. $\overrightarrow{BA} = \mathbf{a} - \mathbf{b} = -2\mathbf{i} + 2\mathbf{j} - 8\mathbf{k}$ (so $\overrightarrow{CD} = -2\mathbf{i} + 2\mathbf{j} - 8\mathbf{k}$) $\mathbf{d} = \mathbf{c} + \overrightarrow{CD} = -\mathbf{i} + 3\mathbf{j} + 6\mathbf{k} + -2\mathbf{i} + 2\mathbf{j} - 8\mathbf{k} = -3\mathbf{i} + 5\mathbf{j} - 2\mathbf{k}$	M1 dM1 A1 (3)
(b)	$\overrightarrow{BA} = \mathbf{a} - \mathbf{b} = -2\mathbf{i} + 2\mathbf{j} - 8\mathbf{k}$ and $\overrightarrow{BC} = \mathbf{c} - \mathbf{b} = -4\mathbf{i} + 4\mathbf{j}$ $\cos \theta = \frac{\begin{pmatrix} -2 \\ 2 \\ -8 \end{pmatrix} \cdot \begin{pmatrix} -4 \\ 4 \\ 0 \end{pmatrix}}{\sqrt{(-2)^2 + 2^2 + (-8)^2} \sqrt{(-4)^2 + 4^2}} = \frac{16}{\sqrt{72}\sqrt{32}} = \frac{1}{3}$ So angle is awrt 1.23 radians or awrt 70.5 degrees	M1 dM1 A1 A1 (4)
(c)	Area = $\sqrt{72}\sqrt{32} \times \sin 70.5^\circ = 45.3$ or $32\sqrt{2}$	M1A1 (2)
(d)	Area = $\frac{3}{2} \times 45.3 = 67.9$ or $48\sqrt{2}$	M1 A1 (2)
		(11 marks)

(a) Note that one correct component of $-3\mathbf{i} + 5\mathbf{j} - 2\mathbf{k}$ scores M1dM1A0 if no incorrect working seen

M1: For attempting one of $\mathbf{b} - \mathbf{a}$ or $\mathbf{a} - \mathbf{b}$ or $\mathbf{c} - \mathbf{b}$ or $\mathbf{b} - \mathbf{c}$. It must be correct for at least one of the components $\pm(-2\mathbf{i} + 2\mathbf{j} - 8\mathbf{k})$ or $\pm(-4\mathbf{i} + 4\mathbf{j})$. Condone coordinate notation. May be implied by at least one correct component of $-3\mathbf{i} + 5\mathbf{j} - 2\mathbf{k}$

dM1: For attempting $\mathbf{d} = \mathbf{a} - \mathbf{b} + \mathbf{c}$ and proceeding to a position vector for D . It must be correct for at least one of the components. Condone coordinate notation. It is dependent on the previous method mark.

A1: $-3\mathbf{i} + 5\mathbf{j} - 2\mathbf{k}$ oe $\begin{pmatrix} -3 \\ 5 \\ -2 \end{pmatrix}$ Condone without brackets. Condone $(-3\mathbf{i}, 5\mathbf{j}, -2\mathbf{k})$

Correct answer no working scores all 3 marks. Condone coordinates.

Alt(a) Finding the mid point E of AC and then using $\mathbf{d} = \mathbf{b} + 2\overrightarrow{BE}$ Must be a full method:

M1: Attempts $mp_{AC} = (0, 2, 2)$ and uses $\mathbf{d} = \mathbf{b} + 2\overrightarrow{BE}$

M1: Attempts $(3, -1, 6) + 2 \times (-3, 3, -4) \Rightarrow \dots$

A1: $-3\mathbf{i} + 5\mathbf{j} - 2\mathbf{k}$ oe (see main scheme notes)

(b)

- M1: Uses a correct pair of vectors, so $\pm \overrightarrow{BA}$ and $\pm \overrightarrow{BC}$. Must be seen or used in (b). May be implied by further work e.g. in the dot product formula or an attempt to find the magnitude of each of these vectors. Each must be correct for at least two of the components.
- dM1: Attempts to use the dot product formula to find $\cos \theta = k, -1 < k < 1$. Dep. on the previous M. Condone arithmetical slips in both their dot product calculation and the moduli, but the process must be correct.
- A1: For $\frac{1}{3}$ or $-\frac{1}{3}$ or from correct working - may be implied by 70.5 or 109.5 or 1.23 radians or 1.91 radians.
- A1: cso for awrt 70.5 degrees or awrt 1.23 radians. (Note that $\cos^{-1} = -\frac{1}{3} \Rightarrow 109.5$ followed by 70.5 is A0 unless accompanied by a convincing argument that the angle 109.5 is the exterior angle, and therefore the interior angle is 70.5. It is not awarded for simply finding the acute angle. A diagram with correct angles would be ok)

Alt(b)

- M1: See main scheme notes
- dM1: Attempts $\pm \overrightarrow{AC}$, finds all three magnitudes and uses the cosine rule with the values in the correct positions to find $\cos \theta = k, -1 < k < 1$. e.g. $\cos \theta = \frac{"72" + "32" - "72"}{2" \sqrt{72} " " \sqrt{32} " } \Rightarrow \theta = \dots$ Dep on previous M
- Condone slips in finding the magnitudes but the process must be correct.
- A1A1: See main scheme notes

(c)

- M1: Uses correct area formula for parallelogram with their angle from (b). The values embedded is sufficient. They must be using their $\pm \overrightarrow{BA}$ and $\pm \overrightarrow{BC}$, each must be correct for at least two of the components. Condone slips. May see the area of the triangle ABC doubled. May be implied by awrt 45.2/45.3
- A1: Obtains awrt 45.3. Allow this from an angle of 109.5

Alt(c) – vector cross product example

- M1: Attempts e.g. $\overrightarrow{BA} \times \overrightarrow{BC} = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ -2 & 2 & -8 \\ -4 & 4 & 0 \end{vmatrix} = 32\mathbf{i} - 32\mathbf{j} \Rightarrow \text{Area} = |\overrightarrow{BA} \times \overrightarrow{BC}| = \sqrt{32^2 + 32^2}$ using $\pm \overrightarrow{BA}$ and $\pm \overrightarrow{BC}$, each must be correct for at least two of the components. Condone sign slips for their cross product
- A1: Obtains awrt 45.3. Allow this from an angle of 109.5

(d) Must use their answer to part (c) to score

- M1: Uses 1.5 times answer to the area of their $ABCD$ (It can be implied by awrt 67.9). Alternatively, uses their answer to part (c) and adds the area of the triangle
- e.g. $h = 4\sqrt{2} \times \sqrt{1 - \frac{16}{9\sqrt{2} \times 6\sqrt{2}}} = \frac{16}{3} \Rightarrow \text{Area} = \frac{1}{2} \times \frac{16}{3} \times 6\sqrt{2} + "32\sqrt{2}"$
- A1: awrt 67.9 or $48\sqrt{2}$

Please check the examination details below before entering your candidate information

Candidate surname		Other names	
Centre Number		Candidate Number	

Pearson Edexcel International Advanced Level

Thursday 22 January 2026

Morning (Time: 1 hour 30 minutes) **Paper reference** **WMA14/01**

Mathematics
International Advanced Level
Pure Mathematics P4

You must have:
 Mathematical Formulae and Statistical Tables (Yellow), calculator

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 9 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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C:1/1/1/




Pearson

1. **In this question you must show all stages of your working.**
Solutions relying on calculator technology are not acceptable.

Given that the binomial expansion of $(1 + ax)^n$, in ascending powers of x , is

$$1 - 4x + \frac{24}{5}x^2 + px^3 + \dots$$

where a , n and p are constants,

- (a) find the value of a and the value of n .

(5)

Hence

- (b) find the value of p ,

(2)

- (c) state the set of values of x for which the expansion is valid.

(1)



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Question 1 continued

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Question 1 continued

Handwriting practice area with horizontal lines.

(Total for Question 1 is 8 marks)



2.

**In this question you must show all stages of your working.
Solutions relying on calculator technology are not acceptable.**

Using algebraic integration, find the exact value of

$$\int_2^{2e^2} x^3 \ln\left(\frac{1}{2}x\right) dx$$

giving the answer in simplest form.

(5)



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Question 2 continued

Handwriting practice area with horizontal lines.

(Total for Question 2 is 5 marks)



3. (a) Factorise $x^2 - 4y^2$

(1)

(b) Use proof by contradiction to prove that there are no positive integers x and y such that

$$x^2 - 4y^2 = 27$$

(4)



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Question 3 continued

Handwriting practice area with horizontal lines.

(Total for Question 3 is 5 marks)



4. (a) Use the substitution $u = e^x + 4$ to show that

$$\int_0^{\ln 6} \frac{2e^x + 3}{e^x + 4} dx = \int_a^b \frac{cu + d}{u(u-4)} du$$

where a , b , c and d are constants to be found.

(3)

- (b) Hence, using algebraic integration, show that

$$\int_0^{\ln 6} \frac{2e^x + 3}{e^x + 4} dx = P \ln 2 + Q \ln 3$$

where P and Q are constants to be found.

(6)



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Question 4 continued

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Question 4 continued

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(Total for Question 4 is 9 marks)



5.

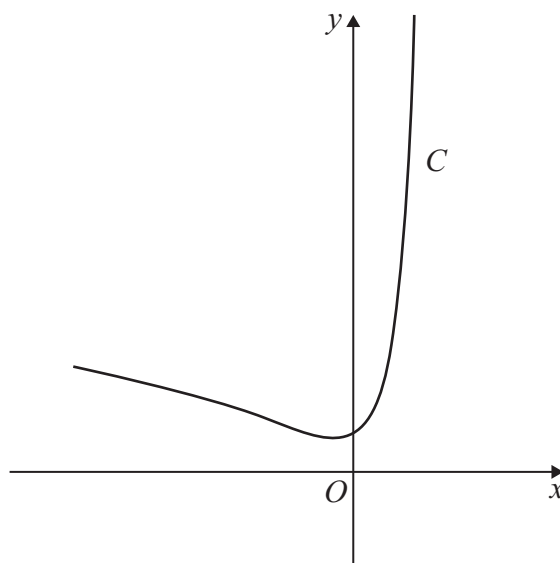


Figure 1

The curve C , shown in Figure 1, has parametric equations

$$x = \frac{4t - 5}{2t + 1} \quad y = 2t^2 - 4t + 4 \quad t \geq 0$$

The point P lies on C and has parameter $t = 3$

(a) Find the coordinates of P . (2)

(b) Find $\frac{dy}{dx}$ in terms of t , writing the answer in simplest form. (4)

(c) Hence find the equation of the tangent to C at P . Write the answer in the form $y = mx + c$, where m and c are constants. (2)

Given that

- the Cartesian equation of C is $y = f(x)$
- the function f is defined for all values of x on C

(d) (i) find the domain of f
 (ii) find the range of f (3)



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Question 5 continued

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Question 5 continued

(Total for Question 5 is 11 marks)



6. With respect to a fixed origin O , the line l_1 has equation

$$\mathbf{r} = \begin{pmatrix} -3 \\ 0 \\ 5 \end{pmatrix} + \lambda \begin{pmatrix} 2 \\ 1 \\ -3 \end{pmatrix}$$

where λ is a scalar parameter.

The point P lies on l_1

Given that P is the point on l_1 that is nearest O ,

- (a) find the coordinates of P .

(4)

With respect to the same fixed origin O , the line l_2 has equation

$$\mathbf{r} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} + \mu \begin{pmatrix} 4 \\ a \\ -2 \end{pmatrix}$$

where a is a constant and μ is a scalar parameter.

Given that l_1 and l_2 intersect at the point Q ,

- (b) find the value of a ,

(4)

- (c) find the coordinates of Q .

(2)



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Question 6 continued

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Question 6 continued

(Total for Question 6 is 10 marks)



7.

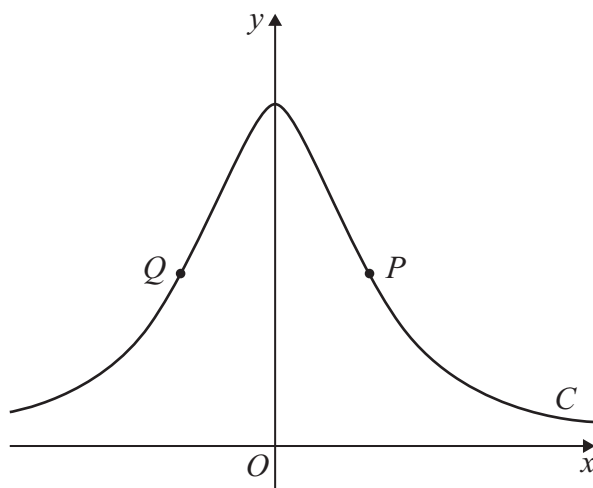


Figure 2

The curve C , shown in Figure 2 has equation

$$x^2 \tan y + \frac{32y^2}{\pi^2} = 11 \qquad 0 < y \leq \frac{\pi}{2}$$

The points P and Q , shown in Figure 2, lie on C and have y coordinate $\frac{\pi}{4}$

- (a) Find the x coordinate of P and the x coordinate of Q . (2)
- (b) Use algebraic differentiation to find the exact value of $\frac{dy}{dx}$ at P . (5)
- (c) Hence, showing your working, find the value of
- (the gradient of the tangent to C at P) $\times$ (the gradient of the normal to C at Q) (2)



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Question 7 continued

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Question 7 continued

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(Total for Question 7 is 9 marks)



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Question 8 continued

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Question 8 continued

(Total for Question 8 is 10 marks)



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Question 9 continued

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(Total for Question 9 is 8 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (Results)

January 2026

Pearson Edexcel International Advanced Level in
Pure Mathematics P4
WMA14/01

Edexcel and BTEC Qualifications

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January 2026

Question Paper Log Number P81324A

Publication Code WMA14_01_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN:

- bod – benefit of doubt
- ft – follow through
 - the symbol $\checkmark$ will be used for correct ft
- cao – correct answer only
- cso – correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC – special case
- oe – or equivalent (and appropriate)
- d... or dep – dependent
- indep – independent
- dp – decimal places
- sf – significant figures
- * – The answer is printed on the paper or ag- answer given

- $\square$ or d... – The second mark is dependent on gaining the first mark
4. All A marks are 'correct answer only' (cao), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.
 5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. If you are using the annotation facility on ePEN, indicate this action by 'MR' in the body of the script.
 6. If a candidate makes more than one attempt at any question:
 - a) If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - b) If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
 7. Ignore wrong working or incorrect statements following a correct answer.

General Principles for Pure Mathematics Marking

(NB specific mark schemes may sometimes override these general principles)

Method mark for solving 3 term quadratic:

1. Factorisation

$(x^2 + bx + c) = (x + p)(x + q)$, where $|pq| = |c|$ leading to $x = \dots$

$(ax^2 + bx + c) = (mx + p)(nx + q)$, where $|pq| = |c|$ and $|mn| = |a|$ leading to $x = \dots$

2. Formula

Attempt to use correct formula (with values for a, b and c)

3. Completing the square

Solving $x^2 + bx + c = 0$: $(x \pm \frac{b}{2})^2 \pm q \pm c$, $q \neq 0$ leading to $x = \dots$

Method marks for differentiation and integration:

1. Differentiation

Power of at least one term decreased by 1 ($x^n \rightarrow x^{n-1}$)

2. Integration

Power of at least one term increased by 1 ($x^n \rightarrow x^{n+1}$)

Use of a formula

Where a method involves using a formula that has been learnt, the advice given in recent examiners' reports is that the formula should be quoted first.

Normal marking procedure is as follows:

Method mark for quoting a correct formula and attempting to use it, even if there are small mistakes in the substitution of values.

Where the formula is not quoted, the method mark can be gained by implication from correct working with values, but may be lost if there is any mistake in the working.

Exact answers

Examiners' reports have emphasised that where, for example, an exact answer is asked for, or working with surds is clearly required, marks will normally be lost if the candidate resorts to using rounded decimals.

Answers without working

The rubric says that these may not gain full credit. Individual mark schemes will give details of what happens in particular cases. General policy is that if it could be done "in your head", detailed working would not be required. Most candidates do show working, but there are occasional awkward cases and if the mark scheme does not cover this, please contact your team leader for advice.

Question Number	Scheme	Marks
1 (a)	$nax = \pm 4x \text{ OR } \frac{n(n-1)(ax)^2}{2} = \frac{24}{5}x^2$ $na = -4 \text{ AND } \frac{n(n-1)a^2}{2} = \frac{24}{5}$ $\text{Sub } a = \frac{-4}{n} \Rightarrow \frac{n(n-1)16}{2n^2} = \frac{24}{5} \Rightarrow 80(n-1) = 48n \Rightarrow n = \dots$ $a = -\frac{8}{5}, n = \frac{5}{2}$	M1 A1 dM1, A1, A1 (5)
(b)	$p = \frac{\left(\frac{5}{2}\right)\left(\frac{5}{2}-1\right)\left(\frac{5}{2}-2\right)\left(-\frac{8}{5}\right)^3}{6} = -\frac{32}{25}$	M1, A1 (2)
(c)	Allow $ x < \frac{5}{8}$ OR $ x , \frac{5}{8}$ or equivalents such as $-\frac{5}{8} < x < \frac{5}{8}$	B1ft (1) (8 marks)

(a)

M1: For $nax = \pm 4x$ OR $\frac{n(n-1)(ax)^2}{2} = \pm \frac{24}{5}x^2$ which may be implied. Condone missing brackets.

Allow the method mark to be scored for

- non-simplified versions such as $\binom{n}{1}ax = \pm 4x$ or ${}^nC_2(ax)^2 = \frac{24}{5}x^2$
- simplified versions (with x 's cancelled) such as $na = -4$ or $\frac{n(n-1)a^2}{2} = \frac{24}{5}$

A1: Correct equations not involving x 's (and not in combination notation form)

Scored for both $na = -4$ AND $\frac{n(n-1)a^2}{2} = \frac{24}{5}$ o.e.

dM1: Solves two equations of the correct form and proceeds to find a value for either a or n .

Expect to see the following

- 'simplified' initial equations of the form $na = \pm 4$ and $\frac{n(n-1)a^2}{2} = \pm \frac{24}{5}$
- a simplified intermediate equation in a single variable. Look, for example, for equations of the form $80(n-1) = 48n$ or $-2(-4-a) = \frac{24}{5}$ that are easily solvable. Condone slips
- followed by a value for either a or n .

A1: Either $a = -\frac{8}{5}$ or $n = \frac{5}{2}$ following two correct equations which may be in an un-simplified form

Allow equivalent fractions or decimals

A1: Both $a = -\frac{8}{5}$ and $n = \frac{5}{2}$ following correct equations **AND** following the award of all previous marks. Allow equivalent fractions or decimals

(b) The M1 can be awarded from a made up $n \notin \mathbb{N}$ and a . For example, they may say let $n = \frac{1}{2}, a = 6$

M1: Attempts $\frac{n(n-1)(n-2)}{3!} \times a^3 (x^3)$ with their values for a and n with or without the x^3

Condone ${}^nC_3 (ax)^3 = \dots x^3$ provided the value produced implies correct processing

A1: $-\frac{32}{25}$ o.e which must be seen without the x^3

(c)

B1ft: $|x| < \frac{5}{8}, |x|, \frac{5}{8}$ or equivalents such as $-\frac{5}{8} < x < \frac{5}{8}$ but follow through on their a . E.g. $|x| < \frac{1}{a}$

If they haven't got a value for a they can score this for $|x| < \frac{1}{a}$. If they have a value for a it must be used.

Note the demand is to show working and not rely on calculator technology

Solutions that don't show an intermediate equation in a single variable score as follows. If unsure please use review

Scenario I: Writes down two correct simplified initial equations and then correct values for a and n , but no simplified intermediate equation

E.g.I $na = -4$ AND $\frac{n(n-1)a^2}{2} = \frac{24}{5} \Rightarrow a = -\frac{8}{5}, n = \frac{5}{2}$

Score 1,1,0,1,0. All marks in (b) and (c) are available

E.g.II $na = -4$ AND $\frac{n(n-1)a^2}{2} = \frac{24}{5} \Rightarrow \frac{-\frac{4}{a} \left(-\frac{4}{a} - 1 \right) a^2}{2} = \frac{24}{5} \Rightarrow a = -\frac{8}{5}, n = \frac{5}{2}$

Score 1,1,0,1,0. All marks in (b) and (c) are available

Scenario II: Writes down one or two correct un-simplified initial equations and then correct values for a and n

E.g. $na = -4$ AND ${}^nC_2 (ax)^2 = \frac{24}{5} x^2 \Rightarrow a = -\frac{8}{5}, n = \frac{5}{2}$

Score 1,0,0,1,0. All marks in (b) and (c) are available

Scenario III: Writes down one or two correct un-simplified initial equations and then a correct value for just n

E.g. $na = 4$ AND ${}^nC_2 (ax)^2 = \frac{24}{5} x^2 \Rightarrow a = \frac{8}{5}, n = \frac{5}{2}$

Score 1,0,0,1,0. As the value of a is incorrect, then only the M mark in (b) is available

Scenario IV: Only writes down one correct equation and then uses trial and improvement methods to find/show correct values for a and n

E.g. $na = -4$ and then follows with trials including $a = -\frac{8}{5}, n = \frac{5}{2}$ and shows $\frac{\frac{5}{2} \times \frac{3}{2}}{2} \times \left(-\frac{8}{5} \right)^2 = \frac{24}{5}$

Score 1,0,0,1,0. All marks in (b) and (c) are available

Question Number	Scheme	Marks
2	$\int x^3 \ln\left(\frac{1}{2}x\right) dx = \frac{1}{4}x^4 \ln\left(\frac{1}{2}x\right) - \int \frac{1}{4}x^4 \times \frac{1}{x} dx$ $= \frac{1}{4}x^4 \ln\left(\frac{1}{2}x\right) - \frac{1}{16}x^4 (+c)$ $\left[\frac{1}{4}x^4 \ln\left(\frac{1}{2}x\right) - \frac{1}{16}x^4 \right]_2^{2e^2} = \left(\frac{16e^8}{4} \ln e^2 - \frac{16e^8}{16} \right) - \left(\frac{16}{4} \ln 1 - \frac{16}{16} \right)$ $= 7e^8 + 1$	M1 dM1 A1 ddM1 A1 (5 marks)

Condone missing dx's throughout

M1: Attempts to integrate by parts the correct way around.

Look for $\int x^3 \ln\left(\frac{1}{2}x\right) dx = ax^4 \ln\left(\frac{1}{2}x\right) \pm \int bx^4 \times \frac{1}{x} dx$ o.e. such as $ax^4 \ln\left(\frac{1}{2}x\right) \pm \int bx^3 dx$ with $a > 0$

dM1: And then integrates again to a form $px^4 \ln\left(\frac{1}{2}x\right) - qx^4$ where p and q are **positive constants**.

A1: Correct simplified or un-simplified integration. $\frac{1}{4}x^4 \ln\left(\frac{1}{2}x\right) - \frac{1}{16}x^4$ with or without the bracket

ddM1: Attempts to substitute in both limits and subtract either way around, condoning slips. It is dependent upon having an integral of the correct form. To score this mark

- Look for integration that leads to the form $px^4 \ln\left(\frac{1}{2}x\right) \pm qx^4$ where p and q are **positive constants**
- Substitution of both limits and an attempt to subtract either way around
- Correct calculation of both $\ln\left(\frac{1}{2} \times 2e^2\right) = 2$ and $\ln\left(\frac{1}{2} \times 2\right) = 0$ which may be implied

A1: $7e^8 + 1$ which must be in simplest form

Note: You may see D and I methods attempted. For the first three marks score M1, dM1 for integration to the form $px^4 \ln\left(\frac{1}{2}x\right) - qx^4$ where p and q are **positive constants**.

You may see something like this;

D	I
$\ln\left(\frac{1}{2}x\right)$	x^3
$\frac{1}{x}$	$\frac{x^4}{4}$

You could also see methods involving substitution in which the marks are scored as in the main scheme.

E.g. Let $u = \frac{x}{2}$ then $\int_2^{2e^2} x^3 \ln\left(\frac{1}{2}x\right) dx = \int_1^{e^2} 16x^3 \ln u du = \left[4u^4 \ln u - u^4 \right]_1^{e^2} = 7e^8 + 1$

Question Number	Scheme	Marks
3 (a)	$(x + 2y)(x - 2y)$	B1 (1)
(b)	Makes one valid statement. Either $(x + 2y) = 27, (x - 2y) = 1$ or $(x + 2y) = 9, (x - 2y) = 3$ Solves correctly one of the pair; $(x + 2y) = 27, (x - 2y) = 1 \Rightarrow x = 14, y = 6.5$ $(x + 2y) = 9, (x - 2y) = 3 \Rightarrow x = 6, y = 1.5$ States and attempts to solve both valid equations Fully correct proof by contradiction (1) including correct set up, (2) correct solution of both equations and (3) correct conclusion*	M1 A1 dM1 A1* (4) (5 marks)

(a)

B1: $x^2 - 4y^2 \equiv (x + 2y)(x - 2y)$

(b)

M1: Deduces either of the valid pairs of equations, $(x + 2y) = 27, (x - 2y) = 1$ or $(x + 2y) = 9, (x - 2y) = 3$.

There is no requirement to justify that $x + 2y$ must be greater than $x - 2y$ and therefore find the other equations $(x + 2y) = 1, (x - 2y) = 27$ and $(x + 2y) = 3, (x - 2y) = 9$

If they have part (a) incorrect, e.g. $x^2 - 4y^2 \equiv (x + 4y)(x - 4y)$ award for $(x + 4y) = 27, (x - 4y) = 1$ or $(x + 4y) = 9, (x - 4y) = 3$

A1: Correctly solves one of the two valid pairs of equations. No working is required, just the correct solution.

Look for either of $(x + 2y) = 27, (x - 2y) = 1 \Rightarrow y = 6.5, (x = 14)$

Or $(x + 2y) = 9, (x - 2y) = 3 \Rightarrow y = 1.5, (x = 6)$

Note that it is acceptable to only go as far as finding y as it is the non-integer solution

dM1: States and attempts to solve both valid pairs of equations. It is dependent upon the previous M mark

Note that it is acceptable to only go as far as finding y as that is the non-integer

You can **IGNORE** working from non-relevant equations like $(x + 2y) = 1, (x - 2y) = 27 \Rightarrow x = \dots, y = \dots$

or $(x + 2y) = -3, (x - 2y) = 9 \Rightarrow x = \dots, y = \dots$ and incorrect equations like

$(x + 2y) = 18, (x - 2y) = 1.5 \Rightarrow x = \dots, y = \dots$

A1*: Full proof by contradiction. This must follow the award of M1, A1, dM1

Look for

- a correct set up with words such as 'assume there is' or 'let there be' with 'positive integers x and y ' or 'positive integers'
- correct solution of both valid pair of equations
- acceptable (minimal) conclusion

.....
Minimal proof for 4 marks

Assume that there are positive integers x and y such that $x^2 - 4y^2 = 27$

So either $(x + 2y) = 27, (x - 2y) = 1 \Rightarrow y = 6.5$ ✖

Or $(x + 2y) = 9, (x - 2y) = 3 \Rightarrow y = 1.5$ ✖

Hence, we have a contradiction, so statement proven.
.....

Other methods exist.

For example:

There exist positive integers x and y such that $x^2 - 4y^2 = 27 \Rightarrow x^2 = 27 + 4y^2$

Then deduces that x^2 is odd which means that x is odd.

So $x = 2m + 1 \Rightarrow (2m + 1)^2 - 4y^2 = 27$

$$\Rightarrow 4m^2 + 4m - 4y^2 = 26$$

$$\Rightarrow y^2 = 4m^2 + 4m - \frac{13}{2}$$

Hence y^2 and so y cannot be an integer, so we have a contradiction,

Score M1: For correct work in deducing that x^2 or x is odd

A1: For stating that both x^2 and x are odd and x is of the form $2m + 1$ o.e.

dM1: For squaring $2m + 1$ and attempting to make y^2 the subject

A1: Full proof with correct set up, equations and deductions

Candidates who attempt odd and even combinations of x and y will only score marks when they reach an equivalent stage to the above. Please send these to review if you are unsure.
.....

Other more elaborate methods will be seen. If you feel that they deserve credit and you cannot see how to score the response, then please send to review.
.....

Question Number	Scheme	Marks
4 (a)	Limits $a = 5, b = 10$ $\int_0^{\ln 6} \frac{2e^x + 3}{e^x + 4} dx = \int \frac{2 \times (u-4) + 3}{u} \times \frac{du}{(u-4)} = \int \frac{2u-5}{u(u-4)} du$	B1 M1 A1 (3)
(b)	Sets their $\frac{2u-5}{u(u-4)}$ as $\frac{A}{u} + \frac{B}{u-4}$ $"2u-5" = A(u-4) + Bu \Rightarrow A = \frac{5}{4}, B = \frac{3}{4}$ $\int_0^{\ln 6} \frac{2e^x + 3}{e^x + 4} dx = \int_5^{10} \frac{5/4}{u} + \frac{3/4}{(u-4)} du = \left[\frac{5}{4} \ln u + \frac{3}{4} \ln(u-4) \right]_5^{10}$ $= \left(\frac{5}{4} \ln 10 + \frac{3}{4} \ln 6 \right) - \left(\frac{5}{4} \ln 5 + \frac{3}{4} \ln 1 \right)$ $= \frac{5}{4} \ln \frac{10}{5} + \frac{3}{4} \ln 6 = \frac{5}{4} \ln 2 + \frac{3}{4} \ln 2 + \frac{3}{4} \ln 3$ $= 2 \ln 2 + \frac{3}{4} \ln 3$	B1 M1, A1 M1 dM1 A1 (6) (9 marks)

(a)

B1: States either $a = 5, b = 10$ or correctly embeds the values as limits in the correct place within the integral. May be awarded from the limits seen or used in part (b)

M1: Attempts to write $\frac{2e^x + 3}{e^x + 4} dx$ in terms of u .

Look for both of

- A correct $\frac{dx}{du}$ or $\frac{du}{dx}$ in terms of u . E.g. $u = e^x + 4 \Rightarrow \frac{du}{dx} = e^x = u - 4$ or $x = \ln(u - 4) \Rightarrow \frac{dx}{du} = \frac{1}{u - 4}$
- $\frac{2e^x + 3}{e^x + 4} dx$ going to $\frac{cu + d}{u(u-4)}(du)$

A1: Shows that $\int \frac{2e^x + 3}{e^x + 4} dx = \int \frac{2u-5}{u(u-4)} du$ with the dx 's and du 's appropriately placed throughout the solution. This mark does not depend on correct limits but the integral sign and du must present on the final line

(b)

B1: Scored for realising that this integral needs to be attempted via PF. So sets their $\frac{2u-5}{u(u-4)} \equiv \frac{A}{u} + \frac{B}{u-4}$

This may be implied by writing their expression in a form with numerical values for A and B

M1: Valid attempt to find the values for A and B .

Score for a correct identity followed by methods of substitution or equating terms to find values for A and B . For example, sets ' $cu + d = A(u - 4) + Bu$ ' followed by $u = 4 \Rightarrow B = \dots$ and $u = 0 \Rightarrow A = \dots$

This can be implied by a correct value for A or B

A1: Correct values for A and B . This is not a follow through mark

Note that other methods of splitting the fraction are possible but the scheme can be applied.

FYI:
$$\frac{2u-5}{u(u-4)} \equiv \frac{2}{(u-4)} - \frac{5}{u(u-4)} \equiv \frac{2}{(u-4)} - \left\{ -\frac{5}{4u} + \frac{5}{4(u-4)} \right\}$$

M1: Integrates the form $\frac{A}{u} + \frac{B}{u-4}$ to $\dots \ln u + \dots \ln(u-4)$. Don't be concerned by the coefficients

Note that $\dots \ln pu + \dots \ln q(u-4)$ is also correct so you may see $\frac{5}{4u} \rightarrow \frac{5}{4} \ln 4u$

Condone missing brackets only if subsequent work involving limits implies this intention

dM1: Dependent upon the previous M. Scored for;

- Substituting 5 and 10 into $\alpha \ln u + \beta \ln(u-4)$ and subtracting either way around
- correctly applying at least one log law

A1: CAO $2 \ln 2 + \frac{3}{4} \ln 3$

Question Number	Scheme	Marks
5 (a)	(1, 10)	B1, B1 (2)
(b)	$\frac{dy}{dt} = 4t - 4, \quad \frac{dx}{dt} = \frac{4(2t+1) - 2(4t-5)}{(2t+1)^2}$ $\frac{dy}{dx} = \frac{\frac{dy}{dt}}{\frac{dx}{dt}} = \frac{(4t-4)}{\frac{14}{(2t+1)^2}} = \frac{2(t-1)(2t+1)^2}{7}$	B1, M1 dM1 A1 (4)
(c)	Substitutes $t = 3$ into their $\frac{dy}{dx} = (28)$ $y - 10 = 28(x - 1) \Rightarrow y = 28x - 18$	M1, A1 (2)
(d) (i)	$-5, x < 2$	M1 A1
(ii)	$f(x) \dots 2$	B1
		(3) (11 marks)

(a)

B1: One correct coordinate. E.g. (1, ...) or (... , 10). Allow as $x = 1$ or $y = 10$

B1: (1, 10). Allow as $x = 1, y = 10$

(b)

B1: $\frac{dy}{dt} = 4t - 4$. You may see this written as $y' = 4t - 4$ or $\dot{y} = 2 \times 2t - 4$ which is fine.

M1: Attempts to use the quotient rule (or equivalent) to differentiate $x = \frac{4t-5}{2t+1}$.

Look for the form $\frac{dx}{dt} = \frac{p(2t+1) - q(4t-5)}{(2t+1)^2}$ with $p, q > 0$

You may see $x = \frac{4t-5}{2t+1} \equiv 2 - \frac{7}{2t+1} \Rightarrow \frac{dx}{dt} = \frac{14}{(2t+1)^2}$ with M1 scored for the form

$$x = a + \frac{b}{2t+1} \Rightarrow \frac{dx}{dt} = \frac{c}{(2t+1)^2}$$

Or the product rule $x = (4t-5)(2t+1)^{-1} \Rightarrow \frac{dx}{dt} = 4(2t+1)^{-1} - 2(4t-5)(2t+1)^{-2}$ but condone

sign and coefficient slips. Look for the form $\alpha(2t+1)^{-1} \pm \beta(4t-5)(2t+1)^{-2}$

dM1: Attempts to apply the rule $\frac{dy}{dx} = \frac{dy/dt}{dx/dt}$. Dependent upon the previous M and $\frac{dy}{dt}$ being linear

A1: A correct **simplified** expression for $\frac{dy}{dx}$ ISW after a correct answer

Allow $\frac{2(t-1)(2t+1)^2}{7}$, $\frac{(2t-2)(2t+1)^2}{7}$, $\frac{2(4t^3-3t-1)}{7}$ or $\frac{8t^3-6t-2}{7}$

Note that if division was used to find $\frac{dx}{dt}$, all calculations must have been correct.

(c)

M1: Uses the value of their gradient at $t = 3$ and their point from (a) to form the equation of the tangent.

Look for $y - '10' = m(x - '1')$ with m being the value of their $\frac{2(t-1)(2t+1)^2}{7}$ at $t = 3$

If the form $y = mx + c$ is used the method must proceed as far as $c = \dots$

A1: CSO $y = 28x - 18$

(d) (i)

M1: Achieves the correct value for the upper or lower bound. Condone $x > -5$ or $x \leq -2$ or, with incorrect variables e.g. $y > -5$. Solutions such as $x < -5$ OR $x = 2$ will be M0

A1: $-5 \leq x < -2$ or equivalent form such as $[-5, -2)$. The notation must be correct

(d)(ii)

B1: $f(x) \dots 2$ but allow $f \dots 2$, $y \dots 2$ or $[2, \infty)$. Do not allow with x

Question Number	Scheme	Marks
6 (a)	Position vector of a general point on $l_1 = \begin{pmatrix} -3+2\lambda \\ 0+1\lambda \\ 5-3\lambda \end{pmatrix}$ $\begin{pmatrix} -3+2\lambda \\ 0+1\lambda \\ 5-3\lambda \end{pmatrix} \cdot \begin{pmatrix} 2 \\ 1 \\ -3 \end{pmatrix} = 0 \Rightarrow -6+4\lambda + \lambda -15+9\lambda = 0 \Rightarrow \lambda = \frac{3}{2}$ Substitute $\lambda = \frac{3}{2}$ into $\begin{pmatrix} -3+2\lambda \\ 0+1\lambda \\ 5-3\lambda \end{pmatrix} \Rightarrow P = \left(0, \frac{3}{2}, \frac{1}{2}\right)$	M1, A1 dM1, A1 (4)
(b)	Lines intersect when $\begin{pmatrix} -3 \\ 0 \\ 5 \end{pmatrix} + \lambda \begin{pmatrix} 2 \\ 1 \\ -3 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} + \mu \begin{pmatrix} 4 \\ a \\ -2 \end{pmatrix}$ Solves $-3+2\lambda = 4\mu$ and $5-3\lambda = -2\mu \Rightarrow \lambda = \frac{7}{4}, \mu = \frac{1}{8}$ Uses $\mu a = \lambda \Rightarrow \frac{1}{8}a = \frac{7}{4} \Rightarrow a = 14$	M1, A1 dM1, A1 (4)
(c)	For Example: Attempts $\mu \begin{pmatrix} 4 \\ a \\ -2 \end{pmatrix}$ o.e. with their a and $\mu \Rightarrow Q = \left(\frac{1}{2}, \frac{7}{4}, -\frac{1}{4}\right)$	M1, A1 (2)
6 (a) ALT way	$OP^2 = (-3+2\lambda)^2 + (\lambda)^2 + (5-3\lambda)^2 = 14\lambda^2 - 42\lambda + 34$ Find the value of λ at the minimum, e.g. $\frac{d(OP^2)}{d\lambda} = 28\lambda - 42 = 0 \Rightarrow \lambda = \frac{3}{2}$ Substitute $\lambda = \frac{3}{2}$ into $\begin{pmatrix} -3+2\lambda \\ 0+1\lambda \\ 5-3\lambda \end{pmatrix} \Rightarrow P = \left(0, \frac{3}{2}, \frac{1}{2}\right)$	M1, A1 dM1, A1 (4)
		(10 marks)

(a)

M1: Sets up an equation and solves to find λ .

For example, attempts $\begin{pmatrix} -3+2\lambda \\ 0+1\lambda \\ 5-3\lambda \end{pmatrix} \cdot \begin{pmatrix} 2 \\ 1 \\ -3 \end{pmatrix} = 0 \Rightarrow -6+4\lambda+\lambda-15+9\lambda=0 \Rightarrow \lambda=...$

Alternatively attempts to find the distance OP^2 and finds the value of λ at the minimum. For example,

via differentiation $\frac{d(OP^2)}{d\lambda} = 28\lambda - 42 = 0 \Rightarrow \lambda = ...$ or completing the square

$$OP^2 = 14\lambda^2 - 42\lambda + 34 = 14(\lambda - 1.5)^2 - 14 \times 1.5^2 + 34 \text{ but other methods may exist.}$$

Condone slips, e.g. signs, but the overall method must be sound

A1: Achieves $\lambda = \frac{3}{2}$ following M1. **Achieving this by setting the x coordinate = 0 scores 0 marks**

dM1: Uses their value of λ (found using a correct method) to find the coordinates or position vector of P .

If the calculation is not written out it is implied by two correct coordinates for their λ

A1: Correct coordinates or position vector of P .

Withold this mark if the only answer given is written with incorrect notation, e.g. $\left(0\mathbf{i}, \frac{3}{2}\mathbf{j}, \frac{1}{2}\mathbf{k}\right)$

(b)

M1: Set up and solve equations using the x and z components. Condone slips, e.g signs and coefficients as long as the intention is clear. Scored for $-3+2\lambda=4\mu$ and $5-3\lambda=-2\mu \Rightarrow \lambda=..., \mu=...$. The method of solving the simultaneous equations is not important, just look for two equations leading to values for both λ and μ

A1: $\lambda = \frac{7}{4}, \mu = \frac{1}{8}$ o.e

dM1: Dependent upon previous M. Scored for a **correct** method of using the y components to find the value for a .

Look for ' λ ' = ' μ ' $\times a \Rightarrow a = \frac{'\lambda'}{'\mu'}$

A1: $a = 14$. Condone an equivalent value such as $\frac{56}{4}$

(c)

M1: Uses the equation of either line to find the coordinates or position vector of Q .

It is dependent upon the first M mark in part (b)

Look for an attempt at $\mu \begin{pmatrix} 4 \\ a \\ -2 \end{pmatrix}$ with their a and μ OR $\begin{pmatrix} -3+2\lambda \\ 0+1\lambda \\ 5-3\lambda \end{pmatrix}$ with their λ

If the calculation is not explicitly seen it can be implied by two correct coordinates for their values

A1: $Q = \left(\frac{1}{2}, \frac{7}{4}, -\frac{1}{4}\right)$ or correct position vector.

Withold this mark if the only answer given is written with incorrect notation, e.g. $\left(\frac{1}{2}\mathbf{i}, \frac{7}{4}\mathbf{j}, -\frac{1}{4}\mathbf{k}\right)$ but

only penalise this the first time it occurs....so not in both (a) and (c).

Question Number	Scheme	Marks
7(a)	$x^2 \tan \frac{\pi}{4} + \frac{32}{\pi^2} \times \left(\frac{\pi}{4}\right)^2 = 11 \Rightarrow x^2 = (9)$ $x = \pm 3$	M1 A1 (2)
(b)	Attempt at chain rule $y^2 \rightarrow \dots y \frac{dy}{dx}$ Attempt at product rule $x^2 \tan y \rightarrow x^2 \sec^2 y \frac{dy}{dx} + \dots x \tan y$ Correct differentiation $2x \tan y + x^2 \sec^2 y \frac{dy}{dx} + \frac{64y}{\pi^2} \frac{dy}{dx} = 0$ Substitutes $x = 3, y = \frac{\pi}{4} \Rightarrow 18 \frac{dy}{dx} + 6 + \frac{16}{\pi} \frac{dy}{dx} = 0 \Rightarrow \frac{dy}{dx} = -\frac{3\pi}{8+9\pi}$	M1 M1 A1 dM1, A1 (5)
(c)	Calculates the gradient of the tangent at Q is $-\frac{3\pi}{8+9\pi}$ "o.e." $(\text{grad of tan to } C \text{ at } P) \times (\text{grad of norm to } C \text{ at } Q) = -\frac{3\pi}{8+9\pi} \times -\frac{8+9\pi}{3\pi} = 1$	M1 A1 (2)
		(9 marks)

(a)

M1: Substitutes $y = \frac{\pi}{4}$ in equation of curve and proceeds to $x^2 = \dots$ using $\tan \frac{\pi}{4} = 1$

This may be implied by $x^2 + \dots = \dots \Rightarrow x = \dots$

A1: $x = \pm 3$ following the award of M1

(b)

M1: Attempts at chain rule $y^2 \rightarrow \dots y \frac{dy}{dx}$

M1: Attempt at product rule $x^2 \tan y \rightarrow x^2 \sec^2 y \frac{dy}{dx} + \dots x \tan y$

A1: Correct differentiation $x^2 \sec^2 y \frac{dy}{dx} + 2x \tan y + \frac{64y}{\pi^2} \frac{dy}{dx} = 0$

You may see different forms such as $\pi^2 x^2 \sec^2 y \frac{dy}{dx} + 2\pi^2 x \tan y + 64y \frac{dy}{dx} = 0$ or

$$x^2 \sec^2 y dy + 2x \tan y dx + \frac{64y}{\pi^2} dy = 0$$

Do not allow $\frac{dy}{dx} = x^2 \sec^2 y \frac{dy}{dx} + 2x \tan y + \frac{64y}{\pi^2} \frac{dy}{dx}$ unless subsequent work is correct

M1: Substitutes $x = 3, y = \frac{\pi}{4}$ into a differentiated function and finds a value for $\frac{dy}{dx}$.

There must be exactly two $\frac{dy}{dx}$ terms, one from differentiating each of y^2 and $x^2 \tan y$

A1: $\frac{dy}{dx} = -\frac{3\pi}{8+9\pi}$ or exact equivalent such as $\frac{-6\pi}{16+18\pi}$ or $-\frac{6}{18+\frac{16}{\pi}}$

(c) Via calculation

M1: Substitutes $x = -3, y = \frac{\pi}{4}$ into a differentiated function and finds a value for $\frac{dy}{dx}$ at Q .

It is a method that must be seen, via embedded values of $x = -3, y = \frac{\pi}{4}$ or else implied by a correct value for their $x = -3, y = \frac{\pi}{4}$ following the calculation of their $\frac{dy}{dx}$ at P .

You may see an attempt at $-\frac{dx}{dy}$ at Q using $x = -3, y = \frac{\pi}{4}$

A1: Achieves the value 1 following correct and exact values for $\frac{dy}{dx}$ at P and $\frac{dy}{dx}$ or $-\frac{dx}{dy}$ at Q

.....

Alt (c) Via reasoning/deduction. To score via this method

- their $\frac{dy}{dx}$ must be of the correct form e.g. $\frac{dy}{dx} = \frac{Ax \tan y}{Bx^2 \sec^2 y + Cy}$
- and at P and Q , the y values are the same and the x values $\pm k$

M1: Subject to the above conditions, deduces that

‘Gradient of tangent at P is m , gradient of tangent at Q is $-m$ ’

A1: Hence gradient of tangent at $P \times$ gradient of normal at Q is $m \times -\frac{1}{-m} = 1$ o.e., following M1

This can only be scored if $\frac{dy}{dx}$ is correct. If unsure send to review

.....

Question Number	Scheme	Marks
8 (a)	States/ uses $V = \lambda r^3 \Rightarrow \frac{dV}{dr} = \mu r^2$ OR $\frac{dV}{dt} = -C$	M1
	Attempts to use $\frac{dV}{dt} = \frac{dV}{dr} \times \frac{dr}{dt} \Rightarrow -C = \mu r^2 \times \frac{dr}{dt}$	dM1
	$\Rightarrow \frac{dr}{dt} = -\frac{C}{4\pi r^2} = -\frac{k}{r^2}$	A1*
		(3)
(b)	$\frac{dr}{dt} = -\frac{k}{r^2} \Rightarrow \int r^2 dr = \int -k dt$	
	$\frac{1}{3} r^3 = -kt + c$	M1 A1
	Uses $t = 0, r = 30$ $9000 = c$	M1
	Substitutes $r = 12, t = 24$ $\frac{1}{3} \times 12^3 = -k \times 24 + 9000 \Rightarrow k = (351)$	ddM1
	$r = \sqrt[3]{27000 - 1053t}$	A1
		(5)
(c)	$27000 - 1053T = 0 \Rightarrow T = \dots$	M1
	awrt 25.6	A1
		(2)
		(10 marks)

(a)

M1: States or uses either $\frac{dV}{dr} = \mu r^2$ with any constant value for μ or any constant e.g. μ (allow any letter) or $\frac{dV}{dt} = -C$ (Allow with k) but **must be a negative** and not given a value such as 1

If the formula for V is used (attempted) condone slips but it must obey $V = \lambda r^3 \Rightarrow \frac{dV}{dr} = \mu r^2$

dM1: Attempts to use $\frac{dV}{dt} = \frac{dV}{dr} \times \frac{dr}{dt}$ o.e. with $\frac{dV}{dt} = -C$ AND $\frac{dV}{dr} = \mu r^2$

$$\Rightarrow -C = \mu r^2 \times \frac{dr}{dt}$$

See the first M1 for conditions on $\frac{dV}{dt}$ and $\frac{dV}{dr}$

A1*: Proceeds to $\frac{dr}{dt} = -\frac{k}{r^2}$ via a correct method. Look for $-C = 4\pi r^2 \times \frac{dr}{dt} \Rightarrow \frac{dr}{dt} = -\frac{C}{4\pi r^2} = -\frac{k}{r^2}$

Condone a proof such as $-C = \mu r^2 \times \frac{dr}{dt} \Rightarrow \frac{dr}{dt} = -\frac{C}{\mu r^2} = -\frac{k}{r^2}$

If candidates had originally used k they must explain why $-\frac{k}{4\pi r^2}$ can be replaced by $-\frac{k}{r^2}$

If the formula for V is used it must be correct $V = \frac{4}{3}\pi r^3 \Rightarrow \frac{dV}{dr} = 4\pi r^2$

(b)

Case 1: If candidates use any value for k e.g. 0.75 (apart from the correct one) they can only score the first two marks in (b). Candidates using $k = 351$ can score all marks.

Case 2: Some candidates have an extra 4π and start (b) with $\frac{dr}{dt} = -\frac{k}{4\pi r^2} \Rightarrow \int 4\pi r^2 dr = \int -k dt$

This should not affect the solution, so condone with any multiple of a constant for all marks

M1: Separates the variables (condoning lack of integral sign) and integrates to a form $\dots r^3 = \dots t (+c)$

Condone the lack of the constant of integration.

A1: Achieves $\frac{1}{3}r^3 = -kt + c$ or equivalent including the $+c$

Note that $r^3 = -3kt + c$ is also correct

M1: Substitutes $t = 0$ and $r = 30$ in their $r^3 = -3kt + c$ to find a non zero value for c .

This may be awarded following any attempt to integrate.

So $t = 0$, $r = 30$ in their $\Rightarrow f(r) = g(t) + c \Rightarrow c = \dots$

ddM1: Substitutes $r = 12$ and $t = 24$ with their non zero value of c to find a non zero value for k .

It is dependent upon BOTH previous M marks. Condone transcription errors on the value of c

A1: $r = \sqrt[3]{27000 - 1053t}$

.....
You may see k and c found in a different order.

For example, $\int_{30}^{12} r^2 dr = \int_0^{24} -k dt \Rightarrow \frac{1}{3}(12^3 - 30^3) = -k(24 - 0) \Rightarrow k = 351$

In cases like this the 2nd M mark would be awarded for the calculation of k

Hence equation would be $\frac{1}{3}r^3 = -351t + c \Rightarrow r^3 = -1053t + c$

(c)

M1: Sets $r = 0$ and finds a value for T .

The equation must be of the form $r = \sqrt[n]{A - Bt}$ o.e. with $A, B > 0$ and n a positive integer

A1: Awrt 25.6 .

Alt (c) Using the fact that the volume decreases at a constant rate

M1: Finds the rate of decrease in volume $\frac{36000\pi - 2304\pi}{24} = (1404\pi)$ and uses this to find the time $\frac{36000\pi}{1404\pi}$

A1: Awrt 25.6

Question Number	Scheme	Marks
9 (a)	$k = \frac{\pi}{2}$ Attempts $y^2 \frac{dx}{dt} = (5 \sin 2t)^2 6 \cos t = 150 \sin^2 2t \cos t$ $= 600 \sin^2 t \cos^3 t$ $V = 600\pi \int_0^{\frac{\pi}{2}} \sin^2 t \cos^3 t \, dt$	B1 M1 dM1 A1 (4)
(b)	$\int \sin^2 t \cos^3 t \, dt = \int \sin^2 t (1 - \sin^2 t) \cos t \, dt$ $= \int \sin^2 t \cos t - \sin^4 t \cos t \, dt$ $= \frac{1}{3} \sin^3 t - \frac{1}{5} \sin^5 t$ $V = 600\pi \left[\frac{1}{3} \sin^3 t - \frac{1}{5} \sin^5 t \right]_0^{\frac{\pi}{2}} = 600\pi \left(\frac{1}{3} - \frac{1}{5} \right) = 80\pi$	M1 dM1 ddM1, A1 (4)
		(8 marks)

(a)

B1: States or uses $k = \frac{\pi}{2}$. This may be scored from work in part (b) if not seen in (a)

M1: Attempts $y^2 \frac{dx}{dt} = (5 \sin 2t)^2 \dots \cos t = \dots \sin^2 2t \cos t$

Condone missing brackets

dM1: Attempts to use $\sin 2t = 2 \sin t \cos t$ in an expression of the form $\dots \sin^2 2t \cos t$ and reaches

$y^2 \frac{dx}{dt} = \dots \sin^2 t \cos^3 t$. Condone $\sin^2 2t \rightarrow 2 \sin^2 t \cos^2 t$ here

A1: $V = 600\pi \int_0^{\frac{\pi}{2}} \sin^2 t \cos^3 t \, dt$ but allow this to be awarded with any k or in fact a constant k

The dt must be present on the final line

(b)

M1: Writes $\sin^2 t \cos^3 t$ in the form $\pm \sin^2 t \cos t \pm \sin^4 t \cos t$

dM1: And integrates to the form $\pm \dots \sin^3 t \pm \dots \sin^5 t$

ddM1: And uses the limits 0 and $\frac{\pi}{2}$ in an expression of the form $\left[\pm \beta \sin^3 t \pm \delta \sin^5 t \right]$

A1: 80π

Alternative method via substitution. Let $u = \sin t \Rightarrow \frac{du}{dt} = \cos t$

M1: Uses $u = \sin t \Rightarrow \frac{du}{dt} = \pm \cos t \Rightarrow \int \sin^2 t \cos^3 t \, dt = \int u^2 (\pm 1 \pm u^2) \, du$

dM1: $\int u^2 (\pm 1 \pm u^2) \, du = \int \pm u^2 \pm u^4 \, du = \pm \alpha u^3 \pm \beta u^5$

ddM1: And uses limits 0 and 1 in an expression of the form $\left[\pm \chi u^3 \pm \delta u^5 \right]$

A1: 80π

Alternative method via $x = 6 \sin t$ using $\frac{dx}{dt} = 6 \cos t$ can be marked as above

$$V = 600\pi \int_0^{\frac{\pi}{2}} \sin^2 t \cos^3 t \, dt = 100\pi \int_0^6 \frac{x^2}{36} \left(1 - \frac{x^2}{36} \right) dx = \frac{100\pi}{36 \times 36} \int_0^6 (36x^2 - x^4) \, dx = \frac{100\pi}{36 \times 36} \left[12x^3 - \frac{1}{5}x^5 \right]_0^6 = 80\pi$$

M1: $\alpha \int x^2 \left(\pm 1 \pm \frac{x^2}{\beta} \right) dx$

dM1: Integrates to a form $\left[\pm \chi x^3 \pm \delta x^5 \right]$

ddM1: Uses limits 0 and 6 in an expression of the form $\left[\pm \chi x^3 \pm \delta x^5 \right]$

A1: 80π

Pearson Edexcel International Advanced Level

Wednesday 14 January 2026

Morning (Time: 1 hour 30 minutes)

Paper

reference

WST01/01A

Mathematics

International Advanced Subsidiary/Advanced Level

Statistics S1

Question Paper

You must have:

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1. The discrete random variable X has the probability distribution given in the table below.

x	-2	1	3	4	6
$P(X=x)$	$\frac{1}{4}$	$\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{12}$	$\frac{1}{6}$

- (a) Write down the value of $F(5)$ (1)
- (b) Find $E(X)$ (2)
- (c) Find $\text{Var}(X)$ (3)

(Total for Question 1 is 6 marks)



2. A sports teacher recorded the number of press-ups done by his students in two minutes. He recorded this information for a Year 7 class and for a Year 11 class.

The back-to-back stem and leaf diagram shows this information.

Totals	Year 7 class		Year 11 class	Totals
(6)	8 7 6 5 5 4	1		
(10)	9 7 7 6 5 4 4 4 2 2	2	0 5 6 9	(4)
(7)	8 7 5 4 3 3 0	3	3 4 5 8 8	(5)
(5)	9 9 7 2 2	4	0 5 6 7 9	(5)
(3)	8 4 0	5	0 3 5 5 6 6 7 7 7 9 9	(11)
		6	0 3 3 3 3 4 8	(7)

Key: 2|4|0 means 42 press-ups for a Year 7 student and 40 press-ups for a Year 11 student

- (a) Find the median number of press-ups for each class. (2)

For the Year 11 class, the lower quartile is 38 and the upper quartile is 59

- (b) Find the lower quartile and the upper quartile for the Year 7 class. (2)

- (c) Use the medians and quartiles to describe the skewness of each of the two distributions. (3)

- (d) Give two reasons why the normal distribution should not be used to model the number of press-ups done by the Year 11 class. (2)

(Total for Question 2 is 9 marks)

3. A publisher collects information about the amount spent on advertising, £ x , and the sales, y books, for some of her publications. She collects information for a random sample of 8 textbooks and codes the data using $v = \frac{x + 50}{200}$ and $s = \frac{y}{1000}$ to give

v	0.60	8.10	4.30	0.40	1.60	6.40	2.50	5.10
s	1.84	6.73	5.95	1.30	2.45	7.46	4.82	6.25

[You may use: $\sum v = 29$ $\sum s = 36.8$ $\sum s^2 = 209.72$ $\sum vs = 177.311$ $S_{vv} = 55.275$]

- (a) Find S_{vs} and S_{ss} (3)

- (b) Calculate the product moment correlation coefficient for these data. (2)

The publisher believes that a linear regression model may be appropriate to describe these data.

- (c) State, giving a reason, whether or not your answer to part (b) supports the publisher's belief. (1)

- (d) Find the equation of the regression line of s on v , giving your answer in the form $s = a + bv$ (4)

- (e) Hence find the equation of the regression line of y on x for the sample of textbooks, giving your answer in the form $y = c + dx$ (3)

The publisher calculated the regression line for a sample of novels and obtained the equation

$$y = 3100 + 1.2x$$

She wants to increase the sales of books by spending more money on advertising.

- (f) State, giving your reasons, whether the publisher should spend more money on advertising textbooks or novels. (2)

(Total for Question 3 is 15 marks)



4. Anju has a bag that contains 5 socks of which 2 are blue.

Anju randomly selects socks from the bag, one sock at a time. She does not replace any socks but continues to select socks at random until she has both blue socks.

The discrete random variable S represents the total number of socks that Anju has selected.

- (a) Write down the value of $P(S = 1)$ (1)
- (b) Find $P(S > 2)$ (3)
- (c) Find $P(S = 3)$ (2)
- (d) Given that the second sock selected is blue, find the probability that Anju selects exactly 3 socks. (2)
- (e) Find $P(S = 5)$ (3)

(Total for Question 4 is 11 marks)

5. The weights, in grams, of a random sample of 48 broad beans are summarised in the table.

Weight in grams (x)	Frequency (f)	Class midpoint (y)
$0.9 < x \leq 1.1$	9	1.0
$1.1 < x \leq 1.3$	12	1.2
$1.3 < x \leq 1.5$	11	1.4
$1.5 < x \leq 1.7$	8	1.6
$1.7 < x \leq 1.9$	3	1.8
$1.9 < x \leq 2.1$	3	2.0
$2.1 < x \leq 2.7$	2	2.4

(You may assume $\sum fy^2 = 101.56$)

A histogram was drawn to represent these data. The $2.1 < x \leq 2.7$ class was represented by a bar of width 1.5 cm and height 1 cm.

- (a) Find the width and height of the $0.9 < x \leq 1.1$ class. (3)
- (b) Give a reason to justify the use of a histogram to represent these data. (1)
- (c) Estimate the mean and the standard deviation of the weights of these broad beans. (4)
- (d) Use linear interpolation to estimate the median of the weights of these broad beans. (2)

One of these broad beans is selected at random.

- (e) Estimate the probability that its weight lies between 1.1 grams and 1.6 grams. (1)

One of these broad beans having a recorded weight of 0.95 grams was incorrectly weighed.

The correct weight is 1.4 grams.

- (f) State, giving a reason, the effect this would have on your answers to part (c). Do not carry out any further calculations. (2)

(Total for Question 5 is 13 marks)



6. The label on a jar of Amy's jam states that the jar contains about 400 grams of jam. For each jar that contains less than 388 grams of jam, Amy will be fined £100. If a jar contains more than 410 grams of jam then Amy makes a loss of £0.30 on that jar.

The weight of jam, A grams, in a jar of Amy's jam has a normal distribution with mean μ grams and standard deviation σ grams. Amy chooses μ and σ so that $P(A < 388) = 0.001$ and $P(A > 410) = 0.0197$

- (a) Find, using standardisation, the value of μ and the value of σ .

(5)

Amy can sell jars of jam containing between 388 grams and 410 grams for a profit of £0.25

- (b) Calculate the expected amount, in £s, that Amy receives for each jar of jam.

(4)

(Total for Question 6 is 9 marks)

7. Events A and B are such that

$$P(A) = 0.5 \quad P(A|B) = \frac{2}{3} \quad P(A' \cup B') = 0.6$$

(a) Find $P(B)$ (3)

(b) Find $P(A'|B')$ (2)

The event C has $P(C) = 0.15$

The events A and C are mutually exclusive.

The events B and C are independent.

(c) Find $P(B \cap C)$ (2)

(d) Draw a Venn diagram to illustrate the events A , B and C and the probabilities for each region. (5)

(Total for Question 7 is 12 marks)

TOTAL FOR PAPER IS 75 MARKS



Please check the examination details below before entering your candidate information

Candidate surname		Other names	
Centre Number		Candidate Number	

Pearson Edexcel International Advanced Level

Wednesday 14 January 2026

Morning (Time: 1 hour 30 minutes) **Paper reference** **WST01/01A**

Mathematics

International Advanced Subsidiary/Advanced Level

Statistics S1

Answer Book

You must have:

Question paper (sent separately)

Mathematical Formulae and Statistical Tables (Yellow), calculator

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Values from the statistical tables should be quoted in full. If a calculator is used instead of the tables, the value should be given to an equivalent degree of accuracy.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 7 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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Question 1

Write the answer to Question 1 on these 2 pages

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Question 1 continued

This is the end of Question 1 answer space. Please turn the page for Question 2 answer space.

(Total for Question 1 is 6 marks)



Question 2

Write the answer to Question 2 on these 2 pages

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Question 2 continued

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(Total for Question 2 is 9 marks)



Question 3

Write the answer to Question 3 on these 4 pages

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DO NOT WRITE IN THIS AREA

Question 3 continued

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DO NOT WRITE IN THIS AREA

Question 3 continued

Lined area for writing answers to Question 3.

This is the end of Question 3 answer space. Please turn the page for Question 4 answer space.

(Total for Question 3 is 15 marks)



Question 4

Write the answer to Question 4 on these 4 pages

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DO NOT WRITE IN THIS AREA



Question 4 continued

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Question 4 continued

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(Total for Question 4 is 11 marks)



Question 5

Write the answer to Question 5 on these 4 pages

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DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA



Question 5 continued

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DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Question 5 continued

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(Total for Question 5 is 13 marks)



Question 6

Write the answer to Question 6 on these 4 pages

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DO NOT WRITE IN THIS AREA



Question 6 continued

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DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Question 6 continued

This is the end of Question 6 answer space. Please turn the page for Question 7 answer space.

(Total for Question 6 is 9 marks)



Question 7

Write the answer to Question 7 on these 3 pages

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DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA



Question 7 continued

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(Total for Question 7 is 12 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (FINAL)

January 2026

Pearson Edexcel International Advanced Level In
Statistics 1

WST01/01A

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January 2026

Question Paper Log Number P87600A

Publication Code WST01_01A_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:

'M' marks

These are marks given for a correct method or an attempt at a correct method. In Mechanics they are usually awarded for the application of some mechanical principle to produce an equation.

e.g. resolving in a particular direction, taking moments about a point, applying a suvat equation, applying the conservation of momentum principle etc.

The following criteria are usually applied to the equation.

To earn the M mark, the equation

- (i) should have the correct number of terms
- (ii) be dimensionally correct i.e. all the terms need to be dimensionally correct

e.g. in a moments equation, every term must be a 'force x distance' term or 'mass x distance', if we allow them to cancel 'g' s.

For a resolution, all terms that need to be resolved (multiplied by sin or cos) must be resolved to earn the M mark.

M marks are sometimes dependent (DM) on previous M marks having been earned.

e.g. when two simultaneous equations have been set up by, for example, resolving in two directions and there is then an M mark for solving the equations to find a particular quantity – this M mark is often dependent on the two previous M marks having been earned.

'A' marks

These are dependent accuracy (or sometimes answer) marks and can only be awarded if the previous M mark has been earned. E.g. M0 A1 is impossible.

'B' marks

These are independent accuracy marks where there is no method (e.g. often given for a comment or for a graph)

A few of the A and B marks may be f.t. – follow through – marks.

3. General Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
 - ft – follow through
 - the symbol $\checkmark$ will be used for correct ft
 - cao – correct answer only
 - cso – correct solution only. There must be no errors in this part of the question to obtain this mark
 - isw – ignore subsequent working
 - awrt – answers which round to
 - SC: special case
 - oe – or equivalent (and appropriate)
 - dep – dependent
 - indep – independent
 - dp decimal places
 - sf significant figures
 - * The answer is printed on the paper
 - $\square$ The second mark is dependent on gaining the first mark
4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.
5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.
6. If a candidate makes more than one attempt at any question:
- If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
7. Ignore wrong working or incorrect statements following a correct answer.

Special notes for marking Statistics exams (for AAs only)

- Any correct method should gain credit. If you cannot see how to apply the mark scheme but believe the method to be correct then please send to review.
- For method marks, we generally allow or condone a slip or transcription error if these are seen in an expression. We do not, however, condone or allow these errors in accuracy marks.

General Principles for Mechanics Marking

(**N.B.** specific mark schemes may sometimes override these general principles)

- Rules for M marks:
 - correct number of terms
 - dimensionally correct
 - all terms that need resolving (i.e. *multiplied* by cos or sin) are resolved
 - only terms that need resolving are resolved
 - +/- errors are condoned
 - sin/cos confusion is condoned
- Omission or extra g in a resolution is an accuracy error not method error.
- Omission of mass from a resolution is a method error.
- Omission of a length from a moments equation is a method error.
- Omission of units or incorrect units is not (usually) counted as an accuracy error.
- DM indicates a dependent method mark, i.e. one that can only be awarded if a previous specified method mark(s) has been awarded.
- Any numerical answer which comes from use of $g = 9.8$ should be given as a decimal to 2 or 3 SF.
- Use of $g = 9.81$ should be penalised once per (complete) question.
 - N.B. Over-accuracy or under-accuracy of correct answers should only be penalised once per complete question. However, premature approximation should be penalised every time it occurs.
- Marks must be entered in the same order as they appear on the mark scheme.
- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c)... then that working can only score marks for that part of the question.
- Accept column vectors in all cases.
- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft

Question Number	Scheme	Marks
1.(a)	$[F(5) =] \quad \frac{5}{6}$	B1 (1)
(b)	$[E(X) =] \quad -2 \times \frac{1}{4} + 1 \times \frac{1}{6} + 3 \times \frac{1}{3} + 4 \times \frac{1}{12} + 6 \times \frac{1}{6} \quad \text{or} \quad \frac{1}{12}(-6 + 2 + 12 + 4 + 12)$ $= \underline{2}$	M1 A1 (2)
(c)	$[E(X^2) =] \quad (-2)^2 \times \frac{1}{4} + 1 \times \frac{1}{6} + 3^2 \times \frac{1}{3} + 4^2 \times \frac{1}{12} + 6^2 \times \frac{1}{6} \quad (\text{o.e.})$ $\text{or} \quad \frac{1}{12}(12 + 2 + 36 + 16 + 72) \quad \text{or} \quad \frac{138}{12} \quad \text{or} \quad \frac{23}{2} \quad (\text{o.e.})$	M1
	$[\text{Var}(X) =] \quad \frac{23}{2} - 2^2 = \underline{7.5} \quad (\text{o.e.})$	M1A1 (3)
Alt(c)	$E(X - \mu)^2 = (-2 - '2')^2 \times \frac{1}{4} + (1 - '2')^2 \times \frac{1}{6} + (3 - '2')^2 \times \frac{1}{3} + (4 - 2)^2 \times \frac{1}{12} + (6 - '2')^2 \times \frac{1}{6}$ $= \underline{7.5} \quad (\text{o.e.})$	M1M1 A1 (3)
	Notes	Total : 6
(a)	B1 for $\frac{5}{6}$ or exact equivalents e.g. $\frac{10}{12}$ or $0.8\dot{3}$ isw	
(b)	M1 for an attempt at $E(X)$ with at least 3 correct products seen. $E(X) \div 5$ (or n) is M0 May be seen as $-\frac{1}{2} + \frac{1}{6} + 1 + \frac{1}{3} + 1$ or may be implied by 2	
A1	2 cao (answer only 2/2 provided no incorrect method is seen)	
(c)	M1 for an attempt at $E(X^2)$ with at least 3 correct products seen. May be seen as $1 + \frac{1}{6} + 3 + \frac{4}{3} + 6$ May be implied by $\frac{23}{2}$ or $E(X^2) \div 5$ (or n) is M0 Allow expression even if labelled as $\text{Var}(X)$	
M1	for using variance formula with correct substitution ft their $E(X)$ and their $E(X^2)$. May be implied by 7.5 provided a correct $E(X^2)$ is seen	
A1	for 7.5 or any exact equivalent e.g. $\frac{15}{2}$ (answer only 3/3 provided no incorrect method is seen)	
Alt(c)	M1 for an attempt at $E(X - \mu)^2$ with at least 3 correct products seen ft on their $E(X)$. May be seen as $4 + \frac{1}{6} + \frac{1}{3} + \frac{1}{3} + \frac{8}{3}$. If answer $\div 5$ (or n) then M0	
M1	for an attempt at $E(X - \mu)^2$ with all 6 correct products seen ft on their $E(X)$. May be seen as e.g. $4 + \frac{1}{6} + \frac{1}{3} + \frac{1}{3} + \frac{8}{3}$ If answer $\div 5$ (or n) then M0	
A1	for 7.5 or any exact equivalent e.g. $\frac{15}{2}$	

Question Number	Scheme		Marks
2.	(a)	(Year 7 median =) 29 (Year 11 median =) 54	B1 B1 (2)
	(b)	(Lower quartile =) 22 (Upper quartile =) 42	B1 B1 (2)
	(c)	Year 7 $Q_3 - Q_2 > Q_2 - Q_1$ e.g. $13 > 7$ Positive skew	Year 11 $Q_3 - Q_2 < Q_2 - Q_1$ e.g. $5 < 16$ Negative skew M1 A1ft A1ft (3)
	(d)	<u>skewed</u> / <u>not symmetrical</u> oe and <u>not continuous</u> oe	B1dB1 (2)
	Notes		Total: 9
	(a)	B1 cao B1 cao	
	(b)	B1 cao B1 cao	
	(c)	M1 for a comparison for either year using their values of Q_1 , Q_2 , and Q_3 e.g. may write $Q_3 - Q_2 > Q_2 - Q_1$ or allow qualitative comparisons e.g. “median is closer to the lower quartile (than the upper quartile)” but not “median is close to the lower quartile” as that is not a comparison condone slips in their calculations for this mark as long as the method is seen. Allow the comparison to be implied if both $Q_3 - Q_2$ and $Q_2 - Q_1$ calculations are seen. A1ft positive skew for Year 7 or ft their Q_1 , Q_2 , and Q_3 and following a correct comparison. If a calculation is seen it must be correct from their values from (a) and (b). Allow right skew. A1ft negative skew for Year 11 ft their Q_2 and following a correct comparison. If a calculation is seen it must be correct from their values from (a) and (b). Allow left skew.	
	(d)	B1 for one valid reason (see below) dB1 dependent on the previous B mark. For two valid reasons (see below) Ignore reference to positive or negative, allow reference to not symmetrical instead of skewed and allow stating e.g. $Q_3 - Q_2 < Q_2 - Q_1$ provided it is correct for their values. Ignore irrelevant non-contradictory statements allow reference to discrete for not continuous (but not discrete uniform) and allow an explanation that a normal distribution requires continuous data oe Do not allow a reason of mean $\neq$ median or $\neq$ mode unless the mean and/or mode is correctly found (mean (awrt 48.8) mode (63)) and median is 54 or 53 seen Do not allow “insufficient data points to make a model”	

Question Number	Scheme	Marks
3.(a)	$[S_{vs}] = 177.311 - \frac{36.8 \times 29}{8} = 43.911 = \text{awrt } \underline{43.9}$ $[S_{ss}] = 209.72 - \frac{36.8^2}{8} = 40.44 = \text{awrt } \underline{40.4}$	A1 M1 A1 (3)
(b)	$r = \frac{"43.911"}{\sqrt{55.275 \times "40.44"}}, = 0.92875... = \text{awrt } \underline{0.929}$	M1, A1 (2)
(c)	e.g. r is close to 1 so there is support for the publisher's belief/data can be described as a linear regression	B1ft (1)
(d)	$b = \frac{"43.911"}{55.275}, = 0.7944... = \text{awrt } \underline{0.79}$ $a = \bar{s} - b\bar{v} = \frac{36.8}{8} - "0.7944..." \times \frac{29}{8} = 4.6 - "0.7944..." \times 3.625 [= 1.720...]$ $\underline{s = 1.72 + 0.794v}$	M1, A1 M1 A1 (4)
(e)	$\frac{y}{1000} = "1.72" + "0.794" \times \left(\frac{x+50}{200} \right)$ $\underline{y = 1920 + 3.97x}$	M1 A1ft A1 (3)
(f)	Gradient of textbooks is greater spend more advertising on textbooks	B1ft dB1ft (2)
		Total: 15
Notes		
(a)	M1 for a correct expression for S_{vs} or S_{ss} may be implied by awrt 43.9 or awrt 40.4 A1 (for S_{vs} =) awrt 43.9 A1 (for S_{ss} =) awrt 40.4 or allow $\frac{1011}{25}$ Condone missing labels	
(b)	M1 for a correct expression for r, ft their 43.911 (but not 177.311) and their 40.44 (not 209.72) A1 for awrt 0.929 (note awrt 0.929 scores 2/2)	
(c)	B1ft for saying it does support the belief oe and giving a suitable reason e.g. strong correlation or as r is close to 1 ft on their value for r. If $r < 0.5$ then allow e.g. "close to 0" so does not support oe condone a reason that 0.929 is approximately 1	

(d)	M1	for a correct expression for b , ft their 43.911 and allow 3sf values to be used. Implied by awrt 0.79
	A1	for awrt 0.79 or allow an exact fraction including the 3sf values e.g. $\frac{439}{553}$
	M1	for a correct method for a , ft their value of b scored for the values correctly substituted or implied by a correct equation
	A1	for equation for s in terms of v with $a = \text{awrt } 1.72$ and $b = \text{awrt } 0.794$
(e)	M1	for correct substitution into their equation. Must be in y and x . May attempt to find summary statistics in terms of x and y before finding the regression line y on x – in such cases it needs to be a fully correct method, allowing 1 slip but correct value for d
	A1ft	for $d = \text{awrt } 3.97$ (accept awrt 4.0) <u>or</u> $5 \times (\text{their } b)$ (correct to 2 sig. figs.) provided M1 is scored
	A1	for $c = \text{awrt } 1920$ (to 3sf) provided M1 is scored
(f)	B1ft	for a suitable comparison based on gradients, following through on their gradients Condone comparison of ' $3.97x$ ' and ' $1.2x$ '. Must be a comparison not just stating a fact. Does not need to be in context. Ignore other statements provided they do not contradict the comparison Do not allow substituting in values unless it is used to compare gradients i.e. they would need to substitute in at two different values for x (or v) for both lines.
	dB1ft	dependent on the previous B mark. It is for recommending spend more on advertising textbooks (allow "yes" to mean spending more on advertising textbooks). Must be consistent with their correct comparison from their equations. If gradient in (e) < 1.2 then a comparison of gradients leading to spending on novels.

Question Number	Scheme	Marks
4. (a)	$[P(S = 1) =] 0$	B1 (1)
(b)	$[P(S > 2) =] 1 - P(S = 2)$ or $[P(S > 2) =] P(S = 3) + P(S = 4) + P(S = 5)$ $= 1 - \left(\frac{2}{5} \times \frac{1}{4}\right) = \frac{9}{10}$ $= \frac{3}{5} \times \frac{2}{4} \times \frac{1}{3} \times 2 + \frac{3}{5} \times \frac{2}{4} \times \frac{2}{3} \times \frac{1}{2} \times 6 + \frac{3}{5} \times \frac{2}{4} \times \frac{1}{3}$ $= \frac{1}{5} + \frac{3}{5} + \frac{1}{10} = \frac{9}{10}$	M1 M1 A1 (3)
Alt(b)	$[P(S > 2) =] P(\text{at most one blue in first 2})$ $= \frac{3}{5} \times \frac{2}{4} + 2 \times \frac{3}{5} \times \frac{2}{4} = \frac{9}{10}$	M1 M1A1 (3)
(c)	$[P(S = 3) =] \left(\frac{3}{5} \times \frac{2}{4} \times \frac{1}{3} + \frac{2}{5} \times \frac{3}{4} \times \frac{1}{3}\right) = \frac{1}{5}$	M1 A1 (2)
(d)	$[P(S = 3 2\text{nd is blue}) =] \frac{P(S = 3 \cap 2\text{nd is blue})}{P(2\text{nd is blue})} = \frac{\frac{3}{5} \times \frac{2}{4} \times \frac{1}{3}}{\frac{3}{5} \times \frac{2}{4} + \frac{2}{5} \times \frac{1}{4}} = \frac{\frac{1}{10}}{\frac{2}{5}} = \frac{1}{4}$	M1 A1 (2)
(e)	$[P(S = 5) =] 4 \times \left(\frac{3}{5} \times \frac{2}{4} \times \frac{1}{3} \times \frac{2}{2} \times \frac{1}{1}\right) = \frac{2}{5}$	B1 M1 A1 (3)
Alt(e)	$[P(S = 5) =] 1 - P(2 \leq S \leq 4) = 1 - \frac{1}{10} - \frac{1}{5} - \frac{3}{10} = \frac{2}{5}$	B1M1A1
Notes		Total: 11
(a)	B1 cao	
(b)	M1 for writing or using $1 - P(S = 2)$ or $P(S = 3) + P(S = 4) + P(S = 5)$. Condone $1 - P(S \leq 2)$	
	M1 for a correct expression for $P(S = 2)$ or $P(S = 3) + P(S = 4) + P(S = 5)$ Ignore labelling. May be implied by $\frac{1}{10}$ or $\frac{9}{10}$ but not if from an incorrect method. May see use of combinations e.g. $\frac{1}{5C_2}$	
	A1 $\frac{9}{10}$ oe	
	Note: $P(S > 2) = P(S = 3) + P(S = 4) + P(S = 5)$ send to review	
Alt(b)	M1 for explaining or indicating that there is at most one blue in the first 2	
	M1 for a correct expression	
	A1 $\frac{9}{10}$ oe	

- (c) M1 for both correct products (or $2 \times \dots$) and no others. May see use of combinations e.g. $\frac{2}{5C_2}$. May be implied by $\frac{1}{5}$ oe
- Give benefit of the doubt if $\frac{3}{5} \times \frac{2}{4} \times \frac{2}{3}$ oe on its own is seen where the x2 is within the calculation of one product
- A1 $\frac{1}{5}$ oe

- (d) M1 for a correct ratio of probabilities expression (in symbols or described) or ft their values (num<denom).
Do not withhold this mark if they subsequently proceed to e.g. multiply $P(S = 3)$ and $P(2\text{nd is blue})$ in the numerator (assuming independence)
May see use of combinations e.g. $\frac{1}{4C_1}$. May be implied by $\frac{1}{4}$ oe
- A1 $\frac{1}{4}$ oe

- (e) B1 for $\times 4$ or the sum of 4 identical products
- M1 for any one product correct. May use combinations e.g. $\frac{1}{5C_2}$
- A1 $\frac{2}{5}$ oe (note correct answer scores 3/3)

- Alt(e) B1 for writing $1 - (P(S = 2) + P(S = 3) + P(S = 4))$ oe Condone $1 - P(S \leq 4)$
- M1 for an attempt at the three terms with at least one product correct
- A1 $\frac{2}{5}$ oe (note correct answer scores 3/3)

NOTE:

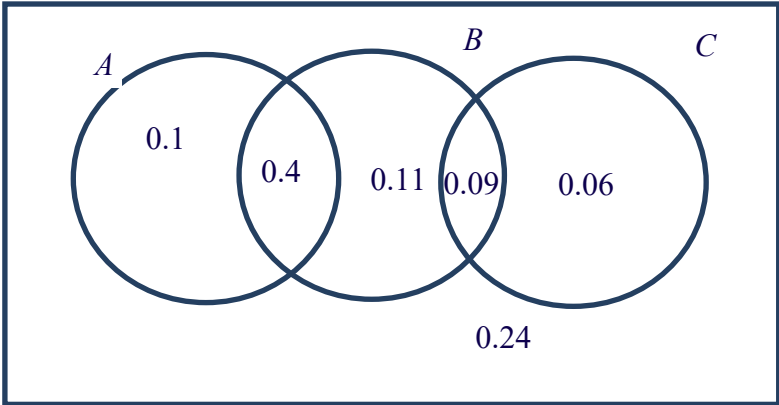
s	2	3	4	5
$P(S = s)$	$\frac{1}{10}$	$\frac{1}{5}$	$\frac{3}{10}$	$\frac{2}{5}$

Note Allow MR using 5 + 2 socks. Deduct up to 2 A1 marks

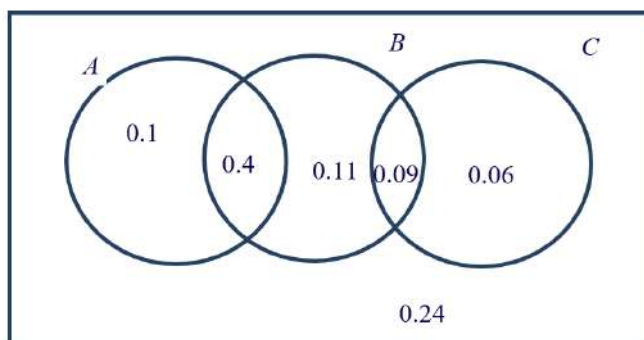
Question Number	Scheme	Marks
5(a)	$0.9 < x \leq 1.1$ group - width 0.5 (cm) e.g. $1.5 \text{ (cm}^2\text{)}$ is 2 seeds <u>or</u> $6.75 \text{ (cm}^2\text{)}$ is 9 seeds) <u>or</u> $0.5c = 6.75$ oe <u>or</u> 45 <u>or</u> $\frac{10}{3}$ $0.9 < x \leq 1.1$ group - height 13.5 (cm)	B1 M1 A1 (3)
(b)	The data are continuous oe	B1 (1)
(c)	Mean = $\frac{67.8}{48} = 1.4125$ awrt 1.41 condone $\frac{113}{80}$ $\sigma = \sqrt{\frac{101.56}{48} - \left(\frac{67.8}{48}\right)^2} = 0.347\dots$ awrt 0.347 ($s =$ awrt 0.351)	B1 M1dM1A1 (4)
(d)	Median = $[1.3] + \frac{3}{11} \times 0.2$ allow $(n+1) = [1.3] + \frac{3.5}{11} \times 0.2$ = awrt 1.35 (or if using $(n+1)$ allow awrt 1.36)	M1 A1 (2)
(e)	$\frac{27}{48} = \frac{9}{16}$ or 0.5625 or 0.563	B1 (1)
(f)	Mean increases AND standard deviation decreases e.g. the 0.95 increases to 1.4 and is now closer the mean	B1 dB1 (2)
Notes		Total: 13
(a)	B1 correct width. May see width = 1.5 copied from the question so look for subsequent work which appears to be their width if not clearly labelled M1 for attempting to find the scale factor. A correct equation in any form scores this mark e.g. $\frac{1.5}{2} = \frac{0.5h}{9}$. Also score for sight of 6.75 ignore any labelling May use the formula height of class = $k \times \frac{\text{frequency}}{\text{class width}} \Rightarrow 1 = k \left(\frac{2}{2.7 - 2.1} \right)$ Score for sight of $\frac{10}{3}$ or 45 which may also be seen in $\frac{\frac{10}{3}}{1} = \frac{45}{h}$ May be implied by a correct height. A1 correct height	
(b)	B1 for a valid reason that the data are continuous oe e.g. allow not discrete Do not allow continuous <u>uniform</u> distribution	
(c)	B1 awrt 1.41 – cannot be scored if only seen within the calculation for the variance. Condone as a fraction but not $\frac{67.8}{48}$	

(d)	M1	attempt at $\frac{101.56}{48} - \mu^2$ no need for square root (allow s). May attempt $\sum fy^2$ using the table – look for an attempt with at least 3 correct products. May be implied by awrt 0.12 or $\frac{2317}{19200}$ or if s then $\frac{2317}{18800}$. May be implied by awrt 0.35
	dM1	dep on previous method mark for using $\sqrt{\frac{101.56}{48} - \mu^2}$ allow s May be implied by awrt 0.35
	A1	awrt 0.347 (or if using sample sd then awrt 0.351)
	M1	for a correct fraction: $[1.3] + \frac{3}{11} \times 0.2$ or $m = 1.5 - \frac{8}{11} \times 0.2$ or alternatively allow the equation: $\frac{24-21}{m-1.3} = \frac{11}{0.2}$ oe May be implied by $\frac{149}{110}$ May be implied by awrt 1.35 or if using $n+1$ then awrt 1.36
	A1	awrt 1.35 (note 1.3545 may be rounded to 1.355 which is fine) If using $(n+1)$ then allow awrt 1.36) Do not accept a fraction
(e)	B1	awrt 0.563
(f)	B1	for suggesting the mean increases and sd decreases
	dB1	dependent on the previous B mark. Gives complete reasoning why the mean increases and sd decreases. May refer to $\sum fy$ increasing which increases the mean instead of specifically referencing 0.95 condone use of e.g. close for closer ignore any non-contradictory statements

Question Number	Scheme	Marks								
6. (a)	$[P(A < 388) = 0.001 \Rightarrow] \frac{388 - \mu}{\sigma} = \pm z$ (where $ z > 2.25$)	M1								
	So $388 - \mu = -3.0902\sigma$ (o.e.)									
	$[P(A > 410) = 0.0197 \Rightarrow] \frac{410 - \mu}{\sigma} = \pm z$ (where $1 < z < 2.5$)	M1								
	So $410 - \mu = 2.06\sigma$ (o.e.)									
	So $22 = 5.1502\sigma$ (calc gives 5.1502323...) $\Rightarrow \mu = \dots, \sigma = \dots$	dM1								
	$\sigma = 4.2716\dots$ (awrt 4.27) and $\mu = 401.20\dots$ (awrt 401)	A1, A1								
(b)	[Let $X = \text{profit in } \pounds$]									
	<table><tr><td>x</td><td>-100</td><td>-0.30</td><td>0.25</td></tr><tr><td>$P(X = x)$</td><td>0.001</td><td>0.0197</td><td>$1 - (0.001 + 0.0197) = 0.9793$</td></tr></table>	x	-100	-0.30	0.25	$P(X = x)$	0.001	0.0197	$1 - (0.001 + 0.0197) = 0.9793$	M1
x	-100	-0.30	0.25							
$P(X = x)$	0.001	0.0197	$1 - (0.001 + 0.0197) = 0.9793$							
	$E(X) = -100 \times 0.001 - 0.30 \times 0.0197 + 0.25 \times "0.9793"$	M1								
	$= 0.138915\dots$ awrt (£) 0.14	A1								
		(4)								
Notes		Total: 9								
(a)	M1 for an attempt to standardise with 388 and set equal to $\pm a z$ value where $ z > 2.25$									
	M1 for an attempt to standardise with 410 and set equal to $\pm a z$ value where $1 < z < 2.5$									
	Note standardisation is required so M1M1 is required to score dM1A1A1									
	dM1 dependent on both of the previous Ms. For solving their 2 linear equations and proceeding to values for σ and μ									
	You do not need to check the mechanics of solving which may be via a calculator. May be implied by correct values for σ and μ									
	A1 for $\sigma = \text{awrt } 4.27$ (must come from accurate z -values – 3sf or better seen somewhere in their solution)									
	A1 for $\mu = \text{awrt } 401$ Note (M1M1M1A0A1 is possible)									
	Note that if they form two the equations $388 - \mu = 3.0902\sigma$ and $410 - \mu = -2.06\sigma$ this leads to $\sigma = \text{awrt } -4.27$ $\mu = \text{awrt } 401$ which is A0A0									
(b)	M1 for 3 correct values of x including signs which may be embedded in a calculation									
	M1 for an attempt to find $P(388 < A < 410)$ (correct numerical expression for 0.9793) or implied by 0.9793 Look out for valid attempts at using their part (a) and standardising to find $P(388 < A < 410)$ which can still score this mark.									
	M1 dep on any 3 values of X and 3 probs. For an expression for $E(X)$ using their value for $P(388 < A < 410)$ condone sign slips for this mark									
	A1 for awrt 0.14 (so don't insist on 2dp). Condone awrt 14p									
	Accept 0.13 if correct answer is seen beforehand									

Question Number	Scheme	Marks
7(a)	$P(A \cap B) = 0.4$ $P(A B) = \frac{0.4}{P(B)}$ $\frac{0.4}{P(B)} = \frac{2}{3}$ $P(B) = 0.6$	B1 M1 A1 (3)
(b)	$P(A' B') = \frac{0.5 + 0.4 - 0.6}{0.4} = \frac{3}{4}$ or $\frac{"0.24" + "0.06"}{0.4} = \frac{3}{4}$	M1A1 (2)
(c)	$P(B \cap C) = 0.6 \times 0.15$ $= 0.09$	M1 A1 (2)
(d)		M1 M1 M1 A1ft A1 (5)
		Total 12
	Notes	
	Mark parts (a), (b), (c) and (d) together. If there is a contradiction between the Venn diagram and the relevant part then the answer stated in the relevant part takes precedence.	
(a)	B1 $P(A \cap B) = 0.4$ oe may be implied by further work. May be seen on the Venn diagram in (d) M1 sets $\frac{\text{their } 0.4}{P(B)} = \frac{2}{3}$ (must be numerical) May be implied by 0.6 A1 $[P(B) =] 0.6$ oe (correct answer with no incorrect working seen 3/3)	

- (b) M1 May attempt e.g.
- $$\frac{P(A' \cap B')}{P(B')} = \frac{P(A') + P(B') - P((A \cap B)')}{P(B')} = \frac{1 - (P(A) + P(B) - P(A \cap B))}{P(B')}$$
- OR $\frac{P(C \cap B') + P((A \cup B \cup C)')}{P(B')}$
- Must see the values substituted in**
- e.g. $\frac{0.5 + \text{their } 0.4 - \text{their } 0.6}{1 - \text{their } 0.6}$ or $\frac{1 - (0.5 + \text{their } 0.6 - \text{their } 0.4)}{\text{their } (0.1 + 0.24 + 0.06)}$
- or $\frac{\text{their } 0.24 + \text{their } 0.06}{\text{their } (0.1 + 0.24 + 0.06)}$
- provided num < denom and both are probabilities
- A1 $\frac{3}{4}$ oe (correct answer with no incorrect working seen scores 2/2)
- (c) M1 their (a) $\times 0.15$ (provided $0 < \text{their (a)} < 1$) – may be implied by their 0.09. You may need to check this on your calculator.
- A1 0.09 oe (correct answer with no incorrect working seen scores 2/2). Allow to be scored if seen on the Venn diagram in (d)
- (d) M1 3 overlapping circles labelled A, B and C oe where $P(A \cap C) = 0$ See main scheme diagram. May appear in a different order. Condone two of the circles to be labelled implying the labelling of the third.
- M0 if one circle lies entirely inside another or if one is entirely separate (usually C) Do not allow blanks as zeros.
- M1 for the two sections of C look for $P(B \cap C) = \text{their } 0.09$ **and** $P(C \cap B') = 0.15 - \text{their } 0.09$ from (c) both non-zero
- M1 for the two sections of A look for $P(A \cap B) = \text{their } 0.4$ from (a) and $P(A \cap B') = 0.5 - \text{their } 0.4$ from (a) both non-zero
- A1ft **dep on all previous method marks.** For 0.24 or prob outside so that all 6 probs add to 1 or ft on their diagram
- A1 all correct including a box and all three labels.



Note: No labels allow access to 2nd and 3rd M1 marks ONLY

Please check the examination details below before entering your candidate information

Candidate surname

Other names

Centre Number

Candidate Number

Pearson Edexcel International Advanced Level

Wednesday 14 January 2026

Morning (Time: 1 hour 30 minutes)

Paper
reference

WST01/01

Mathematics

**International Advanced Subsidiary/Advanced Level
Statistics S1**

You must have:

Mathematical Formulae and Statistical Tables (Yellow), calculator

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Values from the statistical tables should be quoted in full. If a calculator is used instead of the tables, the value should be given to an equivalent degree of accuracy.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 7 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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1. The marks of a group of 31 students in a Statistics test are summarised by the stem and leaf diagram below.

Mark	Totals	Key: 2 6 represents 26 marks
1 8	(1)	
2 6	(1)	
3 2 4 7	(3)	
4 0 6 6 7 8 9	(6)	
5 0 0 1 2 3 5 6 7 9	(9)	
6 2 2 3 3 5 8	(6)	
7 2 4 8	(3)	
8 5	(1)	
9 0	(1)	

- (a) Find the median and the interquartile range of the marks of these students.

(3)

An outlier is defined as a mark that is

either more than $1.5 \times$ interquartile range above the upper quartile
or more than $1.5 \times$ interquartile range below the lower quartile

- (b) On the grid provided on page 3, draw a box plot to represent the marks of the students, indicating clearly any outliers.

(5)

Three students asked for their marks to be checked.

- The mark for student A was changed from 47 to 43
- The mark for student B was changed from 49 to 43
- The mark for student C was changed from 90 to 94

- (c) Explain the effects that these three changes would have on the box plot drawn in part (b).

- Show your calculations clearly
- You do **not** need to draw the new box plot

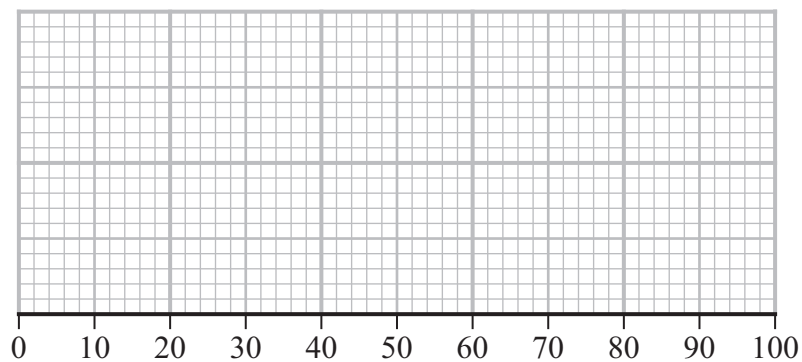
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Turn over for a spare grid if you need to redraw your box plot.



Question 1 continued

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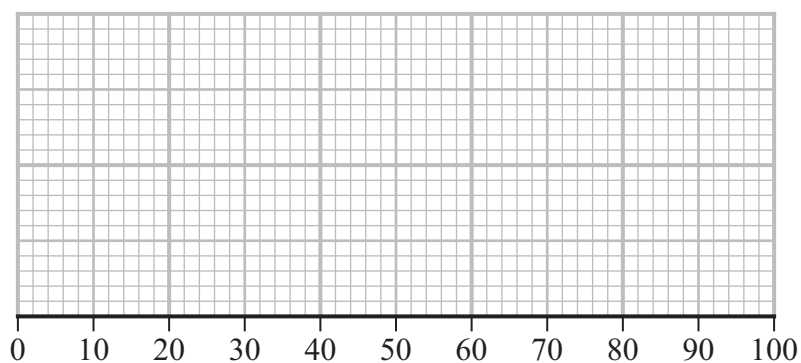
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Question 1 continued

Only use this grid if you need to redraw your box plot.



(Total for Question 1 is 12 marks)



2. A biologist is studying the noises made by dolphins. The biologist records the frequency, f kHz, of the noise made by a dolphin at 10 different sea depths, d m.

Some summary statistics are given below.

$$\bar{d} = 25.7 \quad \sum f = 15 \quad \sum f^2 = 25.5 \quad \sum df = 433.5 \quad S_{dd} = 1090.6$$

- (a) Find the value of S_{ff} and the value of S_{df} (3)
- (b) State, giving a reason, which is the response variable. (1)
- (c) Calculate the value of the product moment correlation coefficient for these data. (2)
- (d) Give an interpretation of your answer to part (c) (1)
- (e) Find the equation of the least squares regression line of f on d , giving your answer in the form $f = \alpha + \beta d$ (3)
- (f) Give an interpretation of (2)
- (i) the gradient of your regression line,
- (ii) the f intercept of your regression line.



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Question 2 continued

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Question 2 continued

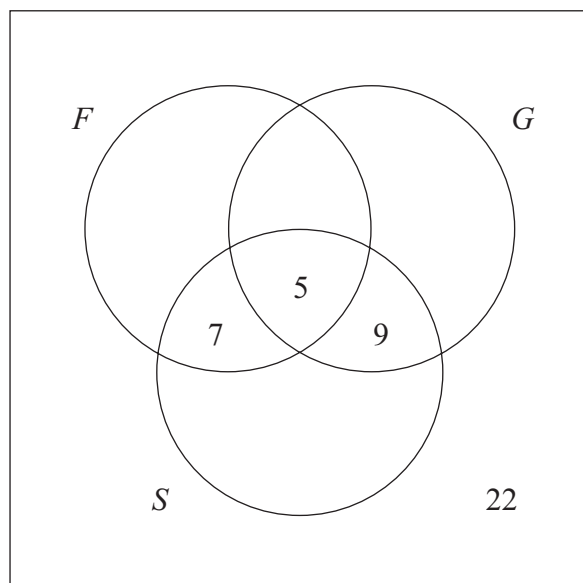
Handwriting practice area with horizontal lines.

(Total for Question 2 is 12 marks)



3. In a survey 120 people were each asked which of the countries France (F), Germany (G) and Spain (S) they had visited.

The incomplete Venn diagram gives some information about the results of the survey.



A person from the survey is chosen at random.

- (a) Find the probability that

- of these three countries, this person only visited France and Spain,
- this person did not visit any of these three countries.

(2)

Given that

- of the 52 people who had visited France, 9 also visited Germany
- $P(F \cup G) = \frac{41}{60}$

- (b) complete the Venn diagram.

(4)

- (c) Find

- $P(F' \cap G')$
- $P(F \cap G | S)$

(3)



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Question 3 continued

(Total for Question 3 is 9 marks)



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4. The discrete random variable X has the following probability distribution

x	0	2	3
$P(X = x)$	a	$2b$	b

where a and b are constants.

The cumulative distribution function of X is given by

x	0	2	3
F(x)	$\frac{1}{2}$	c	d

where c and d are constants.

- (a) Find

- (i) the value of a
- (ii) the value of d
- (iii) the value of b
- (iv) the value of c

(6)

- (b) Find

- (i) $E(12X + 4)$

(3)

- (ii) $\text{Var}(12X + 4)$

(4)



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Question 4 continued

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Question 4 continued

(Total for Question 4 is 13 marks)

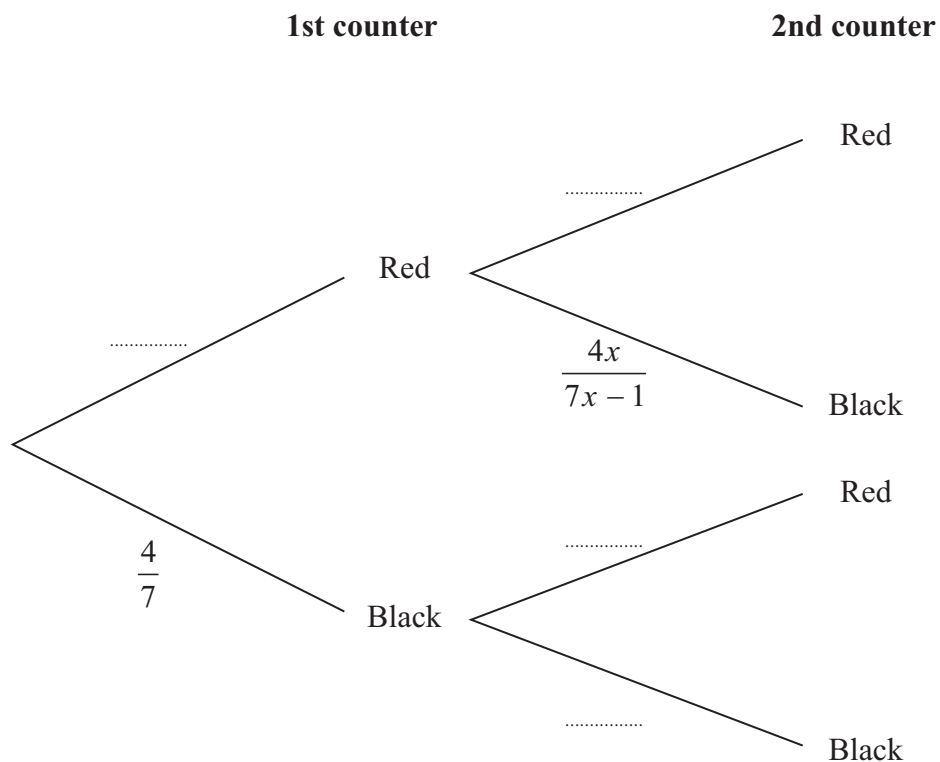


5. There are $7x$ counters in a box.

The box contains red and black counters only, in the ratio 3 : 4

Two counters are selected at random, one at a time without replacement, from the box.

(a) Complete the tree diagram for this information.



(3)

The probability that the two counters selected are different colours is $\frac{32}{63}$

(b) Find the total number of counters in the box before the two counters are selected.

(4)

Given that the second counter is red,

(c) find the probability that the first counter is black.

(3)



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Question 5 continued

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Question 5 continued

Lined area for writing the answer to Question 5.

(Total for Question 5 is 10 marks)



6. The random variable X has a discrete uniform distribution where

$$P(X = x) = \frac{1}{5} \quad \text{for } x = 1, 2, 3, 4, 5$$

- (a) Find $P(X + 2 < 3X - 4)$ (2)

- (b) Find $E(X^2)$ (2)

Given that $E(aX + 5) = 6$ where a is a constant,

- (c) find the value of $\text{Var}(3 - aX)$
You must show your working. (6)



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Question 6 continued

(Total for Question 6 is 10 marks)



7. The time taken, X minutes, to complete an olympic triathlon is modelled by a normal distribution with mean 180 minutes and standard deviation 20 minutes.

- (a) Using standardisation, show that the proportion of competitors that take longer than 210 minutes to complete an olympic triathlon is 6.68% according to the model.

(2)

Russell is preparing for an olympic triathlon. Russell aims to finish in the first 15% of all competitors.

- (b) Using standardisation, estimate the longest time that Russell can take to complete the triathlon and achieve his aim, according to the model.

(3)

The time taken, Y minutes, to complete a sprint triathlon is modelled by a normal distribution with mean μ minutes and standard deviation σ minutes.

Given that $P(Y < \mu + 5) = 0.7967$

- (c) (i) find $P(Y < \mu - 5 \mid Y < \mu)$

(2)

- (ii) Show that, to the nearest whole number, $\sigma = 6$

(2)



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Question 7 continued

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(Total for Question 7 is 9 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (Final)

January 2026

Pearson Edexcel International Advanced Level In
Statistics 1

WST01/01

Edexcel and BTEC Qualifications

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January 2026

Question Paper Log Number P78914A

Publication Code WST01_01_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:

'M' marks

These are marks given for a correct method or an attempt at a correct method. In Mechanics they are usually awarded for the application of some mechanical principle to produce an equation.

e.g. resolving in a particular direction, taking moments about a point, applying a suvat equation, applying the conservation of momentum principle etc.

The following criteria are usually applied to the equation.

To earn the M mark, the equation

- (i) should have the correct number of terms
- (ii) be dimensionally correct i.e. all the terms need to be dimensionally correct

e.g. in a moments equation, every term must be a 'force x distance' term or 'mass x distance', if we allow them to cancel 'g' s.

For a resolution, all terms that need to be resolved (multiplied by sin or cos) must be resolved to earn the M mark.

M marks are sometimes dependent (DM) on previous M marks having been earned.

e.g. when two simultaneous equations have been set up by, for example, resolving in two directions and there is then an M mark for solving the equations to find a particular quantity – this M mark is often dependent on the two previous M marks having been earned.

'A' marks

These are dependent accuracy (or sometimes answer) marks and can only be awarded if the previous M mark has been earned. E.g. M0 A1 is impossible.

'B' marks

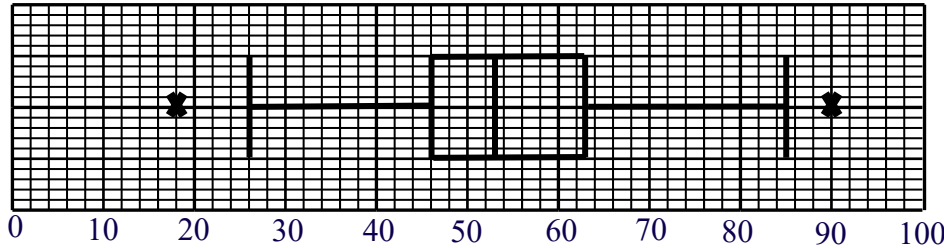
These are independent accuracy marks where there is no method (e.g. often given for a comment or for a graph)

A few of the A and B marks may be f.t. – follow through – marks.

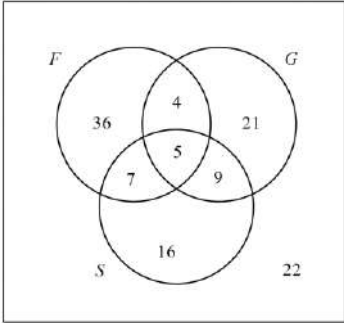
3. General Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
 - ft – follow through
 - the symbol $\checkmark$ will be used for correct ft
 - cao – correct answer only
 - cso – correct solution only. There must be no errors in this part of the question to obtain this mark
 - isw – ignore subsequent working
 - awrt – answers which round to
 - SC: special case
 - oe – or equivalent (and appropriate)
 - dep – dependent
 - indep – independent
 - dp decimal places
 - sf significant figures
 - * The answer is printed on the paper
 - $\square$ The second mark is dependent on gaining the first mark
4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.
5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.
6. If a candidate makes more than one attempt at any question:
- If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
7. Ignore wrong working or incorrect statements following a correct answer.

Question Number	Scheme		Marks
1 (a)	Median = 53		B1
	IQR = 63 – 46		M1
	= 17		A1
			(3)
(b)	'46' – 1.5 × '17' or '63' + 1.5 × '17'		M1
	20.5 and 88.5		A1
			M1 A1ft B1
			(5)
(c)	Lower Quartile changes from 46 to 43		B1
	Lower outlier boundary is now 13 or upper outlier bounday is now 93		M1
	So, X removed at 18 and lower whisker extended to 18 oe		A1
	X at 90 moved to 94		A1
	[All other points remain the same]		(4)
	Notes		Total 12
(a)	B1	Cao	
	M1	For an attempt at IQR. Either Q ₁ or Q ₃ must be correct.	
	A1	Cao	
(b)	M1	For use of either LQ – 1.5 × IQR or UQ + 1.5 × IQR ft their LQ/UQ and their IQR May be implied by 20.5 or 88.5 or a fully correct box plot with outliers plotted correctly	
	A1	Cao May be implied by a fully correct box plot with outliers plotted correctly	
	M1	For a box with an upper and lower whisker	
	A1ft	For a box with an upper and lower whisker and the LQ, median and UQ plotted correctly ft their values [Allow ½ square tolerance]	
	B1	For lower whisker plotted at 26 or their 20.5 and upper whisker plotted at 85 or their 88.5 and only 2 outliers marked at 18 and 90	
(c)	B1	For LQ changes to 43	
	M1	For 13 or 93 identified as the new outlier boundaries	
	A1	Dep on 13 being identified as the new outlier boundary. For outlier removed at 18 and lower whisker extended to 18 (Do not accept the lower whisker is extended to 13)	
	A1	Dep on 93 being identified as the new outlier boundary. For outlier at 90 moved to 94 [and whisker extended to 93 – Ignore any reference to the upper whisker]	

Question Number	Scheme		Marks
2 (a)	$S_{ff} = 25.5 - \frac{15^2}{10}$ $S_{df} = 433.5 - \frac{(25.7 \times 10) \times 15}{10}$		M1
	$S_{ff} = 3$ $S_{df} = 48$		A1 A1
			(3)
(b)	f since the frequency depends on the depth (d) oe		B1
			(1)
(c)	$\frac{'48'}{\sqrt{1090.6 \times '3'}} = 0.8391...$ awrt 0.839		M1 A1
			(2)
(d)	As the depth (d) increases the frequency (f) increases		B1ft
			(1)
(e)	$\beta = \frac{'48'}{1090.6} [= 0.04401...]$		M1
	$\alpha = \frac{15}{10} - '\beta' \times 25.7 [= 0.3688...]$		M1
	$f = 0.369 + 0.0440d$		A1
			(3)
(f) (i)	For every extra metre of depth, the frequency increases by '0.044' [kHz] oe		B1ft
(ii)	[Assuming the model is valid,] the frequency at the surface would be '0.369' [kHz] oe		B1ft
			(2)
	Notes		Total 12
(a)	M1	For a correct method to find either S_{ff} or S_{df} May be implied by a correct answer	
	A1	For $S_{ff} = 3$	
	A1	For $S_{df} = 48$	
(b)	B1	f identified with a correct reason e.g. f and is dependent on.../affected by.../changed by.../influenced by... determined by d or f and reference to d being controlled e.g. f since d is the variable that is controlled	
(c)	M1	For a correct method to calculate the PMCC follow through their S_{ff} and S_{df} May be implied by awrt 0.839	
	A1	awrt 0.839	
(d)	B1ft	A correct interpretation follow through their part (c) e.g. As d increases f increases. Ignore any reference to numbers	
(e)	M1	A correct method to find the gradient ft their S_{df} May be implied by awrt 0.04 or $\frac{240}{5453}$	
	M1	A correct method to find the f intercept ft their β May be implied by awrt 0.37 or $\frac{4023}{10906}$	
	A1	For a correct equation, with α = awrt 0.369 and β = awrt 0.044 Allow $\alpha = \frac{4023}{10906}$ and $\beta = \frac{240}{5453}$ Must be in terms of f and d only	
(f) (i)	B1ft	A correct interpretation, follow through their β . Must have the units metre oe	
(ii)	B1ft	A correct interpretation, follow through their α Allow $d = 0$ to imply 'at the surface'	

Question Number	Scheme		Marks
3 (a)(i)	$\frac{7}{120}$		B1
(ii)	$\frac{22}{120}$		B1
			(2)
(b)			B1 M1 A1 B1ft
			(4)
(c)(i)	$\left[P(F' \cap G') = \frac{'16'+22}{120} \right] = \frac{19}{60}$		B1ft
(ii)	$\left[P(F \cap G S) = \right] \frac{5}{7+5+9+'16'}$		M1
	$= \frac{5}{37}$		A1
			(3)
	Notes		Total 9
(a)(i)	B1	Oe Allow 0.058 or better	
(ii)	B1	Oe Allow 0.183 or better	
(b)	B1	For 36 and 4 in the correct place on the Venn diagram	
	M1	For $2 \times 41 - 7 - 5 - 9 - '36' - '4'$ or $\frac{41}{60} = \frac{'52'}{120} + \frac{'18'+x}{120} - \frac{'9'}{120}$ (May be implied by 21) If $'36'+ '4'+ '21' = 61$ this will imply this mark	
	A1	For 21 in the correct place on the Venn diagram	
	B1ft	For 16 in the correct place on the Venn diagram or ft their Venn diagram (total = 120)	
(c)(i)	B1ft	For $\frac{19}{60}$ oe or ft their 16 Allow 0.317 or better	
(ii)	M1	For a correct method to find the conditional probability ft their 16	
	A1	Oe Allow 0.135 or better	

Question Number	Scheme		Marks
4 (a)(i)(ii)	$a = \frac{1}{2}$		B1
(ii)	$d = 1$		B1
(iii)	$a + 3b = 1 \Rightarrow \frac{1}{2} + 3b = 1 \Rightarrow b = \frac{1}{6}$		M1A1
(iv)	$a + 2b = c \Rightarrow \frac{1}{2} + 2 \times \frac{1}{6} = c$ or $d - b = c \Rightarrow 1 - \frac{1}{6} = c$ So $c = \frac{5}{6}$		M1A1
			(6)
(b) (i)	$E(X) = \left[0 \times \frac{1}{2} \right] + 2 \times \frac{1}{3} + 3 \times \frac{1}{6} \left[= \frac{7}{6} \right]$	4, 28 and 40 seen	M1
	$E(12X + 4) = 12E(X) + 4 = 12 \times \frac{7}{6} + 4 = 18$	$4 \times \frac{1}{2} + 28 \times \frac{1}{3} + 40 \times \frac{1}{6} = 18$	M1 A1
			(3)
(ii)	$E(X^2) = \left[0^2 \times \frac{1}{2} \right] + 2^2 \times \frac{1}{3} + 3^2 \times \frac{1}{6} \left[= \frac{17}{6} \right]$	16, 784 and 1600 seen oe	M1
	$\text{Var}(X) = \frac{17}{6} - \left(\frac{7}{6} \right)^2 \left[= \frac{53}{36} \right]$	$4^2 \times \frac{1}{2} + 28^2 \times \frac{1}{3} + 40^2 \times \frac{1}{6} [= 536]$	M1
	$\text{Var}(12X + 4) = 12^2 \text{Var}(X) = 144 \times \frac{53}{36} = 212$	$536 - 18^2 = 212$	M1 A1
			(4)
	Notes		Total 13
(a) (i)	B1	Cao	
(ii)	B1	Cao	
(iii)	M1	For writing or using of $a + 3b = 1$ ft their a provided $0 < a < 1$ May be implied by $b = \frac{1}{6}$	
	A1	Allow awrt 0.167	
(iv)	M1	For writing or using of $a + 2b = c$ ft their a and their b provided $0 < a < 1$ and $0 < b < 1$ or $d - b = c$ ft their d and their b provided $0 < d < 1$ and $0 < b < 1$ May be implied by $c = \frac{5}{6}$	
	A1	Allow awrt 0.833	
(b) (i)	M1	For use of $\sum xP(X = x)$ ft their a and their b provided $0 < b < 1$ (We do not need to see 0×0.5) Allow $\sum xP(X = x) = 7b$ or writing/using 4, 28 and 40	
	M1	For use of $12E(X) + 4$ ft their $E(X)$ Allow $E(12X + 4) = 84b + 4$ or use of $\sum xP(X = x)$ if using 4, 28 and 40 ft their a and their b provided $0 < a < 1$ and $0 < b < 1$ Allow $\sum xP(X = x) = 4a + 96b$	
	A1	Cao	
(ii)	M1	For use of $\sum x^2P(X = x)$ ft their a and their b , provided $0 < b < 1$ (We do not need to see $0^2 \times 0.5$). Allow $\sum x^2P(X = x) = 17b$ or writing/using 16, 784 and 1600 May be implied by the 2 nd M mark	
	M1	For use of $\text{Var}(X) = E(X^2) - E(X)^2$ ft their $E(X^2)$ and their $E(X)$ Allow $\text{Var}(X) = 17b - 49b^2$ or use of $\sum x^2P(X = x)$ if using 16, 784 and 1600 ft their a and their b provided $0 < a < 1$ and $0 < b < 1$ Allow $\sum x^2P(X = x) = 16a - 3168b$	
	M1	For use of $12^2 \text{Var}(X)$ ft their $\text{Var}(X)$ Allow $2448b - 7056b^2$ or $\text{Var}(X) = E(X^2) - E(X)^2$ if using 16, 784 and 1600 Allow $16a - 3168b - (4a + 96b)^2$	
	A1	Cao	

Question Number	Scheme			Marks	
5 (a)			$\frac{3}{7}$ in the correct place on the tree diagram	B1	
			$\frac{3x-1}{7x-1}$ in the correct place on the tree diagram	B1	
			$\frac{3x}{7x-1}$ and $\frac{4x-1}{7x-1}$ in the correct place on the tree diagram	B1	
				(3)	
(b)	$\frac{3}{7} \times \frac{4x}{7x-1} + \frac{4}{7} \times \frac{3x}{7x-1} = \frac{32}{63}$		$\frac{3}{7} \times \frac{4x}{7x-1} = \frac{16}{63}$	$\frac{4}{7} \times \frac{3x}{7x-1} = \frac{16}{63}$	M1
	$\frac{24x}{7x-1} = \frac{32}{9} \Rightarrow x = 4$		$\frac{12x}{7x-1} = \frac{16}{9} \Rightarrow x = 4$	$\frac{12x}{7x-1} = \frac{16}{9} \Rightarrow x = 4$	dM1 A1
	[So $7 \times '4' =$]28 counters in total				dA1ft
					(4)
(c)	$P(B \text{ and } R) = \frac{4}{7} \times \frac{12}{27} = \frac{16}{63}$ or $P(BR \text{ and } RR) = \frac{4}{7} \times \frac{12}{27} + \frac{3}{7} \times \frac{11}{27} = \frac{3}{7}$				M1
	$P(\text{1st black} \text{2nd Red}) = \frac{\frac{4}{7} \times \frac{12}{27}}{\frac{4}{7} \times \frac{12}{27} + \frac{3}{7} \times \frac{11}{27}} = \frac{16}{27}$				M1 A1
					(3)
Notes					Total 10
(a)	B1	for $\frac{3}{7}$ in the correct place on the tree diagram. Allow $\frac{3x}{7x}$			
	B1	for $\frac{3x-1}{7x-1}$ in the correct place on the tree diagram Allow equivalent expressions e.g. $1 - \frac{4x}{7x-1}$			
	B1	both $\frac{3x}{7x-1}$ and $\frac{4x-1}{7x-1}$ in the correct place on the tree diagram. Allow equivalent expressions			
(b)	M1	for setting their $P(\text{two counters are different colours}) = \frac{32}{63}$ or $P(R \text{ and } B) = \frac{16}{63}$ or $P(B \text{ and } R) = \frac{16}{63}$ ft their tree diagram			
	dM1	Dependent on previous M mark. For an attempt to simplify the probability expression leading to $x = \dots$ (At least one correct step needed) May be implied by $x = 4$			
	A1	for $x = 4$			
	dA1ft	Dep on 2 nd M mark. Ft their x provided x is a positive integer			
(c)	M1	For a correct probability expression for either $P(B \text{ and } R)$ or $P(BR \text{ and } RR)$ ft their tree diagram and their x , provided that x is an integer Allow expressions given in terms of x e.g. $\frac{4}{7} \times \frac{3x}{7x-1}$ or $\frac{4}{7} \times \frac{3x}{7x-1} + \frac{3}{7} \times \frac{3x-1}{7x-1}$ ft their tree diagram			
	M1	For a correct ratio of probabilities ft their tree diagram and their x , provided that x is an integer Allow expressions given in terms of x e.g. $\frac{\frac{4}{7} \times \frac{3x}{7x-1}}{\frac{4}{7} \times \frac{3x}{7x-1} + \frac{3}{7} \times \frac{3x-1}{7x-1}}$ ft their tree diagram			
	A1	Allow awrt 0.593			

Question Number	Scheme		Marks
6 (a)	$[P(X+2 < 3X-4) =]P(X > 3) = \frac{2}{5}$		M1 A1
			(2)
(b)	$E(X^2) = \frac{1}{5}(1^2 + 2^2 + 3^2 + 4^2 + 5^2) = 11$		M1 A1
			(2)
(c)	$E(X) = 3$		B1
	$\text{Var}(X) = '11' - ('3')^2 [= 2] \text{ or } \frac{25-1}{12} \text{ or } \frac{(5+1)(5-1)}{12}$		M1
	$E(aX+5) = 6 \Rightarrow '3'a + 5 = 6$		M1
	$a = \frac{1}{3}$		A1
	$\text{Var}(3-aX) \Rightarrow \left(\frac{1}{3}\right)^2 \times '2'$		M1
	$= \frac{2}{9}$		A1
			(6)
	Notes		Total 10
(a)	M1	For rearranging to $P(X > 3)$ Allow $P(3 < X)$ or $x > 3$ or identifying that $P(X=4)$ and $P(X=5)$ are needed e.g $6 < 8$ and $7 < 11$ identified	
	A1	For $\frac{2}{5}$ oe NB $\frac{2}{5}$ with no incorrect working seen scores M1A1 Watch out for $P(X < 3) = \frac{2}{5}$ which scores M0A0	
(b)	M1	For a correct method to find $E(X^2)$ May be implied by $E(X^2) = 11$	
	A1	Cao	
(c)	B1	For $E(X) = 3$ May be seen in an expression for $\text{Var}(X)$ or implied by a correct value for $\text{Var}(X)$ ft their $E(X^2)$ or implied by $a = \frac{1}{3}$ Allow if seen in part (b)	
	M1	For a correct method to find $\text{Var}(X)$ ft their $E(X^2)$ and their $E(X)$	
	M1	For writing or using $aE(X) + 5 = 6$ ft their $E(X)$ May be implied by $a = \frac{1}{3}$	
	A1	For $\frac{1}{3}$ oe Allow 0.333	
	M1	Use of $\text{Var}(3-aX) = a^2\text{Var}(X)$ ft their a and their $\text{Var}(X)$ May be implied by $\text{Var}(3-aX) = \frac{2}{9}$	
	A1	For $\frac{2}{9}$ oe allow awrt 0.222	

Question Number	Scheme		Marks
7 (a)	$P(X > 210) = P\left(Z > \frac{210-180}{20}\right)$		M1
	$= P(Z > 1.5) = 1 - 0.9332 = 0.0668$ So 6.68%*		A1*
			(2)
(b)	$\frac{n-180}{20} = -1.0364$		M1 B1
	$n = 159.272$	awrt 159	A1
			(3)
(c)(i)	$P(Y < \mu - 5 \mid Y < \mu) = \frac{1-0.7967}{0.5}$		M1
	$= 0.4066$	awrt 0.407	A1
			(2)
(ii)	$\frac{5}{\sigma} = 0.83$		M1
	$\sigma = \frac{5}{0.83} = 6.02... \text{ So } \sigma = 6 *$		A1*
			(2)
	Notes		Total 9
(a)	M1	For standardising using 210, 180 and 20 (Standardisation must be seen)	
	A1*	Answer is given so no incorrect working can be seen 0.0668 is sufficient for this mark	
(b)	M1	For standardising using any letter, 180 and 20 = z value, where $1 < z < 1.5$	
	B1	For -1.0364 or better Allow 1.0364 or better	
	A1	awrt 159 NB M1B0A1 is possible	
(c)(i)	M1	For a correct method to find the conditional probability	
	A1	awrt 0.407	
(ii)	M1	For use of 0.83 or better (calc 0.82989...) in an equation with σ only. Allow $\frac{\mu+5-\mu}{\sigma} = 0.83$	
	A1*	Answer is given so no incorrect working can be seen awrt 6.02 – awrt 6.025 is sufficient for this mark	

Pearson Edexcel International Advanced Level

Tuesday 20 January 2026

Morning (Time: 1 hour 30 minutes)

**Paper
reference**

WST02/01A

Mathematics

International Advanced Subsidiary/Advanced Level

Statistics S2

Question Paper

You must have:

Answer book (sent separately).

Do not return this question paper with the answer book.

Turn over ►

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1. A shop sells rods of nominal length 200 cm. The rods are bought from a manufacturer who uses a machine to cut rods of length L cm, where $L \sim N(\mu, 0.2^2)$

The value of μ is such that there is only a 5% chance that the rod, selected at random from those supplied to the shop, will have a length less than 200 cm.

- (a) Find the value of μ to one decimal place. (3)

A customer buys a random sample of 8 of these rods.

- (b) Find the probability that at least 3 of these rods will have a length less than 200 cm. (3)

Another customer buys a random sample of 60 of these rods.

- (c) Using a suitable approximation, find the probability that more than 5 of these rods will have length less than 200 cm. (3)

(Total for Question 1 is 9 marks)

2. The random variable $X \sim B(10, p)$

- (a) (i) Write down an expression for $P(X = 3)$ in terms of p
(ii) Find the value of p such that $P(X = 3)$ is 16 times the value of $P(X = 7)$ (4)

The random variable $Y \sim \text{Po}(\lambda)$

- (b) Find the value of λ such that $P(Y = 3)$ is 5 times the value of $P(Y = 5)$ (3)

The random variable $W \sim B(n, 0.4)$

- (c) Find the value of n and the value of α such that W can be approximated by the normal distribution, $N(32, \alpha)$ (3)

(Total for Question 2 is 10 marks)



3. The continuous random variable X has cumulative distribution function given by

$$F(x) = \begin{cases} 0 & x < 0 \\ \frac{1}{6}x(x+1) & 0 \leq x \leq 2 \\ 1 & x > 2 \end{cases}$$

- (a) Find the value of a such that $P(X > a) = 0.4$
Give your answer to 3 significant figures.

(3)

- (b) Use calculus to find

(i) $E(X)$

(ii) $\text{Var}(X)$

(Solutions relying on calculator technology are not acceptable.)

(8)

(Total for Question 3 is 11 marks)

4. A company claims that 35% of its peas germinate. In order to test this claim Ann decides to plant 15 of these peas and record the number which germinate.

- (a) (i) State suitable hypotheses for a two tailed test of this claim.

- (ii) Using a 5% level of significance, find an appropriate critical region for this test.
The probability in each of the tails should be as close to 2.5% as possible.

(4)

- (b) Ann found that 8 of the 15 peas germinated. State whether or not the company's claim is supported. Give a reason for your answer.

(2)

- (c) State the actual significance level of this test.

(1)

(Total for Question 4 is 7 marks)

5. A string of length 40 cm is cut into 2 pieces at a random point.
The continuous random variable L represents the length of the longer piece of string.

(a) Write down the distribution of L (2)

(b) Find the probability that the length of the longer piece of string is 28 cm to the nearest cm. (2)

Each piece of string is used to form the perimeter of a square.

(c) Calculate the probability that the area of the larger square is less than 64 cm^2 (3)

(d) Calculate the probability that the difference in area between the two squares is greater than 81 cm^2 (4)

(Total for Question 5 is 11 marks)



6. The continuous random variable X has probability density function $f(x)$ given by

$$f(x) = \begin{cases} \frac{1}{20}x^3 & 0 \leq x \leq 2 \\ \frac{1}{10}(6-x) & 2 < x \leq 6 \\ 0 & \text{otherwise} \end{cases}$$

(a) Sketch the graph of $f(x)$ for all values of x (3)

(b) Write down the mode of X (1)

(c) Show that $P(X > 2) = 0.8$ (2)

(d) Define fully the cumulative distribution function $F(x)$ (4)

Given that $P(X < a \mid X > 2) = \frac{5}{8}$

(e) find the value of $F(a)$ (2)

(f) Hence, or otherwise, find the value of a . Give your answer to 3 significant figures. (3)

(Total for Question 6 is 15 marks)

7. Members of a conservation group record the number of sightings of a rare animal. The number of sightings follows a Poisson distribution with a rate of 1 every 2 months.
- (a) Find the smallest value of n such that the probability that there are at least n sightings in 2 months is less than 0.05 (2)
- (b) Find the smallest number of months, m , such that the probability of no sightings in m months is less than 0.05 (2)
- (c) Find the probability that there is at least 1 sighting per month in each of 3 consecutive months. (3)
- (d) Find the probability that the number of sightings in an 8 month period is equal to the expected number of sightings for that period. (2)
- (e) Given that there were 4 sightings in a 4 month period, find the probability that there were more sightings in the last 2 months than in the first 2 months. (3)

(Total for Question 7 is 12 marks)

TOTAL FOR PAPER IS 75 MARK



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Please check the examination details below before entering your candidate information

Candidate surname		Other names	
Centre Number		Candidate Number	

Pearson Edexcel International Advanced Level

Tuesday 20 January 2026

Morning (Time: 1 hour 30 minutes) **Paper reference** **WST02/01A**

Mathematics

International Advanced Subsidiary/Advanced Level

Statistics S2

Answer Book

You must have:

Question paper (sent separately)

Mathematical Formulae and Statistical Tables (Yellow), calculator

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Values from the statistical tables should be quoted in full. If a calculator is used instead of the tables, the value should be given to an equivalent degree of accuracy.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 7 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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Question 1

Write the answer to Question 1 on these 2 pages

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Question 1 continued

This is the end of Question 1 answer space. Please turn the page for Question 2 answer space.

(Total for Question 1 is 9 marks)



Question 2

Write the answer to Question 2 on these 4 pages

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Question 2 continued

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Question 2 continued

This is the end of Question 2 answer space. Please turn the page for Question 3 answer space.

(Total for Question 2 is 10 marks)



Question 3

Write the answer to Question 3 on these 4 pages

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Question 3 continued

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Question 3 continued

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(Total for Question 3 is 11 marks)



Question 4

Write the answer to Question 4 on these 2 pages

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Question 4 continued

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(Total for Question 4 is 7 marks)



Question 5

Write the answer to Question 5 on these 4 pages

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Question 5 continued

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Question 5 continued

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(Total for Question 5 is 11 marks)



Question 6

Write the answer to Question 6 on these 4 pages

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Question 6 continued

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Question 6 continued

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(Total for Question 6 is 15 marks)



Question 7

Write the answer to Question 7 on these 3 pages

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Question 7 continued

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(Total for Question 7 is 12 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (Final)

January 2026

International Advanced Level in Statistics

S2 WST02_01A

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January 2026

Question Paper Log Number P87601A

Publication Code WST02_01A_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)

Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN:

- bod – benefit of doubt
 - ft – follow through
 - the symbol $\surd$ will be used for correct ft
 - cao – correct answer only
 - cso – correct solution only. There must be no errors in this part of the question to obtain this mark
 - isw – ignore subsequent working
 - awrt – answers which round to
 - SC – special case
 - oe – or equivalent (and appropriate)
 - d... or dep – dependent
 - indep – independent
 - dp – decimal places
 - sf – significant figures
 - * – The answer is printed on the paper or ag- answer given
 - $\square$ or d... – The second mark is dependent on gaining the first mark
4. All A marks are 'correct answer only' (cao), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. If you are using the annotation facility on ePEN, indicate this action by 'MR' in the body of the script.
6. If a candidate makes more than one attempt at any question:
 - a) If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - b) If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
7. Ignore wrong working or incorrect statements following a correct answer.

1. A shop sells rods of nominal length 200 cm. The rods are bought from a manufacturer who uses a machine to cut rods of length L cm, where $L \sim N(\mu, 0.2^2)$

The value of μ is such that there is only a 5% chance that the rod, selected at random from those supplied to the shop, will have a length less than 200 cm.

- (a) Find the value of μ to one decimal place.

(3)

A customer buys a random sample of 8 of these rods.

- (b) Find the probability that at least 3 of these rods will have a length less than 200 cm.

(3)

Another customer buys a random sample of 60 of these rods.

- (c) Using a suitable approximation, find the probability that more than 5 of these rods will have length less than 200 cm.

(3)

(Total for Question 1 is 9 marks)

Question Number	Scheme		Marks
1(a)	$\frac{200-\mu}{\sqrt{0.04}}=-1.6449$		M1 A1
	$\mu=200.3$		A1
			(3)
(b)	$X\sim B(8, 0.05)$		B1
	$P(X\geq 3)=1-P(X\leq 2)=1-0.9942$		M1
	$=0.0058$	awrt 0.0058	A1
			(3)
(c)	$Y\sim \text{Po}(3)$		B1
	$P(Y>5)=1-P(Y\leq 5)=1-0.9161$		M1
	$=0.0839$	awrt 0.0839	A1
			(3)
	Notes		Total 9
1(a)	M1	$\pm \frac{200-\mu}{\sqrt{0.04}}=\pm z$ value, where $ z >1$	
	A1	For a correct equation with compatible z value and $z=1.6449$ or better	
	A1	200.3 Condone awrt 200.3 NB M1A0A1 is possible	
(b)	B1	Writing or using $B(8, 0.05)$ May be implied by e.g. 0.9428 or 0.9996 or 0.0571 or 0.0004 or awrt 0.0058	
	M1	Writing or using $1-P(X\leq 2)$	
	A1	Awrt 0.0058	
(c)	B1	Writing or using $\text{Po}(3)$ May be implied by e.g. 0.8153 or 0.9665 or 0.1847 or 0.0335 or awrt 0.0839	
	M1	Writing or using $1-P(Y\leq 5)$	
	A1	Awrt 0.0839	

2. The random variable $X \sim B(10, p)$

(a) (i) Write down an expression for $P(X = 3)$ in terms of p

(ii) Find the value of p such that $P(X = 3)$ is 16 times the value of $P(X = 7)$

(4)

The random variable $Y \sim \text{Po}(\lambda)$

(b) Find the value of λ such that $P(Y = 3)$ is 5 times the value of $P(Y = 5)$

(3)

The random variable $W \sim B(n, 0.4)$

(c) Find the value of n and the value of α such that W can be approximated by the normal distribution, $N(32, \alpha)$

(3)

(Total for Question 2 is 10 marks)

Question Number	Scheme		Marks
2(a)(i) (ii)	$120(p)^3(1-p)^7$		B1
	$[^{10}C_3](p)^3(1-p)^7 = [^{10}C_7]16(p)^7(1-p)^3$ or their (a) = $[^{10}C_7]16(p)^7(1-p)^3$		M1
	$(1-p)^4 = 16(p)^4 \Rightarrow (1-p) = 2(p)$ or $15p^4 + 4p^3 - 6p^2 + 4p - 1 = 0$ oe		M1
	$p = \frac{1}{3}$		A1
			(4)
(b)	$\frac{e^{-\lambda} \lambda^3}{3!} = 5 \frac{e^{-\lambda} \lambda^5}{5!}$		M1
	$4 = \lambda^2$		M1
	$\lambda = 2$		A1
			(3)
(c)	$np = 32$		M1
	$n = 80$		A1
	$\alpha = 19.2$		A1
			(3)
	Notes		Total 10
(a)(i)	B1	Allow equivalent expressions e.g. $^{10}C_3(p)^3(1-p)^7$	
(ii)	M1	correct equation ft their (a)(i) (condone missing binomial coefficients) but 16 must be on the correct side.	
	M1	Attempt to solve their equation as far as a linear equation in p or a correct quartic equation May be implied by $3p^2 + 2p - 1 = 0$ oe Implied by $p = \frac{1}{3}$ If 16 is on the wrong side then their correct quartic is $15p^4 - 64p^3 + 96p^2 - 64p + 16 = 0$ oe Implied by $p = \frac{2}{3}$	
	A1	For $\frac{1}{3}$ or an exact equivalent (condone 0.333 or better). If other roots shown they must be rejected. Allow 3/3 for correct answer only in (ii)	
(b)	M1	correct equation	
	M1	attempt to solve their equation as far as $\lambda^2 = k$ or $\lambda = \sqrt{k}$.	
	A1	for $\lambda = 2$ only	
(c)	M1	Writing or using of $np = 32$ Allow any value of p provided $0 < p < 1$ Implied by $n = 80$	
	A1	$n = 80$	
	A1	$\alpha = 19.2$ NB M1A0A1 is possible	

3. The continuous random variable X has cumulative distribution function given by

$$F(x) = \begin{cases} 0 & x < 0 \\ \frac{1}{6}x(x+1) & 0 \leq x \leq 2 \\ 1 & x > 2 \end{cases}$$

- (a) Find the value of a such that $P(X > a) = 0.4$
Give your answer to 3 significant figures.

(3)

- (b) Use calculus to find

(i) $E(X)$

(ii) $\text{Var}(X)$

(Solutions relying on calculator technology are not acceptable.)

(8)

(Total for Question 3 is 11 marks)

Question Number	Scheme		Marks	
3(a)	$\frac{1}{6}a(a+1)=0.6$		M1	
	$a^2+a-3.6=0$ So $a=\frac{-1\pm\sqrt{1+4\times3.6}}{2}$		M1	
	$=1.462\dots$ awrt 1.46		A1	
			(3)	
(b)(i)	$[f(x)=\frac{d}{dx}F(x)]=\frac{1}{3}x+\frac{1}{6}$		M1A1	
	$[E(X)]=\int_0^2x\left(\frac{1}{3}x+\frac{1}{6}\right)dx$		M1	
	$=\left[\frac{x^3}{9}+\frac{x^2}{12}\right]_0^2$		A1	
	$=\frac{11}{9}$ awrt 1.22		A1	
	(ii)	$[Var(X)]=\int_0^2x^2\left(\frac{1}{3}x+\frac{1}{6}\right)dx-\left(\frac{11}{9}\right)^2$		M1
		$=\left[\frac{x^4}{12}+\frac{x^3}{18}\right]_0^2-\left(\frac{11}{9}\right)^2$		A1ft
		$=\frac{23}{81}$ awrt 0.284		A1
				(8)
	Notes		Total 11	
(a)	M1	putting $F(x)=0.6$ or $1-0.4$		
	M1	attempting either completing the square or quadratic formula (one slip allowed) (condone + instead of $\pm$) Must set $F(a)=0.6$ or $F(a)=0.4$ to score this mark May be implied by awrt 1.46 or awrt -2.46 (if set = 0.4 then may be implied by awrt 1.13 or awrt -2.13)		
	A1	awrt 1.46 (must reject other root if stated)		
(b)(i)	M1	attempting to differentiate $F(x)$ at least one $x^n\rightarrow x^{n-1}$ May be seen in part a		
	A1	Cao		
	M1	attempting $\int_0^2xf(x)dx$ at least one $x^n\rightarrow x^{n+1}$ using their $f(x)$ which must be a changed function from $F(x)$. No need for limits		
	A1	For $\frac{x^3}{9}+\frac{x^2}{12}$ (may be unsimplified) Ignore limits		
	A1	Awrt 1.22		
(ii)	M1	M1 attempting $\int x^2f(x)dx$ at least one $x^n\rightarrow x^{n+1}$ using their $f(x)$ which must be a changed function from $F(x)$. Ignore limits.		
	A1ft	For $\frac{x^4}{12}+\frac{x^3}{18}-\mu^2$ (may be unsimplified) Ft their $E(X)$. Ignore limits. The subtraction may be seen after the evaluation of $E(X^2)$		
	A1	Awrt 0.284		

4. A company claims that 35% of its peas germinate. In order to test this claim Ann decides to plant 15 of these peas and record the number which germinate.
- (a) (i) State suitable hypotheses for a two tailed test of this claim.
- (ii) Using a 5% level of significance, find an appropriate critical region for this test. The probability in each of the tails should be as close to 2.5% as possible. (4)
- (b) Ann found that 8 of the 15 peas germinated. State whether or not the company's claim is supported. Give a reason for your answer. (2)
- (c) State the actual significance level of this test. (1)

(Total for Question 4 is 7 marks)

Question Number	Scheme		Marks
4(a)(i) (ii)	$H_0 : p = 0.35 \quad H_1 : p \neq 0.35$		B1
	B(15,0.35)		M1
	CR $X \leq 1 \cup X \geq 10$		A1A1
			(4)
(b)	8 is not in CR/Do not reject H_0 /Not significant		M1
	There is evidence that the Company's claim is true		A1ft
			(2)
(c)	$0.0142 + 0.0124 = 0.0266$		B1
			(1)
	Notes		Total 7
(a)(i)	B1	Both hypotheses correct. Must be attached to H_0 and H_1 . Must be in terms of p or π Allow seen in (ii) if no answer given in (i)	
(ii)	M1	Writing or using B(15,0.35) May be seen in (i) May be implied by e.g. $P(X \leq 1) = 0.0142$ or $P(X \leq 9) = 0.9876$ or $X \leq 1$ and $X \geq 10$ oe	
	A1	$X \leq 1$ (Allow any letter) (accept $X < 2$) Allow $0 \leq X \leq 1$ but $P(X \leq 1)$ is A0	
	A1	$X \geq 10$ (Allow any letter) (accept $X > 9$) Allow $10 \leq X \leq 15$ but $P(X \geq 10)$ is A0	
(b)	M1	For a non contextual statement that matches their CR. If they write their CR as $P(X \geq 10)$ take this to mean $X \geq 10$ Allow calculation of $P(X \geq 8) = 0.1132$ or $P(X \leq 8) = 0.9578$ and not significant/do not reject H_0 Do not allow contradictory non contextual statements e.g.8 is not in the CR so significant This may be implied by a correct contextual statement on its own	
	A1ft	For a correct contextual conclusion for their CR. Must mention claim or peas and germinate e.g. there is evidence that 35% (oe) of peas germinate	
(c)	B1	For 0.0266 or awrt 0.0266 (cal gives 0.02662196...) May be seen in part (b)	

5. A string of length 40 cm is cut into 2 pieces at a random point.
The continuous random variable L represents the length of the longer piece of string.

(a) Write down the distribution of L (2)

(b) Find the probability that the length of the longer piece of string is 28 cm to the nearest cm. (2)

Each piece of string is used to form the perimeter of a square.

(c) Calculate the probability that the area of the larger square is less than 64 cm^2 (3)

(d) Calculate the probability that the difference in area between the two squares is greater than 81 cm^2 (4)

(Total for Question 5 is 11 marks)

Question Number	Scheme		Marks
5(a)	$L \sim U[20,40]$ or $f(l) = \begin{cases} \frac{1}{20} & 20 \leq l \leq 40 \\ 0 & \text{otherwise} \end{cases}$		B1dB1
			(2)
(b)	$P(27.5 < L < 28.5) = \frac{28.5 - 27.5}{40 - 20} = \frac{1}{20}$ oe		M1A1
			(2)
(c)	$\left(\frac{L}{4}\right)^2 < 64 = \left(\frac{L}{4}\right) < 8$		M1
	$P(L < 32) = \frac{32 - 20}{40 - 20} = 0.6$ oe		M1A1
			(3)
(d)	$\left(\frac{L}{4}\right)^2 - \left(\frac{40-L}{4}\right)^2 > 81 \Rightarrow \left(\frac{-1600 + 80L}{16}\right) > 81$		M1
	$L > 36.2$		A1
	$P(L > "36.2") = \frac{40 - "36.2"}{40 - 20} = 0.19$ oe or $1 - \frac{36.2 - 20}{40 - 20} = 0.19$ oe		M1A1
			(4)
	Notes		Total 11
(a)	B1	For U[niform] or rectangular or $f(l) = \frac{1}{20}$	
	dB1	Dep on 1 st B1 For [20, 40] or correct pdf fully specified. Must be seen in part (a)	
(b)	M1	for finding $P(27.5 < L < 28.5)$ from a uniform distribution. May be implied by $\frac{1}{20}$	
	A1	Oe	
(c)	M1	for a correct expression for the area and comparison with 64 (allow equation or inequality) (may be implied by 32)	
	M1	using $P(L < 32)$ with uniform distribution. May be implied by 0.6 oe	
	A1	Oe	
(d)	M1	a correct expression to find the difference between the two areas and comparison with 81 (allow equation or inequality) (may be implied by 36.2 oe) Condone $\left(\frac{40-L}{4}\right)^2 - \left(\frac{L}{4}\right)^2 > 81$	
	A1	Oe e.g. $\frac{181}{5}$ (allow equation or inequality)	
	M1	using $P(L > "36.2")$ or $1 - P(L < "36.2")$ with uniform distribution. Ft their 36.2	
	A1	Oe	

6. The continuous random variable X has probability density function $f(x)$ given by

$$f(x) = \begin{cases} \frac{1}{20}x^3 & 0 \leq x \leq 2 \\ \frac{1}{10}(6-x) & 2 < x \leq 6 \\ 0 & \text{otherwise} \end{cases}$$

(a) Sketch the graph of $f(x)$ for all values of x (3)

(b) Write down the mode of X (1)

(c) Show that $P(X > 2) = 0.8$ (2)

(d) Define fully the cumulative distribution function $F(x)$ (4)

Given that $P(X < a \mid X > 2) = \frac{5}{8}$

(e) find the value of $F(a)$ (2)

(f) Hence, or otherwise, find the value of a . Give your answer to 3 significant figures. (3)

(Total for Question 6 is 15 marks)

Question Number	Scheme	Marks
6(a)		B1B1B1
		(3)
(b)	[Mode] = 2	B1
		(1)
(c)	$[P(X > 2)] = \int_2^6 \frac{1}{10}(6-x)dx \text{ or } \frac{1}{2}(6-2)(0.4) \text{ oe or } 1 - \int_0^2 \frac{1}{20}x^3 dx$	M1
	= 0.8*	A1*
		(2)
(d)	$\left[F(x) = \int_0^x \frac{1}{20}t^3 dt = \right] \frac{1}{80}x^4, 0 \leq x \leq 2$	B1
	$[2 < x \leq 6, F(x) =] \int_0^2 \frac{1}{20}t^3 dt + \int_2^x \frac{1}{10}(6-t)dt = 0.2 + \frac{1}{10} \left[6t - \frac{1}{2}t^2 \right]_2^x \text{ or}$ $\int \frac{1}{10}(6-x)dx = \frac{1}{10} \left(6x - \frac{x^2}{2} \right) + c \text{ or } -\frac{1}{20}(6-x)^2 \text{ with } F(2) = 0.2 \text{ or } F(6) = 1$	M1
	$F(x) = \begin{cases} 0, & x < 0 \\ \frac{1}{80}x^4, & 0 \leq x \leq 2 \\ \frac{1}{10} \left(6x - \frac{1}{2}x^2 - 8 \right), & 2 < x \leq 6 \\ 1, & x > 6 \end{cases}$	A1B1
		(4)
(e)	$\left[P(X < a X > 2) = \frac{5}{8} \Rightarrow F(a) = \right] \frac{5}{8}(0.8) + "0.2"; = 0.7 \text{ or } 0.5 + "0.2"; = 0.7$	M1A1
		(2)
(f)	$\frac{1}{10} \left(6a - \frac{1}{2}a^2 - 8 \right) = " \frac{7}{10} " \text{ or } 1 - \frac{1}{20}(6-a)^2 = " \frac{7}{10} " \text{ or } \frac{1}{2}(6-a) \times \frac{1}{10}(6-a) = 1 - "0.7" \text{ or}$ $\frac{(6-a)^2}{4^2} = \frac{1 - "0.7"}{0.8}$	M1
	$[a^2 - 12a + 30 = 0 \Rightarrow] a = \frac{12 \pm \sqrt{12^2 - 4(1)(30)}}{2} \text{ or } [(6-a)^2 = 6 \Rightarrow] a = 6 \pm \sqrt{6}$	dM1
	$[a = 3.5505102... \Rightarrow] a = 3.55 \text{ (3 sf)}$	A1
		(3)
Notes		Total 15

(a)	B1	Correct shape with correct curvature. Must start at the x -axis
	B1	Straight line with negative gradient. Must end at the x -axis
	B1	2, 6 and 0.4 labelled in the correct place
(b)	B1	Cao
(c)	M1	A correct expression for $P(X > 2)$
	A1*	Answer is given so no incorrect working can be seen
(d)	B1	2 nd line of $F(x)$ with correct limits. Condone use of $<$ rather than $\leq$
	M1	For a complete method to find $F(x)$ for $2 < x < 6$ Either attempt to integrate (at least one $t^n \rightarrow t^{n+1}$) both parts of $f(t)$ with correct limits or with $+ c/d$ and uses $F(2) = 0.2$ or $F(6) = 1$
	A1	3 rd line of $F(x)$ with correct limits May be written as $1 - \frac{1}{20}(6 - x)^2$ Condone use of $\leq$ rather than $<$
	B1	1 st and 4 th line of $F(x)$ with correct limits (Allow otherwise for one of these two limits) Condone use of $\leq$ rather than $<$ or $\geq$ rather than $>$
(e)	M1	For $[F(a)] = \frac{5}{8}(0.8) + \text{their } F(2)$ oe or $0.5 + \text{their } F(2) = [F(a)]$ oe May be implied by $F(a) = 0.7$
	A1	0.7 oe
(f)	M1	Setting the 3 rd line of their $F(x)$ equal to their answer to part (e) or finding the area of the right hand triangle and setting $= 1 - \text{their part (e)}$ or using the square of ratio of areas equal to the ratio of sides
	dM1	Dep on 1 st M1 for solving a 3TQ (If the 3TQ is incorrect then working must be shown)
	A1	For 3.55 (Allow awrt 3.55)

7. Members of a conservation group record the number of sightings of a rare animal. The number of sightings follows a Poisson distribution with a rate of 1 every 2 months.
- (a) Find the smallest value of n such that the probability that there are at least n sightings in 2 months is less than 0.05 (2)
- (b) Find the smallest number of months, m , such that the probability of no sightings in m months is less than 0.05 (2)
- (c) Find the probability that there is at least 1 sighting per month in each of 3 consecutive months. (3)
- (d) Find the probability that the number of sightings in an 8 month period is equal to the expected number of sightings for that period. (2)
- (e) Given that there were 4 sightings in a 4 month period, find the probability that there were more sightings in the last 2 months than in the first 2 months. (3)

(Total for Question 7 is 12 marks)

Question Number	Scheme		Marks
7(a)	$X \sim \text{Po}(1) \quad P(X \geq n) < 0.05 \quad \text{or} \quad P(X < n) > 0.95$		M1
	$n = 4$		A1
			(2)
(b)	$Y \sim \text{Po}(0.5m) \quad P(Y = 0) < 0.05 \quad \text{or} \quad e^{-\frac{1}{2}m} < 0.05$		M1
	$m = 6$		A1
			(2)
(c)	$W \sim \text{Po}(0.5) \text{ and } P(W \geq 1)$		M1
	$[P(W \geq 1)]^3 = (1 - P(W = 0))^3 = (1 - 0.6065)^3 = 0.06093\dots$ awrt 0.0609		M1A1
			(3)
(d)	$S \sim \text{Po}(4)$		M1
	$P(S = 4) = 0.1953\dots$ awrt 0.195		A1
			(2)
(e)	$A \sim \text{Po}(1) \quad B \sim \text{Po}(2)$ $P(\text{sightings in last 2 months} > \text{sightings in first 2 months} \mid 4 \text{ sightings in 4 months}) =$ $\frac{P(A = 1) \times P(A = 3) + P(A = 0) \times P(A = 4)}{P(B = 4)} = \frac{e^{-1} \times \frac{e^{-1}}{3!} + e^{-1} \times \frac{e^{-1}}{4!}}{\frac{e^{-2} \times 2^4}{4!}}$		M1M1
	$= \frac{5}{16} \text{ oe}$		A1
			(3)
ALT (e)	$X \sim B(4, 0.5)$		M1
	$P(X \leq 1) \text{ or } P(X \geq 3)$		M1
	$= \frac{5}{16} \text{ oe}$		A1
	Notes		Total 12
(a)	M1	for writing or using $\text{Po}(1)$ and $P(X \geq n) < 0.05$ or $P(X < n) > 0.95$ or for $\text{Po}(1)$ and $[P(X \leq 2) =] 0.9197$ or $[P(X \leq 3) =] 0.9810$ or $[P(X > 2) =] 0.0803$ or $[P(X > 3) =] 0.019$	
	A1	Cao Answer only is 2/2	
(b)	M1	for $P(Y = 0) = 0.1353$ from $\text{Po}(2)$ <u>or</u> $P(Y = 0) = 0.0821$ from $\text{Po}(2.5)$ <u>or</u> $P(Y = 0) = 0.0498$ from $\text{Po}(3)$ or $e^{-\frac{1}{2}m} < 0.05$ (May be implied by $0.5m = \text{awrt } 3$)	
	A1	Cao Answer only is 2/2	
(c)	M1	For writing or using $\text{Po}(0.5)$ and $P(W \geq 1)$	
	M1	for using $(1 - P(W = 0))^3$ Allow $W \sim \text{Po}(\lambda) \lambda > 0$	
	A1	Awrt 0.0609	
(d)	M1	For use of $\text{Po}(4)$	
	A1	Awrt 0.195	
(e)	M1	For $P(A = 1) \times P(A = 3) [=0.02255\dots] + P(A = 0) \times P(A = 4) [=0.0056\dots]$ from $\text{Po}(1)$ or 0.0282... May be implied by awrt 0.312/0.313 or writing or using $B(4, 0.5)$	
	M1	For a conditional probability with $P(B = 4) [=0.0902\dots]$ on the denominator from $\text{Po}(2)$ provided this gives a probability. May be implied by awrt 0.312/0.313 or for writing or using $P(X \leq 1)$ or $P(X \geq 3)$ if $B(4, 0.5)$ stated	
	A1	Allow awrt 0.312/0.313	

Please check the examination details below before entering your candidate information

Candidate surname		Other names	
Centre Number		Candidate Number	

Pearson Edexcel International Advanced Level

Tuesday 20 January 2026

Morning (Time: 1 hour 30 minutes) **Paper reference** **WST02/01**

Mathematics

International Advanced Subsidiary/Advanced Level

Statistics S2

You must have:
Mathematical Formulae and Statistical Tables (Yellow), calculator.

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Values from the statistical tables should be quoted in full. If a calculator is used instead of the tables, the value should be given to an equivalent degree of accuracy.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 7 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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Question 1 continued

Handwriting practice area with horizontal lines.

(Total for Question 1 is 7 marks)



2. A continuous random variable X has cumulative distribution function

$$F(x) = \begin{cases} 0 & x < 4 \\ k(x - 4) & 4 \leq x \leq 10 \\ 1 & x > 10 \end{cases}$$

where k is a constant.

- (a) Show that $k = \frac{1}{6}$ (1)
- (b) Write down the value of $P(X = 5)$ (1)
- (c) Find $P(5 < X < 7)$ (2)
- (d) Specify the probability density function of X , for all values of x (2)
- (e) Hence sketch the probability density function of X (2)
- (f) Write down the value of $E(X)$ (1)
- (g) Find $E(2X^2 - 1)$ (3)
You must make your method clear.



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Question 2 continued

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Question 2 continued

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(Total for Question 2 is 12 marks)



3. Remy's house has a sensor which detects motion.

The number of times the sensor detects motion in a 15-minute period during every morning is modelled by a Poisson distribution with mean 2.5

(a) Find the probability that during a randomly selected morning the sensor detects motion

(i) at least 4 times in a randomly selected 30-minute period,

(ii) at least 4 times in each of 3 randomly selected non-overlapping 30-minute periods.

(4)

Remy decides to clean the sensor.

After cleaning the sensor, Remy records the number of times the sensor detects motion in a one-hour period in the morning.

Remy will use this data to test, at a 5% significance level, if there is evidence that the mean rate of detecting motion has increased.

(b) Write down suitable null and alternative hypotheses for Remy's test.

(1)

(c) Find the critical region for the test **and** state its associated probability.

(3)

In the one-hour period after the sensor is cleaned, the sensor detects motion 13 times.

Using this observation and your answer to part (c)

(d) state the conclusion to the test, giving a reason for your answer.

(1)



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Question 3 continued

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Question 3 continued

(Total for Question 3 is 9 marks)



4. An optician is testing patients for a specific eye condition.

It is known from past records that 5% of patients have this eye condition.

- (a) Find the probability that from a random sample of 30 patients

- (i) exactly one patient has the eye condition,
(ii) no more than 2 patients have the eye condition.

(2)

The optician claims that the proportion of patients with the eye condition has changed.

A random sample of 150 patients is taken and 13 have the eye condition.

- (b) Using a suitable approximation, carry out an appropriate test to investigate the optician's claim. Use a 5% level of significance and state your hypotheses clearly.

(6)



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Question 4 continued

(Total for Question 4 is 8 marks)



- (2)

The selling price of a wrap is the same for supplier A and supplier B .

	Sandwich	Wrap	Panini
Price	£ 3	£ 4	£ 5

(2)

- (3)

- (3)

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Question 5 continued

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Question 5 continued

(Total for Question 5 is 10 marks)



6.

In this question you must show all stages of your working. Solutions relying entirely on calculator technology are not acceptable.

A farmer grows watermelons on a farm. The weights, in kilograms, of the watermelons are modelled by the random variable W with probability density function

$$f(w) = \begin{cases} \frac{1}{9}(6-w)(w-2) & 2 \leq w \leq 5 \\ 0 & \text{otherwise} \end{cases}$$

- (a) Sketch the graph of $f(w)$ (2)
- (b) State the mode of W (1)
- (c) Find the mean weight of these watermelons. (4)

Given that $E(W^2) = \frac{73}{5}$

- (d) find the standard deviation of the weights of these watermelons, giving the answer to 3 significant figures. (2)
- (e) Show that the median lies between $w = 3.7$ and $w = 3.8$ (5)

The farmer inspects the watermelons to check whether or not they are spoiled.

The number of spoiled watermelons found by the farmer in an area of 150m^2 on the farm is modelled by a Poisson distribution with mean 5

The farmer randomly selects an area of 900 m^2 from the farm and counts the number of spoiled watermelons.

- (f) Use a normal approximation to find the probability that the farmer finds fewer than 20 spoiled watermelons. (5)



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Question 6 continued

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Question 6 continued

(Total for Question 6 is 19 marks)



7. A train travels daily between two cities.

The probability that the train arrives no more than 2 minutes late is 0.45

Bobby randomly selects 30 of these train journeys between the two cities. The random variable X represents the number of times the train arrives no more than 2 minutes late.

- (a) Find $P(X > 16)$

(2)

Hallie takes a random sample of 180 of these train journeys between the two cities.

Using a normal approximation, the probability that more than k of these 180 train journeys arrive no more than 2 minutes late is less than 0.0427 to 4 decimal places.

- (b) Using standardisation, find the smallest possible value of k
You must show all stages of your working.

(8)



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Question 7 continued

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(Total for Question 7 is 10 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (Final)

January 2026

International Advanced Level in Statistics S2

WST02/01

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January 2026

Question Paper Log Number P81357A

Publication Code WST02_01_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

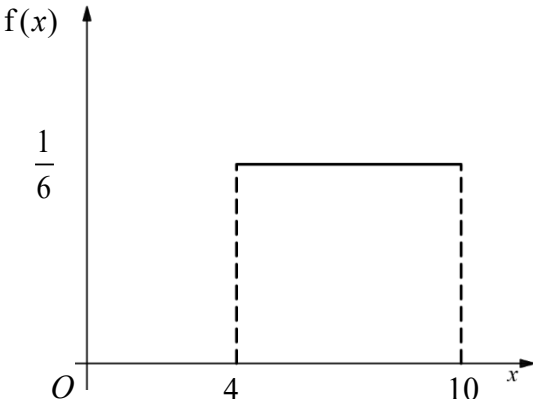
1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: method marks are awarded for ‘knowing a method and attempting to apply it’, unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)
 - Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
 - ft – follow through
 - the symbol $\surd$ will be used for correct ft
 - cao – correct answer only
 - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
 - isw – ignore subsequent working
 - awrt – answers which round to
 - SC: special case
 - oe – or equivalent (and appropriate)
 - dep – dependent
 - indep – independent
 - dp decimal places
 - sf significant figures
 - * The answer is printed on the paper
 - $\square$ The second mark is dependent on gaining the first mark
4. All A marks are ‘correct answer only’ (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.
 5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.
 6. If a candidate makes more than one attempt at any question:
 - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
 7. Ignore wrong working or incorrect statements following a correct answer

Question Number	Scheme		Marks
1(a)(i) (ii)	e.g. A database of all the customers		B1
	e.g. The customer(s)		B1
			(2)
(b)	e.g. It is cheaper		B1
			(1)
(c)	B(50, 0.35)		M1A1
			(2)
(d)	$[P(X > 20) =] 1 - P(X \leq 20) (= 1 - 0.8139)$		M1
	$= 0.1861$ awrt 0.186		A1
			(2)
	Notes		Total 7
(a)(i) (ii)	B1	for a suitable sampling frame e.g. a list / spreadsheet / register and indicating it contains all the customers who have the internet service. All can be implied but not a partial list.	
	B1	for a suitable sampling units e.g. people who pay for the service, subscriber (s), customer (s). Do not allow customer (s) satisfaction o.e.	
(b)	B1	for a suitable reason e.g. it is quicker, cheaper, easier to process	
(c)	M1	Binomial distribution or B(...) seen	
	A1	B(50, 0.35) or binomial stated with $n = 50$, $p = 0.35$	
(d)	M1	For $1 - P(X \leq 20)$, may be implied by $1 - 0.8139$ or $P(X \geq 21)$	
	A1	awrt 0.186 (Calc: 0.186054...) (Correct answer 2/2)	

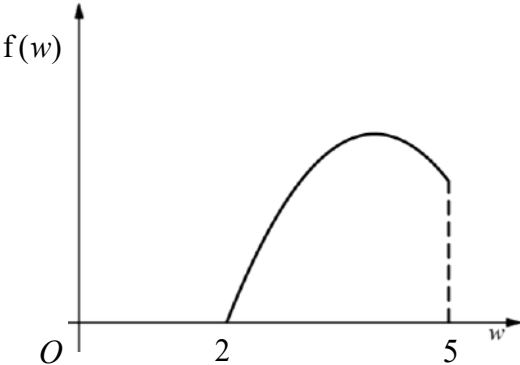
Question Number	Scheme		Marks
2(a)	$[F(10)] = k \times 6 = 1 \Rightarrow k = \frac{1}{6} *$		B1cso
			(1)
(b)	$[P(X = 5) =] 0$		B1
			(1)
(c)	$[P(5 < X < 7) =] F(7) - F(5) \left(= \frac{1}{6}(3 - 1) \right)$		M1
	$= \frac{1}{3}$		A1
			(2)
(d)	$f(x) = \begin{cases} \frac{1}{6} & 4 \leq x \leq 10 \\ 0 & \text{otherwise} \end{cases}$		M1A1
			(2)
(e)			M1A1ft
			(2)
(f)	$E(X) \left(= \frac{4 + 10}{2} \right) = 7$		B1
			(1)
(g)	$[Var(X)] = \frac{(10 - 4)^2}{12} = 3 \quad \text{or} \quad [E(X^2)] = \int_{[4]}^{[10]} \frac{x^2}{6} \, dx \quad \text{or} \quad [E(2X^2 - 1)] = \int_{[4]}^{[10]} \frac{2x^2 - 1}{6} \, dx$		M1
	$E(2X^2 - 1) = 2 \times ("3" + "7"^{n^2}) - 1 \quad \text{or} \quad 2 \left[\frac{x^3}{18} \right]_4^{10} - 1 = 2 \left(\frac{1000}{18} - \frac{64}{18} \right) - 1$		M1
	$= 103 \quad \quad \quad = 103$		A1
			(3)
	Notes		Total 12
(a)	B1*	cso for substituting $x = 10$ into $F(x)$, setting equal to 1 and rearranging to achieve the given answer. Alternatively, substituting $x = 10$ and $k = \frac{1}{6}$, and achieves an answer of 1 but must state a conclusion confirming that $k = \frac{1}{6}$	

(b)	B1	cao
(c)	M1	for sight or use of $F(7) - F(5)$
	A1	$\frac{1}{3}$ or exact equivalent. (Answer coming from incorrect working (e.g. substituting 6 and 4 o.e. is M0A0))
(d)	M1	for $f(x) = \frac{1}{6}$ with or without the interval
	A1	fully correct with both lines and correct intervals (o.e)
(e)	M1	for a horizontal line \ rectangle drawn in the first quadrant
	A1ft	fully correct with 4, 10 and “1/6” labelled (condone missing vertical lines at 4 and 10 and axes labels)
(f)	B1	cao
(g)	M1	attempts to find $\text{Var}(X)$ or attempts to integrate $x^2 \times f(x)$. (Ignore limits and labelling) May be seen as part of $\int_{[4]}^{[10]} \frac{2x^2 - 1}{6} dx$ Condone omission of dx
	M1	for a full attempt to find $E(2X^2 - 1)$ (Implied by $2 \times ("52") - 1$). Follow through their $E(X^2)$ evaluated, even if labelled as $\text{Var}(X)$.
	A1	Cao (Working must be seen)

Question Number	Scheme		Marks
3(a)(i)	$X \sim \text{Po}(5) \quad [[P(X \geq 4) (=1 - P(X \leq 3)) = 1 - 0.2650]$		M1
	$= 0.735$ awrt 0.735		A1
	"0.735" ³ = 0.397065... awrt 0.397		M1A1
			(4)
(b)	$H_0: \lambda = 2.5 \quad H_1: \lambda > 2.5$		B1
			(1)
(c)	$X \sim \text{Po}(10)$ where X is the number of detections in one hour		
	$P(X \leq 15) = 0.9513 \Rightarrow P(X \geq 16) = 0.0487$		M1A1
	Critical region $X \geq 16$		A1
			(3)
(d)	13 is not in the critical region (so do not reject H_0) so insufficient evidence to suggest that the <u>mean rate</u> (o.e) of <u>detecting</u> (o.e) motion has <u>increased</u> (o.e).		B1ft
			(1)
	Notes		Total 9
(a)(i)	M1	Sight or use of the correct Poisson distribution. May be implied by awrt 0.265	
	A1	awrt 0.735 Calc: 0.73497...) (Correct answer 2/2)	
(ii)	M1	for attempting their (a)(i) ³ or ³ C ₃ (a)(i) ³ (1- a(i)) ⁰	
	A1	awrt 0.397	
(b)	B1	correct hypotheses in terms of λ or μ (may write 10 instead of 2.5)	
(c)	M1	for attempting to use Po(10). May be implied by awrt 0.9513, awrt 0.9730, awrt 0.0487, awrt 0.0270	
	A1	for finding $P(X \geq 16) =$ awrt 0.0487 (or a clear statement that probability is awrt 0.0487).	
	A1	for a correct critical region. Must be expressed as e.g. $X \geq 16$ (o.e.) and not a probability statement. Can use a different letter to X and condone $CR \geq 16$	
(d)	B1ft	dep on a CR $X \geq a$ o.e. such that 13 is not in the critical region (condone a probability statement for a CR) For 13 is not in the critical region and a correct conclusion in context that there is insufficient evidence to suggest that the <u>mean rate</u> of <u>detections</u> has <u>increased</u> . (o.e). Withhold this mark if there are contradictory statements or incorrect comparisons.	

Question Number	Scheme		Marks
4(a)(i) (ii)	$[P(X = 1)] = 0.3389...$ awrt 0.339		B1
	$[P(X \leq 2)] = 0.8122$ awrt 0.812		B1
			(2)
(b)	$H_0: p = 0.05 \quad H_1: p \neq 0.05$		B1
	$Y \sim \text{Po}(7.5)$		M1
	$P(Y \geq 13) = 1 - P(Y \leq 12)$ or $1 - 0.9573$		M1
	$= 0.0426658...$ awrt 0.0427		A1
	"0.0427" > 0.025 (so do not reject H_0) / 13 is not in the critical region. o.e		dM1
	Insufficient evidence to suggest that the proportion of patients with the eye condition has changed		A1ft
			(6)
	Notes		Total 8
(a)(i)	B1	awrt 0.339	
(ii)	B1	awrt 0.812	
(b)	B1	for correct hypotheses and attached to H_0 and H_1 in terms of p . Accept $H_0: \lambda = 7.5$, $H_1: \lambda \neq 7.5$	
	M1	for a correct Poisson distribution with $\lambda = 7.5$. May be implied by awrt 0.957 or awrt 0.043	
	M1	$P(Y \geq 13) = 1 - P(Y \leq 12)$ or $1 - 0.9573$ or allow for CR: $X \geq 14$ or CR: $X \leq 2$ o.e	
	A1	awrt 0.0427 or allow for fully defined critical region of CR: $X \leq 2$, $X \geq 14$ o.e	
	dM1	dep on 2nd M1 for a correct non-contextual comparison ft on their "0.0427" or a comparison with their critical region	
	A1ft	dependent on all previous method marks. For a correct contextual conclusion using the bolded words. (o.e) Condone "the optician's claim is incorrect" o.e	
	SC	if no approximation (use of B (150,0.05)) is used leading to 0.03851568... then maximum score B1M0M1A0dM1A0ft	
	SC	if a normal approximation (N (7.5,7.125)) is used leading to awrt 0.0305 – awrt 0.0307 then maximum score B1M0M1A1dM1A0ft. 2 nd M1 is for working out z-value of 1.87 or better, 1 st A mark for awrt 0.0305 – awrt 0.0307, 3 rd M1 (dep) a correct comparison.	

Question Number	Scheme				Marks							
5(a)	All the possible combinations: <i>SSW, SSP, SWW(x2), SWP(x2), WWW, WWP</i>				M1A1							
					(2)							
(b)	{10,11,12,13}				M1A1							
					(2)							
(c)	$(P(SSW)=)\frac{3}{5}\times\frac{3}{5}\times\frac{1}{2}$ o.e. or $(P(WWP)=)\frac{2}{5}\times\frac{2}{5}\times\frac{1}{2}$ o.e.				B1							
	$(P(T=11))=2\times\frac{3}{5}\times\frac{2}{5}\times\frac{1}{2}+\frac{3}{5}\times\frac{3}{5}\times\frac{1}{2}$ or $(P(T=12))=2\times\frac{3}{5}\times\frac{2}{5}\times\frac{1}{2}+\frac{2}{5}\times\frac{2}{5}\times\frac{1}{2}$				M1							
					A1							
	<table><tr><td><i>t</i></td><td>10</td><td>11</td><td>12</td><td>13</td></tr><tr><td>P(<i>T</i> = <i>t</i>)</td><td>$\frac{9}{50}$=0.18</td><td>$\frac{21}{50}$ = 0.42</td><td>$\frac{8}{25}$=0.32</td><td>$\frac{2}{25}$=0.08</td></tr></table>	<i>t</i>	10	11		12	13	P(<i>T</i> = <i>t</i>)	$\frac{9}{50}$ =0.18	$\frac{21}{50}$ = 0.42	$\frac{8}{25}$ =0.32	$\frac{2}{25}$ =0.08
	<i>t</i>	10	11	12	13							
P(<i>T</i> = <i>t</i>)	$\frac{9}{50}$ =0.18	$\frac{21}{50}$ = 0.42	$\frac{8}{25}$ =0.32	$\frac{2}{25}$ =0.08								
				(3)								
(d)	{0, 1, 2}				B1							
					M1A1							
	<table><tr><td><i>r</i></td><td>0</td><td>1</td><td>2</td></tr><tr><td>P(<i>R</i> = <i>r</i>)</td><td>$\frac{2}{25}$=0.08</td><td>$\frac{1}{2}$=0.5</td><td>$\frac{21}{50}$=0.42</td></tr></table>	<i>r</i>	0	1		2	P(<i>R</i> = <i>r</i>)	$\frac{2}{25}$ =0.08	$\frac{1}{2}$ =0.5	$\frac{21}{50}$ =0.42		
<i>r</i>	0	1	2									
P(<i>R</i> = <i>r</i>)	$\frac{2}{25}$ =0.08	$\frac{1}{2}$ =0.5	$\frac{21}{50}$ =0.42									
					(3)							
Notes					Total 10							
(a)	M1	lists at least 3 valid combinations (do not be concerned if there are any extras). Ignore any reference to <i>A</i> and <i>B</i> in their combinations, e.g. the use of subscripts. Allow in words.										
	A1	lists all 6 possible combinations (condone permutations) with no additional incorrect ones.										
(b)	M1	for at least 2 correct values (ignore any incorrect extra values)										
	A1	for all four values and no others (condone if not ordered). Must be seen in b.										
(c)	B1	for finding the probability of the event <i>SSW</i> or the event <i>WWP</i> . Implied by $\frac{9}{50}$ o.e. or $\frac{2}{25}$ o.e. May be seen in the table.										
	M1	for an attempt at P(<i>T</i> = 11) or P(<i>T</i> = 12). Implied by $\frac{21}{50}$ o.e. or $\frac{8}{25}$ o.e. May be seen in the table										
	A1	for a fully correct table, or all values of <i>T</i> correctly paired with their probabilities										
(d)	B1	for all three values and no others (may be seen in a table) (If listed condone if not ordered)										
	M1	for at least one correct value for <i>r</i> with a correct probability or calculation. Correctly paired in table is fine if not explicitly written down.										
	A1	for a fully correct table, or all values of <i>R</i> correctly paired with their probabilities										

Question Number	Scheme	Marks
6(a)		M1 A1
		(2)
(b)	Mode = 4	B1
		(1)
(c)	$E(W) = \frac{1}{9} \int_2^5 w(6-w)(w-2) \, dw$	M1
	$E(W) = \frac{1}{9} \int_2^5 (-w^3 + 8w^2 - 12w) \, dw = \frac{1}{9} \left[-\frac{w^4}{4} + \frac{8w^3}{3} - 6w^2 \right]_2^5$	M1
	$= \frac{1}{9} \left(\left(-\frac{5^4}{4} + \frac{8 \times 5^3}{3} - 6 \times 5^2 \right) - \left(-\frac{2^4}{4} + \frac{8 \times 2^3}{3} - 6 \times 2^2 \right) \right)$	dM1
	= 3.75 (kg)	A1
		(4)
(d)	$\text{Standard deviation} = \sqrt{\frac{73}{5} - \left(\frac{15}{4} \right)^2}$	M1
	$= \frac{\sqrt{215}}{20} = 0.73314... \text{ (kg)}$	awrt 0.733 A1
		(2)
(e)	$\frac{1}{9} \int (-w^2 + 8w - 12) \, dw = \frac{1}{9} \left(-\frac{w^3}{3} + 4w^2 - 12w \right)$	M1A1
	$F(3.7) = \frac{1}{9} \int_2^{3.7} (-w^2 + 8w - 12) \, dw = 0.460... (< 0.5)$	M1
	$F(3.8) = \frac{1}{9} \int_2^{3.8} (-w^2 + 8w - 12) \, dw = 0.504 (> 0.5)$	M1
	3.7 and 3.8 give values either side of 0.5 hence median lies between 3.7 and 3.8	A1
		(5)
(f)	$X \sim N(30, 30)$	B1
	$P\left(Z < \frac{19.5 - "30"}{\sqrt{"30"}}\right) = P(Z < -1.917...)$	M1M1 A1ft
	= awrt 0.0274 or awrt 0.0276	A1
		(5)
		Total 19

	Notes	
(a)	M1	a negative quadratic shape which is in the first quadrant
	A1	correct graph with 2 and 5 labelled. Do not be concerned by the value of the maximum labelled. (condone missing axes labels\ missing vertical line at $w=5$) (If sketch shown for $w<2$ and $w>5$, must have $f(w) = 0$)
(b)	B1	Cao (accept $w = 4$)
(c)	M1	for attempting $\int wf(w) dw$. Does not require limits. Condone omission of dw or use of another variable.
	M1	for an attempt at integration of $wf(w)$ with correct limits. Look for $w^n \rightarrow w^{n+1}$ for at least one term
	dM1	dependent on both previous method marks. For correct use of limits.
	A1	3.75 (kg) o.e. (Must see evidence of all previous M marks)
(d)	M1	for a correct standard deviation calculation using their part (c) including square root. May see $\sqrt{\frac{43}{80}}$ or $\sqrt{0.5375}$ or $\sqrt{\frac{215}{400}}$ (o.e)
	A1	awrt 0.733 (kg)
(e)	M1	for an attempt at integration of $f(x)$. Look for $w^n \rightarrow w^{n+1}$ for at least one term Ignore limits. Condone missing $1/9$ for this mark
	A1	correct integrated expression, including the $1/9$ with or without $+ c$. Limits do not need to be substituted in.
	dM1	dependent on the 1 st M1. For one correct evaluation using 2 and 3.7 or 2 and 3.8 (Allow equivalent substitution into re-arrangements)
	dM1	dependent on the previous method marks. For two correct evaluations using 2 and 3.7 and 2 and 3.8 (Allow equivalent substitution into re-arrangements)
	A1	correct calculations, reasoning and conclusion (e.g. comparing awrt = 0.46 or awrt 0.504 with 0.5 \ median) o.e
	ALT	Finding the value of m
	M1 A1	See scheme
	dM1	dependent on the 1 st M1. Uses $\frac{1}{9} \int_2^m (-w^2 + 8w - 12) dw = 0.5$ must see limits.
	dM1	dependent on the previous method marks. Substituting both limits to obtain a cubic $am^3 + bm^2 + cm + d = 0$ where a, b, c and d are constants and solves by any method (including calculator) to obtain $m = \dots$, for at least one root. Allow substitution of 3.7 and 3.8 into the cubic expression.
	A1	All 3 correct roots seen and indicates awrt 3.79 and give a reason for rejecting the other two roots (other roots awrt 0.65 (condone 0.64) awrt 7.6 (condone 7.5)) Allow substitution of 3.7 and 3.8 into the cubic expression and identifying a sign change.
(f)	B1	for a correct normal approximation to a Poisson
	M1	for attempting to use a continuity correction (19.5 or 20.5)
	M1	for attempting to standardise (They can achieve this with 19.5, 20 or 20.5)
	A1ft	Dependent on both previous method marks for correct standardisation following through their mean and variance
	A1	awrt 0.0274 (Calc: 0.027617...) or awrt 0.0276 NB Use of Poisson distribution gives 0.02187... and scores 0 marks.

Question Number	Scheme		Marks
7(a)	$X \sim B(30, 0.45) \Rightarrow P(X > 16) = 1 - P(X \leq 16) = 1 - 0.8644$		M1
	$= 0.1356$ awrt 0.136		A1
			(2)
(b)	$Y \sim N(81, 44.55)$ where Y is the number of trains which arrive no more than 2 minutes late		M1A1
	$P\left(Y > \frac{k + 0.5 - "81"}{\sqrt{"44.55"}}\right) < 0.0427$		M1 M1 A1ft
	$\frac{k + 0.5 - "81"}{\sqrt{"44.55"}} > 1.72$		M1B1
	$k > 91.98... \Rightarrow k = 92$		A1
			(8)
	Notes		Total 10
(a)	M1	for use of a binomial with $n = 30$, $p = 0.45$ (you may need to check probabilities if no distribution is given.) (e.g. awrt 0.864, awrt 0.769, awrt 0.231, awrt 0.645, awrt 0.355)	
	A1	awrt 0.136 (Correct answer scores 2/2)	
(b)	M1	for attempting the correct binomial to normal approximation. Score for sight of $N(81, ...)$ o.e.	
	A1	correct normal distribution $N(81, 44.55)$	
	M1	for attempting a continuity correction ($k + 0.5$ or $k - 0.5$)	
	M1	for attempting to standardise with their “81” and their $\sqrt{"44.55"}$ or awrt 6.67, with or without a continuity correction.	
	A1ft	dependent on both of the previous method marks. For a correct standardisation using $k + 0.5$ but ft their “81” and their $\sqrt{"44.55"}$ or awrt 6.67	
	M1	for setting their standardised expression more than a z -value $1 < z < 3$ (Condone equals)	
	B1	correct z -value awrt 1.72 (Allow -1.72 if consistent with their standardisation)	
	A1	dependent on all the previous marks for 92	
	SC	if no continuity correction is used leading to 92.48027526...then maximum score is M1A1M0M1A0ftM1B1A0	
	SC	if the incorrect continuity correction ($k - 0.5$) is used leading to 92.9802... then maximum score is M1A1M1M1A0ftM1B1A0	

Pearson Edexcel International Advanced Level

Thursday 22 January 2026

Afternoon (Time: 1 hour 30 minutes)

**Paper
reference**

WST03/01A

Mathematics

International Advanced Subsidiary/Advanced Level

Statistics S3

Question Paper

You must have:

Answer book (sent separately).

Do not return this question paper with the answer book.

Turn over ►

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1. The table below shows the distance travelled by car and the amount of commission earned by each of 8 salespersons in 2015

Salesperson	Distance travelled (in 1000s of km)	Commission earned (in \$1000s)
<i>A</i>	20.4	17.7
<i>B</i>	22.2	24.1
<i>C</i>	29.9	20.3
<i>D</i>	37.8	28.3
<i>E</i>	25.5	34.9
<i>F</i>	30.2	29.3
<i>G</i>	35.3	23.6
<i>H</i>	16.5	26.8

- (a) Find Spearman's rank correlation coefficient for these data. (4)
- (b) Stating your hypotheses clearly, test, at the 5% level of significance, whether or not there is evidence of a positive correlation between the distance travelled by car and the amount of commission earned. (4)

(Total for Question 1 is 8 marks)

2. The random variable X follows a continuous uniform distribution over the interval $[\alpha - 3, 2\alpha + 3]$ where α is a constant.

The mean of a random sample of size n is denoted by $\bar{X}$

- (a) Show that $\bar{X}$ is a biased estimator of α , and state the bias. (3)

Given that $Y = k\bar{X}$ is an unbiased estimator for α

- (b) find the value of k . (1)

A random sample of 10 values of X is taken and the results are as follows

3 5 8 12 4 13 10 8 5 12

- (c) Hence estimate the maximum value of X (3)

(Total for Question 2 is 7 marks)



3. A researcher investigates the results of candidates who took their driving test at one of three driving test centres.

A random sample of 620 candidates gave the following results.

		Driving test centre			Total
		<i>A</i>	<i>B</i>	<i>C</i>	
Result	Pass	99	110	68	277
	Fail	108	116	119	343
Total		207	226	187	620

- (a) Test, at the 5% level of significance, whether there is an association between the results of candidates' driving tests and the driving test centre. Show your working clearly. You should state your hypotheses, expected frequencies, test statistic and the critical value for this test.

(10)

The researcher decides to conduct a further investigation into the results of candidates' driving tests.

- (b) State which driving test centre you would recommend for further investigation. Give a reason for your answer.

(2)

(Total for Question 3 is 12 marks)

4. A company produces a certain type of mug. The masses of these mugs are normally distributed with mean μ and standard deviation 1.2 grams. A random sample of 5 mugs is taken and the mass, in grams, of each mug is measured. The results are given below.

229.1 229.6 230.9 231.2 231.7

- (a) Find a 95% confidence interval for μ , giving your limits correct to 1 decimal place.

(4)

Sonia plans to take 20 random samples, each of 5 mugs. A 95% confidence interval for μ is to be determined for each sample.

- (b) Find the probability that more than 3 of these intervals will not contain μ .

(3)

(Total for Question 4 is 7 marks)

5. Jeff records the number of births announced in his local weekly newspaper each week for n consecutive weeks, where n is an integer. He decides the resulting data can be modelled as independent samples from a Poisson distribution with mean 2.8 and calculates the expected frequencies using this model.

The following table shows the observed frequencies and the expected frequencies, to 2 decimal places.

The observed and expected frequencies for 5 births are not given.

Number of births	Observed frequency (O)	Expected frequency (E)
0	8	5.84
1	27	16.35
2	25	22.88
3	16	21.36
4	12	14.95
5	a	b
6	2	3.91
≥ 7	1	2.34

- (a) Find the value of a and the value of b

(2)

The value of $\sum \frac{(O - E)^2}{E}$ for the given values for the number of births 0, 1, 2, 3 and 4 is 9.86

- (b) Using a 5% significance level, test whether or not this Poisson model is suitable. Show your working clearly, stating your hypotheses, test statistic and critical value.

(7)

(Total for Question 5 is 9 marks)



6. A large company surveyed its staff to investigate the awareness of company policy. The company employs 6000 full-time staff and 4000 part-time staff.

(a) Describe how a stratified sample of 200 staff could be taken. (3)

(b) Explain an advantage of using a stratified sample rather than a simple random sample. (1)

A random sample of 80 full-time staff and an independent random sample of 80 part-time staff were given a test of policy awareness. The results are summarised in the table below.

	Mean score ($\bar{x}$)	Variance of scores (s^2)
Full-time staff	52	21
Part-time staff	50	19

(c) Stating your hypotheses clearly, test, at the 1% level of significance, whether or not the mean policy awareness scores for full-time and part-time staff are different. (7)

(d) Explain the significance of the Central Limit Theorem to the test in part (c). (2)

(e) State an assumption you have made in carrying out the test in part (c). (1)

After all the staff had completed a training course the 80 full-time staff and the 80 part-time staff were given another test of policy awareness. The value of the test statistic z was 2.53

(f) Comment on the awareness of company policy for the full-time and part-time staff in light of this result. Use a 1% level of significance. (2)

(g) Interpret your answers to part (c) and part (f). (1)

(Total for Question 6 is 17 marks)

7. (i) As part of a recruitment exercise candidates are required to complete three separate tasks. The times taken, A , B and C , in minutes, for candidates to complete the three tasks are such that

$$A \sim N(21, 2^2), B \sim N(32, 7^2) \text{ and } C \sim N(45, 9^2)$$

The time taken by an individual candidate to complete each task is assumed to be independent of the time taken to complete each of the other tasks.

A candidate is selected at random.

- (a) Find the probability that the candidate takes a total time of more than 90 minutes to complete all three tasks.

(4)

- (b) Find $P(A > B)$

(4)

- (ii) A simple random sample, X_1, X_2, X_3, X_4 , is taken from a normal population with mean μ and standard deviation σ

Given that

$$\bar{X} = \frac{X_1 + X_2 + X_3 + X_4}{4}$$

and that

$$P(X_1 > \bar{X} + k\sigma) = 0.1$$

where k is a constant,

find the value of k , giving your answer correct to 3 significant figures.

You should show all stages of your working.

(7)

(Total for Question 7 is 15 marks)

TOTAL FOR PAPER IS 75 MARKS



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Please check the examination details below before entering your candidate information

Candidate surname		Other names	
Centre Number		Candidate Number	

Pearson Edexcel International Advanced Level

Thursday 22 January 2026

Afternoon (Time: 1 hour 30 minutes) **Paper reference** **WST03/01A**

Mathematics

International Advanced Subsidiary/Advanced Level

Statistics S3

Answer Book

You must have:
Mathematical Formulae and Statistical Tables (Yellow), calculator,
Question paper (sent separately)

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Values from the statistical tables should be quoted in full. If a calculator is used instead of the tables, the value should be given to an equivalent degree of accuracy.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 7 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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Question 1

Write the answer to Question 1 on these 2 pages

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Question 1 continued

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(Total for Question 1 is 8 marks)



Question 2

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Question 2 continued

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(Total for Question 2 is 7 marks)



Question 3

Write the answer to Question 3 on these 4 pages

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Question 3 continued

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Question 3 continued

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(Total for Question 3 is 12 marks)



Question 4

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Question 4 continued

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(Total for Question 4 is 7 marks)



Question 5

Write the answer to Question 5 on these 4 pages

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Question 5 continued

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Question 5 continued

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(Total for Question 5 is 9 marks)



Question 6

Write the answer to Question 6 on these 4 pages

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Question 6 continued

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Question 6 continued

This is the end of Question 6 answer space. Please turn the page for Question 7 answer space.

(Total for Question 6 is 17 marks)



Question 7

Write the answer to Question 7 on these 5 pages

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Question 7 continued

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Question 7 continued

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(Total for Question 7 is 15 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (Final)

January 2026

International Advanced Level in Statistics

S3 WST03/01A

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Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus

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January 2026

Question Paper Log Number P87602A

Publication Code WST03_01_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: Method marks are awarded for ‘knowing a method and attempting to apply it’, unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)

Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN:

- bod – benefit of doubt
- ft – follow through
 - the symbol $\checkmark$ will be used for correct ft
- cao – correct answer only
- cso – correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC – special case
- oe – or equivalent (and appropriate)
- d... or dep – dependent
- indep – independent
- dp – decimal places
- sf – significant figures
- * – The answer is printed on the paper or ag- answer given
- $\square$ or d... – The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.
5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. If you are using the annotation facility on ePEN, indicate this action by 'MR' in the body of the script.
6. If a candidate makes more than one attempt at any question:
 - a) If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - b) If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
7. Ignore wrong working or incorrect statements following a correct answer.

Question Number	Scheme										Marks		
1. (a)	Salesperson		A	B	C	D	E	F	G	H	Attempt to rank for distance or for commission. (at least four correct).	M1	
	Rank Distance		7	6	4	1	5	3	2	8			
	Rank Commission		8	5	7	3	1	2	6	4			
	Or											For finding the difference between each of the ranks and evaluating $\sum d^2$. $\sum d^2 = 64$ Using $1 - \frac{6 \sum d^2}{8(63)}$ with their $\sum d^2$ $\frac{5}{21}$ or awrt 0.238	M1
	Salesperson		A	B	C	D	E	F	G	H			
	Rank Distance		2	3	5	8	4	6	7	1			
	Rank Commission		1	4	2	6	8	7	3	5	dM1; A1 [4]		
	$\sum d^2 = 1 + 1 + 9 + 4 + 16 + 1 + 16 + 16; = 64$												
	$r_s = 1 - \frac{6(64)}{8(63)}; = 0.238095...$												
	(b)	$H_0 : \rho = 0$, $H_1 : \rho > 0$										Both hypotheses stated correctly	B1
Critical Value $r_s = 0.6429$ or CR: $r_s \geq 0.6429$										Critical value of 0.6429	B1		
Either										see notes	M1		
- Since $r_s = 0.238...$ <u>does not lie in the CR</u> - Result is <u>not significant</u> - Do not reject H_0 (accept H_0)													
conclude that there is a <u>no positive correlation</u> between <u>distance</u> travelled and amount of <u>commission</u> received.													
										Conclusion in context	A1		
											[4] 8		
Notes													
1. (a)	1 st M1	For an attempt to rank at least one row (at least 4 correct)											
	2 nd M1	For an attempt at d^2 row for their ranks (at least 4 correct or correct ft) (may be implied by $\sum d^2 = 64$)											
	3 rd dM1	dependent on 1st M1 for use of $1 - \frac{6 \sum d^2}{8(63)}$ with their $\sum d^2$											
	A1	awrt 0.238											
(b)	1 st B1	Both hypotheses stated in terms of ρ or ρ_s . Must be attached to H_0 and H_1											
	2 nd B1	0.6429 or better											
	M1	For a correct statement relating their r_s ($ r_s < 1$) with their c.v. where $0 < \text{their c.v.} < 1$ (If a comparison is made it must be correct e.g. $0.238 > 0.05$ is M0).											
	A1	For a contextualised comment which is not rejecting H_0 , which must mention “ <u>no positive correlation</u> ”, “ <u>distance</u> ” and “ <u>commission</u> ”. (Use of “association” is A0.) Follow through their r_s with their c.v. (provided $0 < \text{their c.v.} < 1$) Applying a two-tailed test scores a maximum of B0B1M1A0											
	SC 2-tailed test	So Award SC B0B1 for $H_0 : \rho = 0$, $H_1 : \rho \neq 0$ followed by critical value $r_s = (\pm) 0.7381$ and allow access to the M1 mark only (if comparison is made, it must be correct with consistent signs).											

Question Number	Scheme	Marks
2.	X follows a continuous uniform distribution over $[\alpha - 3, 2\alpha + 3]$	
(a)	$\{E(\bar{X}) = \mu = \frac{2\alpha + 3 + \alpha - 3}{2}$ $= \frac{3\alpha}{2}$. [So $\bar{X}$ is a] biased [estimator.] $\text{bias} \left\{ = \frac{3\alpha}{2} - \alpha \right\} = \pm \frac{\alpha}{2}$	M1 A1 B1 [3]
(b)	$k = \frac{2}{3}$	$\frac{2}{3}$ B1 [1]
(c)	$\frac{3\alpha}{2} = \bar{X} \rightarrow \alpha = \frac{2}{3} \bar{X} = \frac{2}{3}(8)$ $\text{Max value} = 2\left(\frac{16}{3}\right) + 3$ $= \frac{41}{3}$	“their k ” $\times$ their $\bar{x}$ $2 \times \text{"their } \alpha" + 3$ See notes $\frac{41}{3}$ or $13\frac{2}{3}$ or awrt 13.7 M1 M1 A1 [3] 7
Notes		
(a)	M1 Using the formula $\left(\frac{a+b}{2}\right)$ or getting $\frac{3\alpha}{2}$ A1 $\frac{3\alpha}{2}$ and concluding. Allow A1 for $\frac{3\alpha}{2} \neq \alpha$. Note Also allow A1 for $\text{bias} = \pm \frac{\alpha}{2} \neq 0$ B1 $\pm \frac{\alpha}{2}$	
(b)	B1 o.e.	
(c)	1st M1 An attempt to use the sample data given to find $\bar{x}$ and multiply by their k . Allow full expression for $\bar{x}$ or $\frac{\sum x}{n}$. Note 1 st M1 can be implied by a correct method leading to $\alpha = \frac{16}{3}$ 2nd M1 $2 \times \text{"their } \alpha" + 3$ where their α is a function of the sample mean – which is found by applying $\frac{\sum x}{n}$ from the data values given in the question. Note $2(13) + 3 = 39$ is M0M0A0	

Question Number	Scheme	Marks																																
3. (a)	H_0 : There is no association between centre and result (independent) H_1 : There is an association between centre and result (dependent)	Correct hypotheses with centre and result at least once B1																																
	<table border="1"><thead><tr><th>Expd</th><th>A</th><th>B</th><th>C</th><th>Total</th></tr></thead><tbody><tr><td>Pass</td><td>92.482...</td><td>100.970...</td><td>83.546...</td><td>277</td></tr><tr><td>Fail</td><td>114.517...</td><td>125.029...</td><td>103.453...</td><td>343</td></tr><tr><td>Total</td><td>207</td><td>226</td><td>187</td><td>620</td></tr></tbody></table>	Expd	A	B	C	Total	Pass	92.482...	100.970...	83.546...	277	Fail	114.517...	125.029...	103.453...	343	Total	207	226	187	620	Some attempt at (Row Total)(Column Total) (Grand Total) Can be implied by at least one correct E_i to awrt 3 sf M1												
	Expd	A	B	C	Total																													
	Pass	92.482...	100.970...	83.546...	277																													
	Fail	114.517...	125.029...	103.453...	343																													
	Total	207	226	187	620																													
		All expected frequencies are correct to awrt 3 sf A1																																
	<table border="1"><thead><tr><th>Observed</th><th>Expected</th><th>$\frac{(O - E)^2}{E}$</th><th>$\frac{O^2}{E}$</th></tr></thead><tbody><tr><td>99</td><td>92.48</td><td>0.4596...</td><td>105.9796...</td></tr><tr><td>110</td><td>100.97</td><td>0.8075...</td><td>119.8375...</td></tr><tr><td>68</td><td>83.55</td><td>2.8941...</td><td>55.3441...</td></tr><tr><td>108</td><td>114.52</td><td>0.3712...</td><td>101.8512...</td></tr><tr><td>116</td><td>125.03</td><td>0.6521...</td><td>107.6221...</td></tr><tr><td>119</td><td>103.45</td><td>2.3373...</td><td>136.8873...</td></tr><tr><td colspan="2">Totals</td><td>7.522</td><td>627.522...</td></tr></tbody></table>	Observed	Expected	$\frac{(O - E)^2}{E}$	$\frac{O^2}{E}$	99	92.48	0.4596...	105.9796...	110	100.97	0.8075...	119.8375...	68	83.55	2.8941...	55.3441...	108	114.52	0.3712...	101.8512...	116	125.03	0.6521...	107.6221...	119	103.45	2.3373...	136.8873...	Totals		7.522	627.522...	At least 2 correct terms for $\frac{(O - E)^2}{E}$ or $\frac{O^2}{E}$ or correct expressions with their E_i . Accept 2 sf accuracy for this mark (dep on 1 st M1). dM1
	Observed	Expected	$\frac{(O - E)^2}{E}$	$\frac{O^2}{E}$																														
	99	92.48	0.4596...	105.9796...																														
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Totals		7.522	627.522...																															
	At least 5 correct $\frac{(O - E)^2}{E}$ or $\frac{O^2}{E}$ terms to at least 2 sf or at least 5 correct (ft) expressions. A1																																	
$X^2 = \sum \frac{(O - E)^2}{E} \text{ or } \sum \frac{O^2}{E} - 620 ; = \text{ awrt } 7.52$	For applying either $\sum \frac{(O - E)^2}{E}$ or $\sum \frac{O^2}{E} - 620$ awrt 7.52 M1																																	
$\nu = (2 - 1)(3 - 1) = 2$	$\nu = 2$ (can be implied) A1																																	
$\chi^2_2(0.05) = 5.991 \Rightarrow \text{CR: } X^2 \geq 5.991$	5.991 Allow ft on their stated d.f. < 6 For ft: 3.841, 7.815, 9.488, 11.070 A correct conclusion in context which is rejecting H_0 B1ft																																	
[in the CR/significant/Reject H_0] conclude that there is <u>an association</u> between driving test <u>centre</u> and <u>result</u> . (or they are <u>not independent</u> .)	based on their X^2 -value and their χ^2 -critical value. Dep on 3 rd M1 and 3 rd B1ft. Do not allow contradictory statements. If hypotheses wrong way around, A0. A1																																	
(b)		[10]																																
	Test centre C	C B1																																
	- e.g. High values of $\frac{(O - E)^2}{E}$ / contributes most to X^2 test statistic - Condone e.g. Observed and expected differences are bigger [for test centre C than for any other test centre.]	Any valid reason relating to the test statistic. dB1																																
		[2] 12																																

Question Number	Scheme		Marks	
4. (a)	$\bar{x} = 230.5$; 95% confidence limits for μ are			
	$230.5 \pm 1.96 \times \frac{1.2}{\sqrt{5}}$		their $\bar{x} \pm z \times \frac{1.2}{\sqrt{5}}$ M1	
	$z = 1.96$		B1	
	$= (229.44815..., 231.55185...) = \text{awrt}(229.4, 231.6)$		At least one end-point is correct. A1	
			Both end-points are correct. A1	
			[4]	
	(b)	{ Let X = number of confidence intervals that <i>don't contain</i> μ }	{ Let Y = number of confidence intervals that <i>contain</i> μ }	
		{ So $X \sim$ } B(20, 0.05)	{ So $Y \sim$ } B(20, 0.95)	M1
		{ $P(X > 3)$ } = $1 - P(X \leq 3)$ or $1 - 0.9841$	$P(Y \leq 16)$	A1
		$\text{awrt } \mathbf{0.0159}$		A1
		[3]		
		7		
	Notes			
4. (a)	M1	Allow $1.5 < z < 2$ (may be implied by one correct end point)		
	B1	1.96 or better		
	1 st A1	either awrt 229.4 or awrt 231.6 (allow 229.45)		
	2 nd A1	both awrt 229.4 and awrt 231.6 (allow 229.45)		
(b)	M1	States or applies either $X \sim \text{B}(20, 0.05)$ or $Y \sim \text{B}(20, 0.95)$		
	1 st A1	A correct probability statement for their distribution		
		$1 - P(X \leq 3)$ or $1 - 0.9841$ or $P(Y \leq 16)$. Can be implied by the final answer.		
	2 nd A1	awrt 0.0159		

Question Number	Scheme		Marks
5(a)			
	$5.84 = e^{-2.8} \times n$ [n = 96]		M1
	Observed (a =) 5 and Expected (b =) awrt 8.37...		A1
			(2)
(b)	H ₀ : Poisson(2.8) is a suitable model H ₁ : Poisson(2.8) is not a suitable model		B1
	For combining last two cells. Observed = 3, Expected = 6.25		M1
	$\chi^2 = \sum \frac{(O-E)^2}{E} = \frac{("5"- "8.37")^2}{"8.37"} + \frac{(3-6.25)^2}{6.25} + 9.86$		M1
	= awrt 12.9		A1
	Degrees of freedom = "7" – 1		M1
	$\chi^2_{6,0.05} = 12.592$		A1
	[Reject H ₀] Data is not consistent with a Poisson [(2.8)] model.		A1
			(7)
	Notes		
(a)	M1	Setting up an equation leading to a value for n. eg $\frac{e^{-2.8}(2.8)^5}{5!} n = n - 87.63$	
	A1	May be implied by n = 96 (not awrt 96) or correct value of a (observed) or correct value of b (expected).	
(b)	B1	both 5 cao and awrt 8.37	
	B1	Both hypotheses correct. Must mention Po(2.8) at least once.	
	M1	For combining last 2 cells to get observed 3 and expected 6.25 or $\frac{(3-6.25)^2}{6.25}$ seen.	
	M1	For $\frac{("5"- "8.37")^2}{"8.37"} + 9.86 + \dots$ or for a full method with 7 terms evaluated (condone 6 or 8 terms)	
	A1	awrt 12.9 (this is dependent upon 1st M1)	
	M1	Using df for their number of cells – 1	
	A1	12.592 (allow 14.067 from df = 8 – 1 if last 2 cells not combined or allow 11.07[0] from df = 6 – 1 if last 3 cells combined)	
	A1	Jeff's model/Poisson is not suitable. Do not need to see 2.8 here. (dep on all M marks) Do not allow contradictory comments.	

Question Number	Scheme		Marks
6(a)	Label full-time staff [1-6000] and part-time staff [1-4000]		M1
	Use random numbers to select		M1
	120 full-time staff and 80 part-time staff		A1
(b)			(3)
	Enables estimation of statistics/errors for each strata or “reduces variability” or “more representative” or “reflects population structure” NOT more accurate		B1
			(1)
(c)	$H_0 : \mu_f = \mu_p \quad H_1 : \mu_f \neq \mu_p$		B1
	$\text{s.e.} = \sqrt{\frac{21}{80} + \frac{19}{80}} \quad , \quad z = \frac{52 - 50}{\sqrt{\frac{21}{80} + \frac{19}{80}}} (= 2\sqrt{2})$		M1, M1
			= awrt 2.83
	C.V. = 2.5758 (or p-value awrt 0.002 (<0.005) or awrt 0.004 (<0.01))		B1
	[2.83 > 2.5758 so] significant evidence to reject H ₀		dM1
	There is evidence of a difference in policy awareness between full-time and part-time staff		A1ft
			(7)
	(d)	$\bar{X}_f$ /Mean score for full-time staff and $\bar{X}_p$ /Mean score for part-time staff.....	
	follow (approximate) Normal distributions.		B1
			(2)
(e)	Have assumed $s^2 = \sigma^2$ or variance of sample = variance of population for both		B1
			(1)
(f)	[2.53 < “2.5758”] not significant or do not reject H ₀		M1
	So there is insufficient evidence of a difference in mean awareness scores		A1ft
			(2)
(g)	Training course has closed the gap between full-time and part-time staff’s mean awareness.		B1 (1)
			[17 marks]
	Notes		
(a)	M1	For numbering/labelling/ordering o.e. staff in each group. Label all 10000 staff is M0.	
	M1	For use of random numbers/random sample/random selection	
	A1	(dep on either M mark) 120 full-time and 80 part-time	
(c)	B1	Both hypotheses clearly labelled (allow equivalent e.g. $\mu_f - \mu_p = 0$)	
	M1	Attempt at s.e. in the form $\sqrt{\frac{p}{q} + \frac{r}{s}}$ condone one number wrong	
	M1	Using their s.e. in correct formula for test statistic. Must be in the form $\frac{\pm(52 - 50)}{\sqrt{\frac{p}{q} + \frac{r}{s}}}$	
	A1	awrt 2.83 allow awrt -2.83	
	B1	±2.5758 or better allow appropriate p-value if used consistently with correct significance level	
	dM1	Dep on previous M1 for a correct statement based on their normal C.V. and their test statistic	
	A1ft	For correct comment in context. Must mention “scores” or “awareness” and “types of staff”.	
(d)	B1	For mention of both means	
	B1	For stating that distributions of mean(s) can be approximate normal	
(f)	M1	For correct (ft) statement (may be implied by correct context. comment) ft C.V. from (c)	
	A1ft	For correct (ft) contextualised comment with “scores” or “awareness”	
(g)	B1	Correct comment in context that implies that there is now no (significant) difference in mean scores. Dep on significant result in part (c) and non-significant result in part (f).	

Question Number	Scheme	Marks
7. (i)	$A \sim N(21, 2^2)$, $B \sim N(32, 7^2)$ and $C \sim N(45, 9^2)$ A, B, C are independent.	
(a)	$T = A + B + C$	
	$E(T) = 21 + 32 + 45 [= 98]$ or $\text{Var}(T) = 2^2 + 7^2 + 9^2 [= 134]$ A fully correct method of finding $E(T)$ or $\text{Var}(T)$	M1
	$E(T) = 98$ and $\text{Var}(T) = 134$ Both $E(A) = 98$ and $\text{Var}(A) = 134$	A1
	{So $T \sim N(98, 134)$ }	
	$\{P(T > 90) = \} \quad P\left(Z > \frac{90 - "98"}{\sqrt{"134"}}\right)$ Standardising ($\pm$) with their mean and their standard deviation	M1
	$= P(Z > -0.69109...)$	
	$= 0.7549$ (or 0.75525...) awrt 0.755	A1
		[4]
(b)	$\{P(A > B) = P(A - B > 0)\}$	
	$E(A - B) = 21 - 32 [= -11]$ or $\text{Var}(T) = 2^2 + 7^2 [= 53]$ A fully correct method of finding $E(A - B)$ or $\text{Var}(A - B)$	M1 o.e.
	$E(A - B) = -11$ and $\text{Var}(A - B) = 53$ Both $E(A - B) = -11$ and $\text{Var}(A - B) = 53$	A1 o.e.
	{So $A - B \sim N(-11, 53)$ }	
	$\{P(A - B > 0)\} \Rightarrow P\left(Z > \frac{0 - "-11"}{\sqrt{"53"}}\right)$ Standardising ($\pm$) with their mean and their standard deviation	M1
	$= P(Z > 1.510966...)$	
	$= 0.06539855...$ (or 0.0655) 0.0655 or awrt 0.0654	A1
		[4]
(ii)	$\{P(X_1 > \bar{X} + k\sigma) = 0.1 \Rightarrow P(X_1 - \bar{X} > k\sigma) = 0.1\}$	
	$X_1 - \bar{X} = X_1 - \frac{(X_1 + X_2 + X_3 + X_4)}{4} = \frac{3X_1 - (X_2 + X_3 + X_4)}{4}$ For writing or using $X_1 - \bar{X}$	M1
	$E(X_1 - \bar{X}) = 0$ Correct mean for $X_1 - \bar{X}$	A1
	$\text{Var}(X_1 - \bar{X}) = \frac{9\sigma^2 + 3\sigma^2}{4^2}$ Correct expression for $\text{Var}(X_1 - \bar{X})$	M1
	$X_1 - \bar{X} \sim N(0, 0.75\sigma^2)$ Correct distribution for $X_1 - \bar{X}$ May be implied by standardisation	A1
	$\left\{P(X_1 - \bar{X} > k\sigma) = 0.1 \Rightarrow P\left(Z > \frac{k\sigma - 0}{\sqrt{0.75\sigma^2}}\right) = 0.1\right\}$	
	So, $\frac{k}{\sqrt{0.75}} = 1.2816$ Standardising with their $\text{Var}(X_1 - \bar{X})$ (must be in terms of σ^2) Note that σ must cancel.	M1
		1.2816 or better B1
	$\{k = \sqrt{0.75} (1.2816)\} \Rightarrow k = 1.109898157...$ Dep on all previous M marks for awrt 1.11	A1
		[7]
		15

Please check the examination details below before entering your candidate information

Candidate surname		Other names	
Centre Number		Candidate Number	

Pearson Edexcel International Advanced Level

Thursday 22 January 2026

Afternoon (Time: 1 hour 30 minutes) **Paper reference** **WST03/01**

Mathematics ▲ ▲

International Advanced Subsidiary/Advanced Level

Statistics S3

You must have:
Mathematical Formulae and Statistical Tables (Yellow), calculator

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebraic manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Values from the statistical tables should be quoted in full. If a calculator is used instead of the tables, the value should be given to an equivalent degree of accuracy.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 8 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ►

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Pearson

1. Zimo wants to apply for a job with a large international company.

All applicants must take an aptitude test to see if they are suitable for the job.

There are two centres where Zimo can take the test, centre A and centre B

Zimo found out that last month

- 90 people took the test at centre A and 60 passed
- 110 people took the test at centre B and 80 passed

Test, at the 5% level of significance, whether or not the aptitude test result is independent of the test centre.

Show your working clearly. You must state your hypotheses, expected frequencies, test statistic and critical value.

(8)



DO NOT WRITE IN THIS AREA



Question 1 continued

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Question 1 continued

Handwriting practice area with horizontal lines.

(Total for Question 1 is 8 marks)



2. At a dog show, 5 Great Dane dogs were ranked by two judges, judge X and judge Y. Spearman's rank correlation coefficient between the judges' ranks is calculated and a test for positive correlation is carried out at the 5% significance level.

(a) State suitable hypotheses for the test.

(1)

Given that the result of the hypothesis test was to reject H_0

(b) show that the largest possible value of $\sum d^2$ is 2

(3)

The table below gives the rank order for judge X

Dog	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>	<i>E</i>
Judge X	1	2	3	4	5

Given that $\sum d^2$ takes its largest possible value,

(c) find a possible order for judge Y's rankings.

(2)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Question 2 continued

Handwriting practice area with horizontal lines.

(Total for Question 2 is 6 marks)



3. A machine produces packets of cereal with weights, X kg, such that $X \sim N(\mu, \sigma^2)$

A random sample of these packets is taken and a 95% confidence interval for μ is found to be (509.1572, 510.8428)

- (a) Find a 90% confidence interval for μ based on the same sample of packets.
You must show your working and give your confidence limits to one decimal place. (6)

Using three different random samples, three 90% confidence intervals are to be found.

- (b) Calculate the probability that at least 1 of these intervals will contain μ (2)



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Question 3 continued

Handwriting practice area with 30 horizontal lines.

(Total for Question 3 is 8 marks)



4. A supermarket sells apples in trays. Each tray contains 10 apples.

Trays are inspected for rotten apples daily.

The following table shows the numbers of rotten apples in a random sample of 150 trays on one day.

Number of rotten apples	0	1	2	3	4	5	6
Frequency	25	47	37	24	8	6	3

The manager believes that these data can be modelled by a binomial distribution $B(10, p)$

- (a) Use these data to estimate the value of the parameter p for this model.

Give your answer to 2 decimal places.

(2)

The manager uses the estimated value of p to 2 decimal places and calculates expected frequencies to 2 decimal places as follows.

Number of rotten apples	0	1	2	3	4	5	≥ 6
Expected frequency	20.62	45.26	44.71	26.17	10.05	r	s

- (b) Show that the value of r is 2.65 to 2 decimal places.

(1)

- (c) Find the value of s to 2 decimal places.

(1)

The manager says that the cells for 4, 5 and ≥ 6 need to be combined into a single cell.

- (d) Explain why it is necessary for the manager to do this.

(1)

The value of $\sum \frac{(O - E)^2}{E}$ for the first 4 frequencies given in each table is 2.51

- (e) Using a 10% significance level, test whether or not a binomial distribution is a suitable model.

You must state your hypotheses, test statistic and the critical value used.

(7)



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Question 4 continued

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Question 4 continued

(Total for Question 4 is 12 marks)



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Question 5 continued

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Question 5 continued

(Total for Question 5 is 12 marks)



6. The random variable $H \sim N(\mu, 6^2)$

The mean of a random sample of n observations of H is denoted by $\bar{H}$

Given that $P(\bar{H} < 55.08) = 0.1151$ and $P(\bar{H} > 56.976) = 0.0250$ using the tables provided

- (a) show that $n = 100$

(6)

- (b) hence, find the value of μ

(2)



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Question 6 continued

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(Total for Question 6 is 8 marks)



7. The random variable X has a continuous uniform distribution over the interval $[a - 1, a + 5]$ where a is a constant.

The mean of a random sample of size 9, taken from this distribution, is denoted by $\bar{X}$

- (a) Find, in terms of $\bar{X}$, an unbiased estimator for a (3)

- (b) Hence find the standard error of the unbiased estimator for a (5)



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Question 7 continued

(Total for Question 7 is 8 marks)



8. A market stall sells cauliflowers classified by three different weights, small (S), medium (M) and large (L)

The weights, in grams, of these cauliflowers are modelled by independent normal distributions as shown below.

$$S \sim \mathcal{N}(265, 78^2) \quad M \sim \mathcal{N}(625, 42^2) \quad L \sim \mathcal{N}(886, 45^2)$$

The random variable T represents the total weight of 2 randomly selected medium cauliflowers minus the weight of 1 randomly selected large cauliflower.

$$T \sim \mathcal{N}(a, b)$$

- (a) Find the value of a and the value of b (3)
- (b) Using standardisation, find the probability that a randomly selected large cauliflower weighs more than 3 times the weight of a randomly selected small cauliflower. (5)

A random sample of 2 small cauliflowers is taken.

- (c) Using standardisation, find the probability that the first cauliflower in this sample weighs at least 100 grams more than the mean weight of both cauliflowers. (5)

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Question 8 continued

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(Total for Question 8 is 13 marks)

TOTAL FOR PAPER IS 75 MARKS





Mark Scheme (Final)

January 2026

International Advanced Level in Statistics S3

WST03/01

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January 2026

Question Paper Log Number P78917A

Publication Code WST03_01_2601_MS

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)

Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN:

- bod – benefit of doubt
- ft – follow through
 - the symbol $\checkmark$ will be used for correct ft
- cao – correct answer only
- cso – correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC – special case
- oe – or equivalent (and appropriate)
- d... or dep – dependent
- indep – independent
- dp – decimal places
- sf – significant figures
- * – The answer is printed on the paper or ag- answer given
- $\square$ or d... – The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. If you are using the annotation facility on ePEN, indicate this action by 'MR' in the body of the script.
6. If a candidate makes more than one attempt at any question:
 - a) If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - b) If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
7. Ignore wrong working or incorrect statements following a correct answer.

Question Number	Scheme				Marks
1	H_0 : The aptitude test result is independent of the test centre H_1 : The aptitude test result is not independent of the test centre				B1
	Observed	Pass	Fail	Total	
	Centre A	60	30	90	M1
	Centre B	80	30	110	
	Total	140	60	200	
	Expected	Pass	Fail		
	Centre A	$\frac{140 \times 90}{200} [= 63]$	$\frac{60 \times 90}{200} [= 27]$		M1
	Centre B	$\frac{140 \times 110}{200} [= 77]$	$\frac{60 \times 110}{200} [= 33]$		
	$\sum \frac{(O-E)^2}{E} = \frac{(60-63)^2}{63} + \frac{(80-77)^2}{77} + \frac{(30-27)^2}{27} + \frac{(30-33)^2}{33}$ or $\sum \frac{O^2}{E} - 200 = \frac{60^2}{63} + \frac{80^2}{77} + \frac{30^2}{27} + \frac{30^2}{33} - 200$				dM1
	= 0.8658... awrt 0.866				A1
	$\nu = (2-1)(2-1) = 1$				B1
	$\chi^2(0.05) = 3.841$				B1ft
	[Do not reject H_0 /not significant/not in the CR] There is insufficient evidence that aptitude test <u>result</u> differs by test <u>centre</u>				dA1ft
					(8)
	Notes				Total 8
	B1	both hypotheses correct with result and centre (Condone aptitude test and test centre). May be written in terms of association			
	M1	for a correct contingency table. May be implied by awrt 0.866			
	M1	attempt at $\frac{\text{row total} \times \text{column total}}{\text{total}}$ (can be implied by at least one correct expected value)			
	dM1	dependent on previous M1. For using $\sum \frac{(O-E)^2}{E}$ or $\sum \frac{O^2}{E} - 200$ (There must be 4 values of $\sum \frac{(O-E)^2}{E}$ or $\sum \frac{O^2}{E}$ calculated)			
	A1	awrt 0.866			
	B1	$\nu = 1$			
	B1ft	3.841 (or better) allow ft from their stated degrees of freedom			
	dA1ft	dependent on 3 rd M1 and 3 rd B1. For a correct contextual conclusion. Must include result and centre. (Condone aptitude test and test centre)			

Question Number	Scheme		Marks
2 (a)	$H_0 : \rho_s = 0$ $H_1 : \rho_s > 0$		B1
			(1)
(b)	$[r_s =] 1 - \frac{6 \sum d^2}{5(24)} \geq 0.9$		M1 B1
	$\sum d^2 \leq 2$ So largest possible value is 2*		A1*
			(3)
(c)	e.g. $d = 0, 0, 0, 1, -1$		M1
	So e.g. $A \ B \ C \ E \ D$		A1
			(2)
	Notes		Total 6
(a)	B1	for both hypotheses correct in terms of ρ or ρ_s . Condone use of p	
(b)	M1	for use of formula for r in an equation or an inequality (condone $>$ rather than $\geq$)	
	B1	for 0.9	
	A1*	answer is given so at least one correct line of working is needed between the M mark and the given answer. Allow $\sum d^2 = 2$ if written as an equation throughout but do not allow $\sum d^2 \geq 2$ or $\sum d^2 > 2$ or $\sum d^2 < 2$	
(c)	M1	for a correct possibility for d or $ d $ May be implied by a correct possibility for rankings	
	A1	for a correct possibility for rankings or eg 1, 2, 3, 5, 4	

Question Number	Scheme		Marks
3 (a)	$\bar{x} = \left[\frac{509.1572 + 510.8428}{2} \right] = 510$		B1
	$2 \times 1.96 \times \frac{\sigma}{\sqrt{n}} = 510.8428 - 509.1572$		M1
	$\frac{\sigma}{\sqrt{n}} = 0.43$		A1
	'510' $\pm$ 1.6449 $\times$ '0.43'		M1 B1
	(509.292..., 510.707...) (awrt 509.3, awrt 510.7)		A1
			(6)
(b)	Let X = The number of confidence intervals containing μ so $X \sim B(3, 0.9)$		
	$P(X \geq 1) = 1 - P(X = 0) = 1 - \left[{}^3C_0 \times 0.9^0 \right] \times 0.1^3$		M1
	$= 0.999$		A1
			(2)
	Notes		Total 8
(a)	B1	for $\bar{x} = 510$	
	M1	for use of $2 \times z$ value $\times \frac{\sigma}{\sqrt{n}} = 510.8428 - 509.1572$ oe	
	A1	Cao	
	M1	for use of $\bar{x} \pm z$ value $\times \frac{\sigma}{\sqrt{n}}$ ft their $\bar{x}$ and their $\frac{\sigma}{\sqrt{n}}$	
	B1	$z = 1.96$ or better and $z = 1.6449$ or better	
	A1	(awrt 509.3, awrt 510.7)	
(b)	M1	for writing or using $P(X \geq 1) = 1 - P(X = 0)$ or $P(X = 1) + P(X = 2) + P(X = 3)$	
	A1	Cao	

Question Number	Scheme		Marks
4 (a)	$\frac{273}{150 \times 10} = 0.18$		M1 A1
			(2)
(b)	$^{10}C_5 \times 0.18^5 \times 0.82^5 \times 150 [= 2.65] *$		B1*
			(1)
(c)	0.54		B1
			(1)
(d)	To ensure that no expected frequency < 5		B1
			(1)
(e)	H ₀ : Binomial distribution is a good fit. H ₁ : Binomial distribution is not a good fit		B1
	Combine cells 8 + 6 + 3 = 17 and 10.05 + 2.65 + '0.54' = 13.24		M1
	$\sum \frac{(O_i - E_i)^2}{E_i} = 2.51 + \frac{(17 - 13.24)^2}{13.24}$		M1
	= 3.5777 awrt 3.58		A1
	$\nu = 5 - 1 - 1 = 3$		B1
	$\chi^2_3(0.05) = 6.251$		B1ft
	[Do not reject H ₀ /not significant] Binomial distribution is a suitable model		dA1
			(7)
	Notes		Total 12
(a)	M1	for a correct method to find the value of p	
	A1	Awrt 0.18	
(b)	B1*	for a correct expression for r	
(c)	B1	for 0.54	
(d)	B1	for a correct explanation	
(e)	B1	for both hypotheses correct (any mention of B(10, p) is B0)	
	M1	for combining cells	
	M1	Dep on an attempt to combine cells. Use of $2.51 + \sum \frac{(O_i - E_i)^2}{E_i}$ for remaining cells	
	A1	awrt 3.58	
	B1	$\nu = 3$	
	B1ft	6.251 or better. Allow ft from their stated DoF	
	dA1	dependent on 2 nd M1. For a correct conclusion which states that the data are consistent with a binomial distribution which must be consistent with the test statistic and CV (Condone any mention of n and p or it supports the managers belief)	

Question Number	Scheme		Marks
5 (a)	$\left[m = \frac{3085}{50} \Rightarrow \right] m = 61.7$		B1
	$v = \frac{190457.2 - 50(61.7)^2}{50 - 1} = 2.3$		M1 A1
			(3)
(b)	$H_0 : \mu_A - \mu_B = 10$ $H_1 : \mu_A - \mu_B > 10$		B1
	$z = \frac{72.2 - '61.7' - 10}{\sqrt{\frac{6.4}{50} + \frac{'2.3'}{50}}}$		M1 M1
	$= 1.1986...$ awrt 1.20		A1
	One tailed c.v. $Z = 1.6449$ or CR: $Z \geq 1.6449$		B1
	Not in CR/Not significant/Do not reject H_0		M1
	No significant evidence to support the head of department's claim		A1
			(7)
(c)	Assume that $s^2 = \sigma^2$ for both samples		B1
	Assume sample sizes are large enough so that CLT applies or the CLT allows us to assume that the distributions of the sample means are (approximately) normal		B1
			(2)
	Notes		Total 12
(a)	B1	Cao	
	M1	for a full attempt at s^2 ft their $\bar{x}$	
	A1	Cao	
(b)	B1	for both hypotheses correct in terms of μ_A and μ_B Allow equivalent rearrangements. Allow other letters as long it is clear which is professor A and which is professor B. Must be attached to H_0 and H_1	
	M1	for $z = \frac{a - b - 10}{\sqrt{\frac{c}{50} + \frac{d}{50}}}$ with at least 2 of a, b, c or d correct (allow $\pm$) ft their 61.7 and their 2.3	
	M1	for $z = \frac{72.2 - '61.7' - 10}{\sqrt{\frac{6.4}{50} + \frac{'2.3'}{50}}}$ (allow $\pm$) ft their 61.7 and their 2.3	
	A1	awrt 1.20	
	B1	for CV = ± 1.6449 and compatible sign with their test statistic	
	M1	for correct statement consistent with their test statistic and CV (no contradictory non-contextual comments) May be implied by correct contextual comment on its own	
	A1	for a contextual conclusion that is consistent with their test statistic and their CV. Must mention head of department's claim	
(c)	B1	for one correct assumption. Must mention both samples.	
	B1	for a second correct assumption. Must mention both samples.	

Question Number	Scheme		Marks
6 (a)	$\left[P\left(\bar{H} < 55.08\right) = 0.1151 \right] \Rightarrow \frac{55.08 - \mu}{\frac{6}{\sqrt{n}}} = -1.20$		M1
	$55.08 + \frac{7.2}{\sqrt{n}} = \mu$		A1
	$\left[P\left(\bar{H} > 56.976\right) = 0.0250 \right] \Rightarrow \frac{56.976 - \mu}{\frac{6}{\sqrt{n}}} = 1.96$		M1
	$56.976 - \frac{11.76}{\sqrt{n}} = \mu$		A1
	$55.08 + \frac{7.2}{\sqrt{n}} = 56.976 - \frac{11.76}{\sqrt{n}}$		M1
	Either $\frac{18.96}{\sqrt{n}} = 1.896$ or $\sqrt{n} = 10$ leading to $n = 100^*$		A1*
			(6)
(b)	$\mu = 55.08 + \frac{7.2}{\sqrt{10}} = 55.8$ or $\mu = 56.976 - \frac{11.76}{\sqrt{10}} = 55.8$		M1 A1
			(2)
	Notes		Total 8
(a)	M1	for standardising with μ and $\frac{6}{\sqrt{n}}$ and setting = to ± 1.2	
	A1	for a correct equation	
	M1	for standardising with μ and $\frac{6}{\sqrt{n}}$ and setting = to ± 1.96	
	A1	for a correct equation	
	M1	for solving simultaneously	
	A1*	for a correct equation leading to the given answer	
(b)	M1	substitution of $n = \text{their } 10$ into an equation to find μ	
	A1	Cao	

Question Number	Scheme		Marks
7 (a)	$E(\bar{X}) = \frac{(a-1) + (a+5)}{2} = a + 2$		M1 A1
	So $\bar{X} - 2$ is an unbiased estimator for a		A1
			(3)
(b)	$SE(\bar{X} - 2) = SE(\bar{X})$		B1ft
	$Var(X) = \frac{((a+5) - (a-1))^2}{12} = 3$		M1 A1
	$SE = \frac{s}{\sqrt{n}} = \frac{\sqrt{3}}{3} = 0.57735...$ awrt 0.577		M1 A1
			(5)
	Notes		Total 8
(a)	M1	for use of $\frac{a+b}{2}$	
	A1	for $a + 2$	
	A1	Cao	
(b)	B1ft	for $SE(\bar{X} - 2) = SE(\bar{X})$ ft their unbiased estimator in part (a) May be implied by awrt 0.577	
	M1	for use of $\frac{(b-a)^2}{12}$	
	A1	Cao	
	M1	for use of $\frac{s}{\sqrt{n}}$	
	A1	awrt 0.577	

Question Number		Scheme		Marks
8 (a)	$[a =]625 + 625 - 886 =]364$			B1
	$[b =]42^2 + 42^2 + 45^2 = 5553$			M1 A1
				(3)
(b)	$X = L - 3S$			
	$[E(X) = 886 - 3 \times 265 =]91$			M1
	$[Var(X) =]45^2 + 3^2 \times 78^2 = 56781$			M1 A1
	$[P(X > 0) =]P\left(Z > \frac{0 - 91}{\sqrt{56781}}\right)$			M1
	$[P(Z > -0.38) =]0.6480$ Cal gives 0.64865... So awrt 0.648 – 0.649			A1
				(5)
(c)	$Y = \frac{S_1 - S_2}{2}$	$R = S_1 - S_2$		M1
	$\left[E(Y) = \frac{265 - 265}{2} = \right]0$	$[E(R) = 265 - 265 =]0$		M1
	$[Var(Y) =]\frac{78^2 + 78^2}{4} = 3042$	$[Var(R) =]78^2 + 78^2 = 12168$		M1
	$[P(Y > 100) =]P\left(Z > \frac{100 - 0}{\sqrt{3042}}\right)$	$[P(R > 200) =]P\left(Z > \frac{200 - 0}{\sqrt{12168}}\right)$		M1
	$[P(Z > 1.81) = 1 - 0.9649 =]0.0351$ Cal gives 0.0349 So awrt 0.0349 – 0.0351			A1
				(5)
		Notes		Total 13
(a)	B1	Cao		
	M1	For writing or using $2 \times Var(M) + Var(L)$		
	A1	Cao		
(b)	M1	for seeing or using $E(X) = 91$ or correct expression for mean		
	M1	for writing or using $Var(L) + 3^2 Var(S)$		
	A1	Cao		
	M1	for standardising using their mean and standard deviation (Allow $\pm$)		
	A1	awrt 0.648 – awrt 0.649		
(c)	M1	for use of $\frac{S_1 - S_2}{2}$ or $S_1 - S_2$		
	M1	for writing or using $E(Y) = 0$ or $E(R) = 0$		
	M1	for using $Var(Y) = 3042$ or $Var(R) = 12168$		
	M1	for standardising using their mean and standard deviation (Allow $\pm$)		
	A1	awrt 0.0349 – awrt 0.0351		