COMPENDIUM EDEXCEL

Pearson Edexcel International A Level

OCT 2025

Gerard Romo Garrido

Toomates Coolección vol. 79.4

Toomates Coolección

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Problem Solving (en español):

Geometría Axiomática Problemas de Geometría Vol. 1 Vol. 2 Vol. 3
Introducción a la Geometría Álgebra Teoría de números Vol. 1 Vol. 2 Combinatoria
Probabilidad Trigonometría Desigualdades Números complejos Calculus & Precalculus

Libros de texto para ESO y bachillerato (en español y en catalán):

Cálculo infinitesimal ESP CAT Álgebra Lineal ESP CAT Geometría Lineal ESP CAT
Números Complejos ESP CAT Combinatoria y probabilidad ESP CAT Estadística ESP CAT
Programación Lineal ESP CAT Álgebra ESP CAT Trigonometria ESP CAT
Geometria analítica ESP CAT Funciones ESP CAT Números (Preálgebra) ESP CAT
Proporcionalidad ESP CAT Medidas geométricas ESP CAT Mates amb Excel

PAU españolas:

Cataluña TEC Cataluña CCSS Valencia Galicia País Vasco Baleares

Reválidas internacionales:

Portugal Italia Francia Rumanía Hungría Polonia Pearson Edexcel Int. A Level
China-Gaokao China-Zhongkao Corea-Suneung Israel-Bagrut Cambridge Int. A Level
Cambridge IGCSE AQA GCSE International Baccalaureate (IB) Pearson Edexcel IGCSE

Evaluación diagnóstica y pruebas de acceso:

ACM6EP ACM4 CFGS PAP

Competiciones matemáticas:

Canguro: España Cataluña Francia USA Reino Unido Austria
USA: Mathcounts AMC 8 10 12 AIME USAJMO USAMO TSTST TST ELMO Putnam HMMT
España: OME OMEFL OMEEX OMC OMEA OMEM OMA CDP OFEM
Europa: OMI Arquimede BMO BalkanMO JBMO OPM OMP OMJ ONM
Internacional: IMO IGO SMT INMO CMO EGMO KMO KJMO
AHSME: Book 1 2 3 4 5 6 7 8 9

Otros materiales:

Pizzazz! (Book A B C D E Pre-Algebra Algebra) , REOIM , Llibre3r , Excalibur

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Versión de este documento: **12/03/2026**

Documentos de este recopilatorio.

Índice de recopilatorios e información general:
http://www.toomates.net/biblioteca/Edexcel.pdf

Hasta MAY 2024 las pruebas están agrupadas por asignaturas:

P1: http://www.toomates.net/biblioteca/EdexcelP1.pdf

P2: http://www.toomates.net/biblioteca/EdexcelP2.pdf

P3: http://www.toomates.net/biblioteca/EdexcelP3.pdf

P4: http://www.toomates.net/biblioteca/EdexcelP4.pdf

FP1: http://www.toomates.net/biblioteca/EdexcelF1.pdf

FP2: http://www.toomates.net/biblioteca/EdexcelF2.pdf

FP3: http://www.toomates.net/biblioteca/EdexcelF3.pdf

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S2: http://www.toomates.net/biblioteca/EdexcelS2.pdf

S3: http://www.toomates.net/biblioteca/EdexcelS3.pdf

M1: http://www.toomates.net/biblioteca/EdexcelM1.pdf

M2: http://www.toomates.net/biblioteca/EdexcelM2.pdf

M3: http://www.toomates.net/biblioteca/EdexcelM3.pdf

D1: http://www.toomates.net/biblioteca/EdexcelD1.pdf

A partir de OCT 2024 las pruebas se presentan cronológicamente:

OCT 2024: http://www.toomates.net/biblioteca/Edexcel1.pdf

GEN 2025: http://www.toomates.net/biblioteca/Edexcel2.pdf

MAY 2025: http://www.toomates.net/biblioteca/Edexcel3.pdf

OCT 2025: http://www.toomates.net/biblioteca/Edexcel4.pdf

GEN 2026: http://www.toomates.net/biblioteca/Edexcel5.pdf

Otros compendiums de pruebas PAU internacionales:

Portugal: http://www.toomates.net/biblioteca/Portugal.pdf

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China Gaokao: http://www.toomates.net/biblioteca/Gaokao.pdf

International Baccalaureate (IB): http://www.toomates.net/biblioteca/CompendiumIB.pdf

Pearson Edexcel International A Level: http://www.toomates.net/biblioteca/Edexcel.pdf

Pearson Edexcel IGCSE: http://www.toomates.net/biblioteca/EdexcelIGCSE.pdf

Cambridge International AS & A Level: http://www.toomates.net/biblioteca/Cambridge.pdf

Cambridge IGCSE: http://www.toomates.net/biblioteca/CambridgeIGCSE.pdf

AQA GCSE: http://www.toomates.net/biblioteca/AQAGCSE.pdf

Corea Suneung: http://www.toomates.net/biblioteca/Suneung.pdf

Israel Bagrut: http://www.toomates.net/biblioteca/Bagrut.pdf

Compendiums de pruebas PAU españolas:

Cataluña (TEC): http://www.toomates.net/biblioteca/Pautec.pdf

Cataluña (CCSS): http://www.toomates.net/biblioteca/Pauccss.pdf

Valencia: http://www.toomates.net/biblioteca/Valencia.pdf

Galicia: http://www.toomates.net/biblioteca/Galiciapau.pdf

País Vasco: http://www.toomates.net/biblioteca/Paisvascopau.pdf

Baleares: http://www.toomates.net/biblioteca/Balears.pdf

Índice.

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

Pearson Edexcel International Advanced Level

Monday 13 October 2025

Afternoon (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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M:1/

P 8 7 4 3 8 A

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1. Two particles P and Q are moving in opposite directions along the same horizontal straight line.
Particle P is moving due east and particle Q is moving due west.
Particle P has mass $2m$ and particle Q has mass $3m$.
The particles collide directly.
Immediately before the collision, the speed of P is $4u$ and the speed of Q is u.
The magnitude of the impulse in the collision is $\frac{33}{5}mu$.

(a) Find the speed and direction of motion of P immediately after the collision.

(3)

(b) Find the speed and direction of motion of Q immediately after the collision.

(3)

(Total for Question 1 is 6 marks)

2.

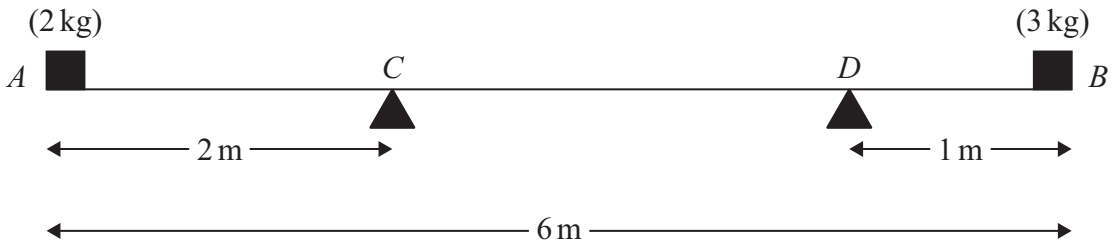

Figure 1

A plank AB, of length 6 m and mass 4 kg, rests in equilibrium horizontally on two supports at C and D, where $AC = 2$ m and $DB = 1$ m.

A brick of mass 2 kg rests on the plank at A and a brick of mass 3 kg rests on the plank at B, as shown in Figure 1.

The plank is modelled as a uniform rod and all bricks are modelled as particles.

(a) Find the magnitude of the reaction exerted on the plank

(i) by the support at C,

(ii) by the support at D.

(6)

The 3 kg brick is now removed and replaced with a brick of mass x kg at B.

The plank remains horizontal and in equilibrium but the reactions on the plank at C and at D now have equal magnitude.

(b) Find the value of x.

(4)

(Total for Question 2 is 10 marks)

3. Two forces, $\mathbf{F}_1$ and $\mathbf{F}_2$, act on a particle A.

$\mathbf{F}_1 = (2\mathbf{i} - 3\mathbf{j})$ N and $\mathbf{F}_2 = (p\mathbf{i} + q\mathbf{j})$ N, where p and q are constants.

Given that the resultant of $\mathbf{F}_1$ and $\mathbf{F}_2$ is parallel to $(\mathbf{i} + 2\mathbf{j})$,

(a) show that $2p - q + 7 = 0$

(5)

Given that $q = 11$ and that the mass of A is 2 kg, and that $\mathbf{F}_1$ and $\mathbf{F}_2$ are the only forces acting on A,

(b) find the magnitude of the acceleration of A.

(5)

(Total for Question 3 is 10 marks)

4. A block A of mass 9 kg is released from rest from a point P which is a height h metres above horizontal soft ground.

The block falls and strikes another block B of mass 1.5 kg which is on the ground vertically below P.

The speed of A immediately before it strikes B is $7\,\text{m}\,\text{s}^{-1}$.

The blocks are modelled as particles.

(a) Find the value of h.

(2)

Immediately after the impact the blocks move downwards together with the same speed and both come to rest after sinking a vertical distance of 12 cm into the ground.

Assuming that the resistance offered by the ground has constant magnitude R newtons,

(b) find the value of R.

(7)

(Total for Question 4 is 9 marks)

5.

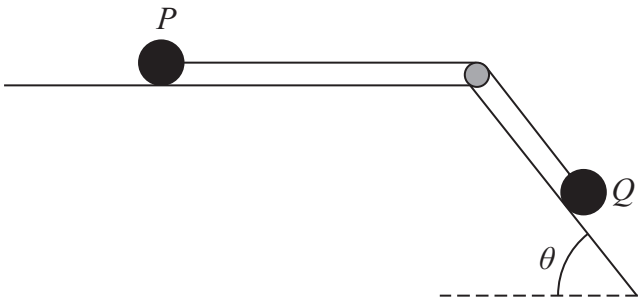

Figure 2

Two particles P and Q have masses 0.1 kg and 0.5 kg respectively.

The particles are attached to the ends of a light inextensible string.

Particle P is held at rest on a rough horizontal table.

The string lies along the table and passes over a small smooth pulley which is fixed to the edge of the table.

Particle Q is at rest on a smooth plane which is inclined to the horizontal at an angle θ, where $\tan\theta = \frac{4}{3}$

The string lies in the vertical plane which contains the pulley and a line of greatest slope of the inclined plane, as shown in Figure 2.

Particle P is released from rest with the string taut.

During the first 0.5 s of the motion P does not reach the pulley and Q moves 0.75 m down the plane.

(a) Find the tension in the string during the first 0.5 s of the motion.

(6)

(b) Find the coefficient of friction between P and the table.

(5)

(Total for Question 5 is 11 marks)

6.

Figure 3

A washing line $ABCD$ is fixed at the points A and D.

There are two heavy items of clothing hanging on the washing line, one fixed at B and the other fixed at C.

The washing line is modelled as a light inextensible string, the item at B is modelled as a particle of mass 3 kg and the item at C is modelled as a particle of mass M kg.

The section AB makes an angle α with the horizontal, where $\tan \alpha = \frac{3}{4}$, the section BC is horizontal and the section CD makes an angle β with the horizontal, where $\tan \beta = \frac{12}{5}$, as shown in Figure 3.

The system is in equilibrium.

(a) Find the tension in AB.

(4)

(b) Find the tension in BC.

(3)

(c) Find the value of M.

(5)

(Total for Question 6 is 12 marks)

7. Two trains, A and B, start together from rest, at time $t = 0$, at a station and move along parallel straight horizontal tracks.

Both trains come to rest at the next station after 180 s.

Train A moves with constant acceleration $\frac{2}{3}$ m s^{-2} for 30 s, then moves at constant speed for 120 s and then moves with constant deceleration for the final 30 s.

Train B moves with constant acceleration for 90 s and then moves with constant deceleration for the final 90 s.

(a) Sketch, on the same axes, the speed–time graphs for the motion of the two trains between the two stations.

(3)

(b) Find the acceleration of train B for the first half of its journey.

(5)

(c) Find the times when the two trains are moving at the same speed.

(4)

(d) Find the distance between the trains 96 s after they start.

(5)

(Total for Question 7 is 17 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

Monday 13 October 2025

Afternoon (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 $g = 9.8$ 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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P 8 7 4 7 2 A 0 1 2 4

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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 6 marks)

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Question 2

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Question 2 continued

Question 2 continued

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Question 2 continued

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(Total for Question 2 is 10 marks)

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Question 3

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Question 3 continued

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(Total for Question 3 is 10 marks)

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Question 4

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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)

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Question 5

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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)

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Question 6

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Question 6 continued

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Question 6 continued

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Question 6 continued

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(Total for Question 6 is 12 marks)

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Question 7

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Question 7 continued

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Question 7 continued

(Total for Question 7 is 17 marks)

TOTAL FOR PAPER IS 75 MARKS

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Mark Scheme (Results)

October 2025

International Advanced Level in Mechanics M1

WME01/01A

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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 $\surd$ 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
   - 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.

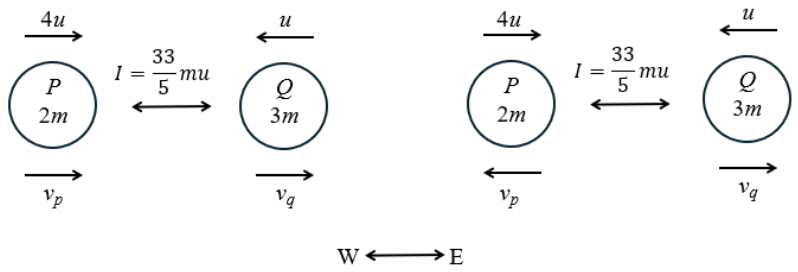
General Principles for Mechanics Marking

(NB 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

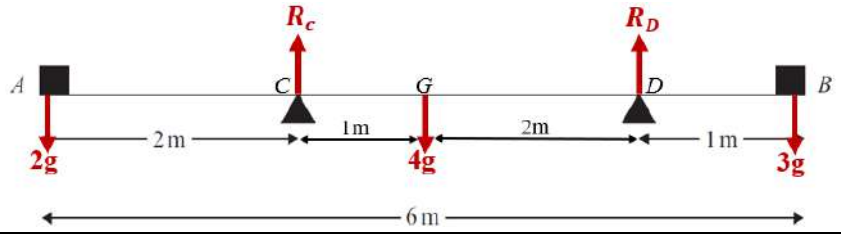
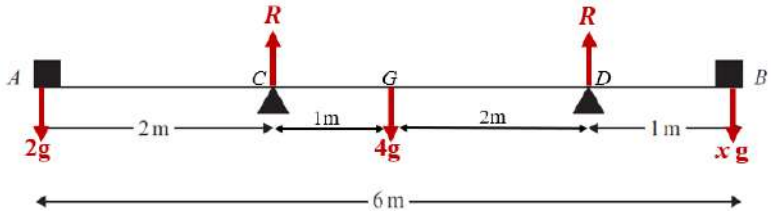
Mechanics Abbreviations

M(A)	Taking moments about A
N2L	Newton's Second Law (Equation of Motion)
NEL	Newton's Experimental Law (Newton's Law of Impact)
HL	Hooke's Law
SHM	Simple harmonic motion
PCLM	Principle of conservation of linear momentum
RHS	Right hand side
LHS	Left hand side

Question Number	Scheme	Marks
1		
(a)	Impulse-momentum equation for P	M1
	$-\frac{33}{5}mu = 2m(v_P - 4u)$ or $-\frac{33}{5}mu = 2m(-v_P - 4u)$	A1
	(speed of P =) $0.7u$ due East	A1
		(3)
(b)	Impulse-momentum equation for Q	M1
	$\frac{33}{5}mu = 3m(v_Q - -u)$	A1
	(speed of Q =) $1.2u$ due East	A1
		(3)
		[6]

Notes	
Note: Parts (a) and (b) may be marked together. Allow part (b) to be answered before part (a).	
1(a)	
M1	Form an equation to find v_P. Either Form a dimensionally correct impulse-momentum equation for P (using $2m$ and $4u$). Must attempt difference in momenta. M0 if g's are included on RHS. Condone sign errors. Or Form a dimensionally correct CLM equation in v_P (m and u) only. Allow consistent extra g's and cancelled m's and sign errors but masses and velocities must be correctly paired. Condone sign errors.
A1	A correct unsimplified equation in v_P (m and u) only CLM: $2m(4u) + 3m(-u) = 2m(v_p) + 3m(1.2u)$
A1	Correct answer, both speed and direction. Direction must be stated, not just seen on a diagram. For direction, accept E (or 'unchanged', 'same' or 'continues in its original direction' or 'towards Q'). A0 if only 'to the right' or 'positive direction'

1(b)	
M1	Form an equation to find v_Q. Either Form a dimensionally correct impulse-momentum equation for Q (using $3m$ and u). Must attempt difference in momenta. M0 if g's are included on RHS. Condone sign errors. Or Form a dimensionally correct CLM equation in v_Q (m and u) only. Allow consistent extra g's and cancelled m's and sign errors but masses and velocities must be correctly paired.
A1	Correct unsimplified equation in v_Q (m and u) only CLM: $2m(4u)+3m(-u)=2m(0.7u)+3m(v_q)$
A1	Correct answer, both speed and direction. Direction must be stated, not just seen on a diagram. For direction, accept E (or 'reverses direction' or 'opposite direction' or 'in the original direction of P', 'away from P') A0 if only 'to the right' or 'positive direction' or 'changed direction'

Question Number	Scheme	Marks
2 **(a)**		
	(i) Form an equation to solve for R_C	M1
	Relevant equations M(*D*): $3R_C+(1\times3g)=(2\times4g)+(5\times2g)$ Vert: $R_C+R_D=4g+2g+3g$ M(C): $3R_D+(2\times2g)=(1\times4g)+(4\times3g)$ M(*A*): $2R_C+5R_D=(3\times4g)+(6\times3g)$ M(*B*): $4R_C+1R_D=(3\times4g)+(6\times2g)$ M(*G*): $1R_C+(3\times3g)=2R_D+(3\times2g)$	A1
	$R_C=49$ (N)	A1
	(ii) Form an equation to solve for R_D	M1
	Correct equation	A1
	$R_D=39$ or 39.2 (N)	A1
		(6)
(b)		
	Moments equation in *x* with new Reaction forces	M1
	M(*B*): $4R_C+1R_D=(3\times4g)+(6\times2g)$ M(*D*): $3R_C+(1\times xg)=(2\times4g)+(5\times2g)$ M(C): $3R_D+(2\times2g)=(1\times4g)+(4\times xg)$ M(*A*): $2R_C+5R_D=(3\times4g)+(6\times xg)$ M(*G*): $1R_C+(3\times xg)=2R_D+(3\times2g)$	A1
	Complete method to find *x* using $R_C=R_D$	dM1
	$x=3.6$	A1
		(4)
		[10]
Notes		
2(a)	**Note: mark parts (i) and (ii) together.**	
(i)		

M1	Form a relevant equation in R_C. Dimensionally correct and the correct number of terms. A consistent missing *g* or including *m* with every mass term is an A error. If solving simultaneous equation in R_C and R_D, mark the first equation seen. If more than 2 equations are written, mark the ones used.
A1	Correct unsimplified equation
A1	Correct reaction at C seen in part (a), accept 5g.
(ii)	
M1	Form a relevant equation in R_D. Dimensionally correct and the correct number of terms. A consistent missing *g* or including *m* with every mass term is an A error. If solving simultaneous equation in R_C and R_D, mark the second equation seen. If more than 2 equations are written, mark the ones used.
A1	Correct unsimplified equation
A1	Correct reaction at *D* seen in part (a), accept 4g.
2(b)	
M1	Form a moments equation in *x* and *R*. Condone re-using notation R_C and R_D M0 if a previous *R* value is used. If more than one moments equation is used, award this mark for their best equation.
A1	Correct unsimplified moments equation. If more than one moments equation is used, award this mark for their best equation.
dM1	Dependent on previous method mark. Dimensionally correct equation with the correct terms. Complete method to find *x*. Must use $R_C = R_D$ and a second equation. The second equation may be another moments equation or vertical equilibrium. Vert: $R_C + R_D = 4g + 2g + xg$
A1	Correct answer oe, accept $\frac{18}{5}$
	SC: In part (b) max mark M1A1 dM1A1 if there is a complete method with a consistent missing *g* in both equations or for including *m* with every mass term in both equations.

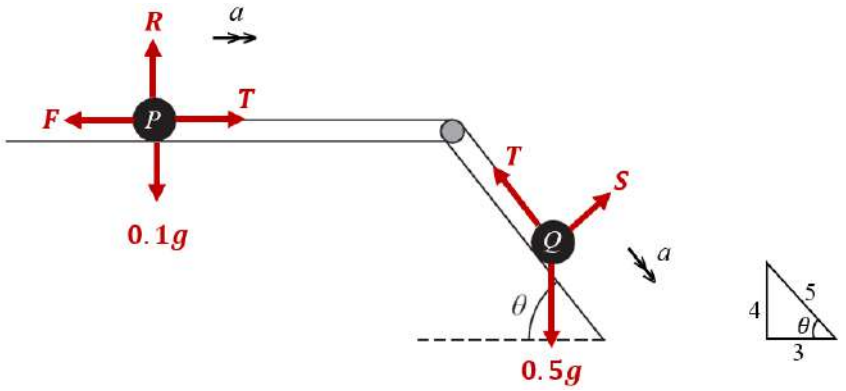
Question Number	Scheme	Marks
3(a)	Resultant force with terms collected $(2\mathbf{i}-3\mathbf{j})+(p\mathbf{i}+q\mathbf{j})=(p+2)\mathbf{i}+(q-3)\mathbf{j}$	M1
	Use parallel vector to form an equation in p and q only	M1
	$\frac{p+2}{q-3}=\frac{1}{2}$	A1
	$4+2p=-3+q$	dM1
	$2p-q+7=0$ *	A1*
		(5)
3(b)	$q=11\Rightarrow p=2$	B1
	Find the resultant force with their p $\mathbf{R}=(p+2)\mathbf{i}+(11-3)\mathbf{j}\quad(=4\mathbf{i}+8\mathbf{j})$	M1
	Use of N2L with their **R** or $\lvert\mathbf{R}\rvert$ Either **F** = m**a** $\Rightarrow$ $4\mathbf{i}+8\mathbf{j}=2\mathbf{a}$ $(\mathbf{a}=2\mathbf{i}+4\mathbf{j})$ or $\lvert\mathbf{F}\rvert = m\lvert\mathbf{a}\rvert$ $\Rightarrow$ $4\sqrt{5}=2\lvert\mathbf{a}\rvert$	M1
	Correct use of Pythagoras to find $\lvert\mathbf{a}\rvert$ or $\lvert\mathbf{R}\rvert$ $\lvert\mathbf{a}\rvert=\sqrt{2^2+4^2}$ or $\lvert\mathbf{R}\rvert=\sqrt{4^2+8^2}$	M1
	$(\lvert\mathbf{a}\rvert=)\sqrt{20}=4.5$ or better (m s^{-2})	A1
		(5)
		[10]
Notes		
Accept column vectors throughout		
3(a)		
M1	Find the resultant force ($\mathbf{F}_1+\mathbf{F}_2$) and collect terms in the form $\mathbf{R}=a\mathbf{i}+b\mathbf{j}$. May be implied by the components $(p+2)$ and $(q-3)$ used correctly in working.	
M1	Use the parallel vector to form a scalar equation in p and q only. For the method mark, condone the reciprocal, $\frac{p+2}{q-3}=\frac{2}{1}$. Note: If using the multiplier approach, the mark is awarded when the equation is reduced to p and q only. However, M0 if $\lambda=1$ $\left.\begin{matrix}p+2=\lambda\\q-3=2\lambda\end{matrix}\right\}\Rightarrow\quad q-3=2(p+2)$	
A1	Correct equation in p and q only (accept any equivalent form)	

Question Number	Scheme	Marks
dM1	Dependent on both previous method marks. Complete and correct method to obtain given answer.	
A1*	Obtain the given answer from complete and correct working with no errors and exact values. There must be at least one stage of working between the initial equation in p and q only and the given answer. Allow rearrangement but must equal zero. A0 for unconventional vector notation, eg $\frac{(2+p)\mathbf{i}}{(-3+q)\mathbf{j}} = \frac{(1)\mathbf{i}}{(2)\mathbf{j}}$	
3(b)		
B1	Correct value seen	
M1	Use p or their p with $q = 11$ to find the resultant force as a vector. Must sum the forces. M0 if weight is included with resultant force.	
M1	Correct use of N2L with their $\mathbf{R}$ or $\lvert\mathbf{R}\rvert$, must attempt ($\mathbf{F}_1 \pm \mathbf{F}_2$) only. Condone g in ma or $m\mathbf{a}$ term but M0 if weight is included with the resultant force. Allow with p or their p.	
M1	Correct use of Pythagoras (must involve square and add) to find the magnitude of their acceleration or the magnitude of their resultant force. Must have two non-zero components. M0 if using just $\lvert\mathbf{F}_1\rvert$ or $\lvert\mathbf{F}_2\rvert$. Allow with p or their p.	
A1	Correct answer from correct working. Accept any equivalent form eg $2\sqrt{5}$	

Question Number	Scheme	Marks
4(a)	Correct use of *suvat* to form an equation in *h* only $7^2 = 0^2 + 2gh$	M1
	$(h =)\ 2.5$	A1
		(2)
4(b)	Correct use of CLM with common velocity after impact	M1
	$9\times 7 = 9v + 1.5v \quad (v = 6)$	A1
	Correct use of *suvat* with their *v* to form an equation in *a* only	M1
	$0^2 = 6^2 + 2a(0.12) \qquad (a = -150)$	A1
	Correct use of N2L with their acceleration	M1
	$10.5g - R = 10.5\ (-150)$	A1
	$R = 1680 \quad \text{or } 1700$	A1
		(7)
		[9]

Notes	
Note: only penalise use of 9.81 once per whole question, only penalise over or under accuracy once per whole question.	
4(a)	
M1	Use of *suvat* to form relevant equation(s) to solve for *h*
A1	Correct answer, must be positive and a decimal.
4(b)	
M1	Use CLM to find the speed of the blocks after impact. Dimensionally correct equation. Must have a common velocity after impact.
A1	Correct unsimplified equation in one unknown
M1	Correct use of *suvat* to form an equation in *a* only. Allow $\pm a$. Allow with their *v* for the method mark where *v* is a calculated value from CLM. Condone use of 12 or 1.2 instead of 0.12. M0 if using $u = 7$.
A1	Correct unsimplified equation in $\pm a$ only
M1	Correct use of N2L to form an equation in *R*. Allow with *a* or their calculated *a* for the method mark but M0 if $a = \pm g$
A1	Correct unsimplified equation in *R* only.
A1	Correct answer. Must be positive with 2sf or 3sf. A0 if $g = 9.81$ is used unless already penalised in this question.
(b) ALT1	**Note**: You may see an energy approach for last 5 marks (WME02 candidate).
M1 M1	Energy equation with all required terms present and no extra. Each term must have the correct structure. Condone sign errors and 12.

	KE + GPE = work done $\frac{1}{2}(10.5)6^2 + (10.5)g(0.12) = 0.12R$	
A1	Correct equation with at most one error	
A1	Correct equation	
A1	1680 or 1700 , correct answer, 2 or 3 sf	

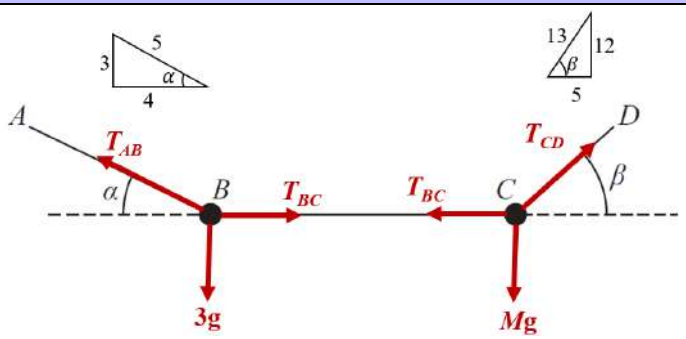
Question Number	Scheme	Marks
		
5 (a)	Correct use of *suvat* to form an equation in *a* only.	M1
	$0.75 = 0 + \frac{1}{2}a(0.5)^2$	A1
	(a =) 6	A1
	Correct use of N2L for Q	M1
	$0.5g\sin\theta - T = 0.5a$	A1ft
	(T =) 0.92 (N)	A1
		(6)
5 (b)	$R = 0.1g$	B1
	Correct use of N2L with *P*	M1
	Either *P*: $T - F = 0.1(6)$ Or system: $0.5g\sin\theta - F = (0.5+0.1)(6)$	A1
	Use of $F = \mu R$ for *P*, $\mu \times$ *their R*	M1
	$\mu = 0.327$ or 0.33	A1
		(5)
		[11]

Notes

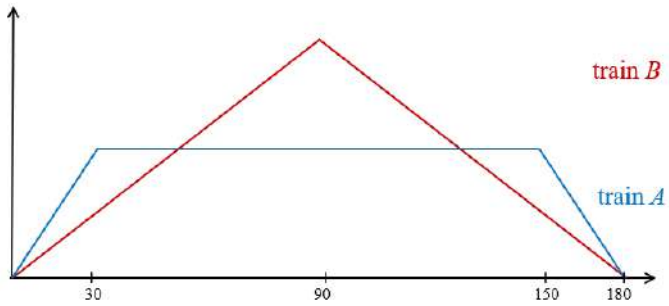
Note: only penalise use of 9.81 once per whole question, only penalise over/under accuracy once per whole question.

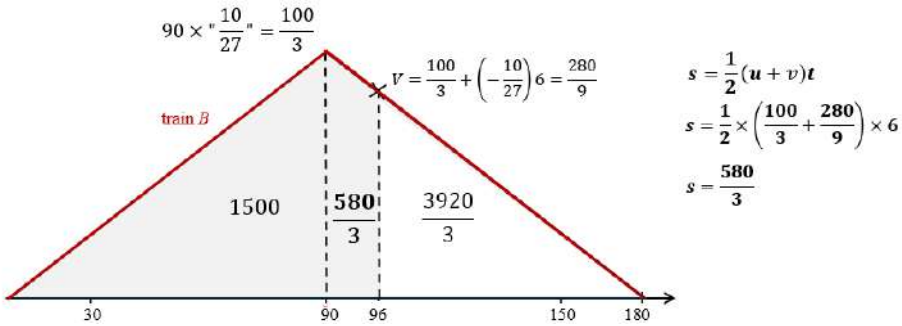
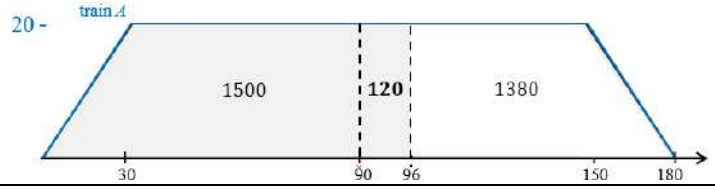
5 (a)	
M1	Use of *suvat* to form sufficient equation(s) to form an equation in *a* only. If using more than one equation, award the method mark when an equation in *a* only has been reached.
A1	Correct equation in *a* only
A1	Correct acceleration

M1	Correct use of N2L for Q to form an equation in T (and a). There is no need to substitute for the trig value or acceleration but M0 if $a = g$. Dimensionally correct and correct terms. Condone sin/cos confusion and sign errors. Including m with every mass term is an A error.
A1ft	Correct equation in T (no need to replace trig). Maybe in a or follow through their calculated a.
A1	Correct answer, must be a decimal.
5(b)	**Note: If both surfaces are assumed to be rough, max possible mark B1 M0A0 M1A0**
B1	Correct expression for R for P seen or implied
M1	Use of N2L horizontally for P or for the whole system (indicated by the mass in the ma term). No need to replace T or a but M0 if $a = g$. If the equation is seen in earlier working, it must be used in (b) to earn the marks here. Dimensionally correct and correct terms. Condone sin/cos confusion and sign errors. Including m with every mass term or g in the ma term is an A error.
A1	Correct unsimplified equation. (Allow with their tension from part (a) if using N2L for P only)
M1	Use of $F = \mu R$. Must be used with their R for P, not simply stated as a formula.
A1	$\mu = 0.327$ or 0.33 Must be a decimal with 2 or 3sf.

Question Number	Scheme	Marks
		
6 (a)	Use of $\sin\alpha=\frac{3}{5}$ or $\cos\alpha=\frac{4}{5}$ or $\alpha=37$ or better	B1
	Vert equilibrium at *B*	M1
	$T_{AB}\sin\alpha=3g$	A1
	$T_{AB}=49\ (\text{N})$	A1
		(4)
6(b)	Horiz equilibrium at *B*	M1
	$T_{AB}\cos\alpha=T_{BC}$	A1
	$T_{BC}=39$ or $39.2\quad(\text{N})$	A1
		(3)
6(c)	Use equilibrium to form at least one equation in T_{CD}	M1
	At least one correct out of: • H at C: $T_{CD}\cos\beta=T_{BC}\quad(102\cos\beta=T_{BC})$ • V at C: $T_{CD}\sin\beta=Mg\quad(102\sin\beta=Mg)$ • H sys: $T_{AB}\cos\alpha=T_{CD}\cos\beta\quad(\frac{4}{5}T_{AB}=102(\frac{5}{13}))$ • V sys: $T_{AB}\sin\alpha+T_{CD}\sin\beta=3g+Mg\quad(\frac{3}{5}T_{AB}+102(\frac{12}{13})=3g+Mg)$	A1
	Two correct equations in T_{CD}	A1
	Form an equation in *M* only Eg $\tan\beta=\frac{Mg}{T_{BC}}\ \Rightarrow\ \frac{12}{5}=\frac{Mg}{"T_{BC}"}$	dM1
	$(M=)\,9.6$	A1
		(5)
		[12]
Note		

Question Number	Scheme	Marks
Note: only penalise use of 9.81 once per whole question, only penalise over or under accuracy once per whole question.		
6 (a)		
B1	Either correct trig ratio for α seen anywhere or implied.	
M1	Method to form an equation in T_{AB} (and α) using equilibrium at B. Trig does not need to be replaced. Including m with a numerical mass term is an A error. Dimensionally correct and condone sin/cos confusion.	
A1	Correct unsimplified equation, trig does not need to be replaced.	
A1	Correct answer, accept 5g.	
6(b)		
M1	Method to form an equation in T_{BC} (and α) using equilibrium at B. Trig does not need to be replaced. Condone re-using the letter T in an equation but M0 if clearly assuming the same tension value in different sections of the string. Including m with a numerical mass term is an A error. Dimensionally correct and condone sin/cos confusion.	
A1	Correct unsimplified equation, trig does not need to be replaced.	
A1	Correct answer, accept 4g.	
6(c)		
M1	Method to form a dimensionally correct equation in T_{CD} using equilibrium at C or the whole system. Trig and tensions do not need to be replaced. If more equations are listed, mark the two that are used. Relevant equations may be seen in earlier working but must be used here to earn the mark. Condone re-using the letter T in an equation. **SC:** Note that T_{CD} =101.92. If the answer to part (b) is 102 (or better) and then 102 is used correctly in (c) then all marks are available in part (c).	
A1	At least one correct unsimplified equation. Trig and tensions do not need to be replaced.	
A1	Two correct equations. Trig and tensions do not need to be replaced.	
dM1	Dependent on previous method mark to form an equation in M only. Must use at least one valid equation but dM0 if $T_{CD} = T_{AB}$ (eg use $T_{CD} = 49$)	
A1	Correct answer, accept 9.60 and $\frac{48}{5}$ since g cancels.	

Question Number	Scheme	Marks
7(a)		B1 (trap) B1 (triangle with 2 inters.) B1 all figs
		(3)
7(b)	Using train *A*, method to find the distance or half distance	M1
	For example, area of trapezium or half trapezium or *suvat* • $\frac{1}{2}(180+120)20$ • $\frac{1}{2}(90+60)20$	A1
	Combining with train *B*, complete method to find the acceleration	M1
	For example, area of triangle or half area of triangle or *suvat* • $"1500"=\frac{1}{2}(90\times V) \Rightarrow V=\frac{100}{3} \Rightarrow a=\frac{V}{90}$ • $"3000"=\frac{1}{2}(180\times V) \Rightarrow V=\frac{100}{3} \Rightarrow a=\frac{V}{90}$ • $"1500"=\frac{1}{2}a90^2$	A1 ft
	$(a=)\frac{10}{27}$, 0.37 or better	A1
		(5)
7(c)	Method to form an equation in *t*	M1
	$"a"t_1="\frac{2}{3}\times 30"$	A1 ft
	$t_1=54\,(s)$ **or** $t_2=126\,(s)$	A1
	$t_1=54\,(s)$ **and** $t_2=126\,(s)$	A1
		(4)
7(d)		
	Method to find maximum speed of train *B* $"a"\times 90 \quad \left(=\frac{100}{3}=33.\dot{3}\right)$	M1

	Complete method to find the distance moved by train *B* for $90,, t,, 96$ or $84,, t,, 90$ 	M1
	Correct distance, for example, • Area of trapezium/suvat $\frac{1}{2}\left(\frac{100}{3}+\frac{280}{9}\right)6 \quad \left(=\frac{580}{3}=193.\dot{3}\right)$ • suvat $\frac{100}{3}\times 6-\frac{1}{2}\left(\frac{10}{27}\right)6^2 \quad \left(=\frac{580}{3}=193.\dot{3}\right)$	A1
	Complete and correct method to fnd the required distance. For example $\frac{580}{3}-(6\times 20)$ 	dM1
	$=\frac{220}{3}$, accept 73 or better (m)	A1
		(5)
		[17]
Notes		
7 (a)		
B1	Shape of graph for train *A*: isosceles (approx.) trapezium, start and finish on the horizontal axis.	
B1	Shape of graph of train *B*: should be an isosceles (approx.) triangle. Must start and finish on the horizontal axis. The graphs should intersect at two points.	
B1	All figures on the same horizontal axis: 30, 90, 150, 180. Accept equivalent delineators.	
7(b)		
M1	Complete method using train *A* to find the distance (or half the distance) between the stations. May use area of their graph but it must be a trapezium. The formula for the area of a trapezium or a triangle must have the correct structure. May use of *suvat* but M0 if $a=\frac{2}{3}$ for $t>30$. May see 20 or their $\frac{2}{3}\times 30$.	
A1	Correct unsimplified expression for the distance or half distance.	

M1	A complete method by combining with train *B* to find the required acceleration.
A1ft	Correct unsimplified equation in *a*, follow through their distance.
A1	Correct answer, accept 0.37 or better
7(c)	
M1	Correct method using train *B* to form an equation in a relevant time, *t*
A1ft	Correct expression, follow through their *a* and their 20 If using second half, with $v = u + at$, follow through their *a*, 20 and $\frac{100}{3}$
A1	At least one correct time
A1	Both correct times
7(d)	
M1	Method to find the maximum speed of train *B*. This may appear on a graph or in earlier working. It must be used in part (d) to earn the mark here.
M1	Method to find the distance travelled by train *B* in the 'extra' 6 seconds **Note**: the method to find the area of the additional trapezium leads straight to the final answer $\frac{1}{2}\left(\frac{40}{3}+\frac{100}{9}\right)6 \quad \left(=\frac{220}{3}\right)$ The final 4 marks are all available.  $s=\frac{1}{2}\times\left[\left(\frac{100}{3}-20\right)+\left(\frac{280}{9}-20\right)\right]\times 6$
A1	Correct distance, accept rounded values in their working eg $\frac{1}{2}\left(\frac{100}{3}+\frac{280}{9}\right)6$ or $\frac{1}{2}(33.3+31.1)6$
dM1	Dependent on both previous method marks. Complete method comparing train *A* and train *B* distances to find the required distance. Must use a correct method for calculating distances before subtraction.
A1	Correct answer, accept 73 or better. Accept more significant figures but must be rounded correctly to their choice of s.f. Exact value is $73.\dot{3}$
(d)	
ALT 1	For candidates who do not use the maximum speed and use the distance from the end.
M1	Complete method to find the distance from the end point for train *B*.
M1	
A1	$s=0-\frac{1}{2}\left(-\frac{10}{27}\right)84^2 \quad \left(=\frac{3920}{3}=1306.\dot{6}\right)$
dM1	Dependent on both previous method marks. Complete and correct method comparing train *A* and train *B* distances to find the required distance. Must use a correct method for calculating distances before subtraction: $1380-\frac{3920}{3}$

A1	Correct answer, accept 73 or better. Accept more significant figures but must be rounded correctly to their choice of s.f. Exact value is $73.\dot{3}$

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 13 October 2025

Afternoon (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.

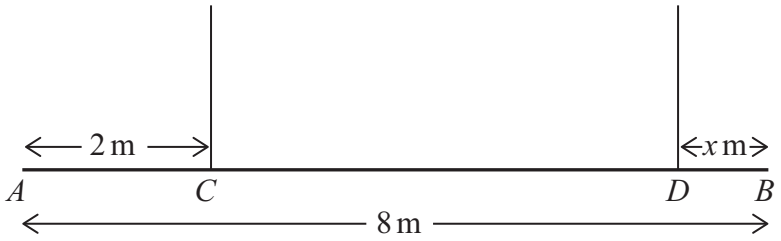

Figure 1

Figure 1 shows a sketch of a beam AB, with weight 240 N and length 8 m.

The beam is held in equilibrium in a horizontal position by two vertical ropes. The ropes are attached to the beam at the points C and D, where $AC = 2$ m and $DB = x$ metres.

The beam is modelled as a uniform rod and the ropes are modelled as light inextensible strings.

The tension in the rope at D is 90 N.

(a) Show that $x = \frac{2}{3}$

(3)

The rope at C will break if its tension exceeds 183 N. The rope at D cannot break. A package of weight W newtons is now attached to the beam at A. The beam remains horizontal and in equilibrium.

The package is modelled as a particle.

It is given that the rope at C does not break.

(b) Find the greatest possible value of W.

(4)

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Question 1 continued

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Question 1 continued

(Total for Question 1 is 7 marks)

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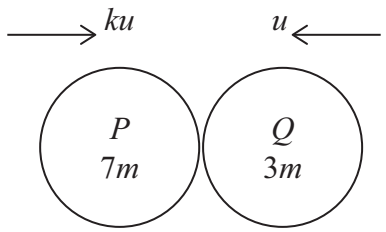

Figure 2

Particle P of mass $7m$ and particle Q of mass $3m$ are moving in opposite directions along the same straight line on a smooth horizontal surface. The particles collide directly.

Immediately **before** the collision, the speed of P is ku and the speed of Q is u, as shown in Figure 2.

Immediately **after** the collision, the speed of P is w and the speed of Q is $2w$.

The direction of motion of Q is reversed by the collision.

The impulse received by Q in the collision has magnitude $\frac{7}{2}mu$.

(a) Find w in terms of u.

(3)

(b) Find the two possible values of k.

(5)

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Question 2 continued

(Total for Question 2 is 8 marks)

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3. [*In this question* **i** *and* **j** *are horizontal perpendicular unit vectors.*]

A particle P of mass 2 kg moves on a smooth horizontal surface under the action of two forces $\mathbf{F}_1$ and $\mathbf{F}_2$, where $\mathbf{F}_1 = (-2\mathbf{i} + 3\mathbf{j})$ N and $\mathbf{F}_2 = (4\mathbf{i} + 2\mathbf{j})$ N.

(a) Find the acceleration of P.

(3)

At time $t = 0$, the velocity of P is $(3\mathbf{i} - 4\mathbf{j})\,\text{m s}^{-1}$

(b) Find the speed of P when $t = 3$ seconds.

(4)

An additional force, $\mathbf{F}_3 = (b\mathbf{i} + c\mathbf{j})$ N, is applied to P.

The resultant of $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$ is equal to $\lambda(\mathbf{i} + \mathbf{j})$ N, where λ is a constant.

(c) Show that $b - c = 3$

(3)

The resultant of $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$ has magnitude $10\sqrt{2}$ N.

(d) Find the two possible $\mathbf{F}_3$ forces.

(4)

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Question 3 continued

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Question 3 continued

(Total for Question 3 is 14 marks)

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4. The point A is 10 m above horizontal ground.
At time $t = 0$, a particle P is projected vertically upwards with speed $5\,\text{m s}^{-1}$ from A.
Particle P moves freely under gravity.

(a) Find the greatest height above A reached by P.

(3)

The point B is on the ground, vertically below A.
At time $t = 1$ second, a particle Q is projected vertically upwards with speed $7\,\text{m s}^{-1}$ from B.
Particle Q moves freely under gravity.

Particles P and Q collide at time $t = T$ seconds.

(b) Find the value of T.

(4)

(c) Find the speed of P at the instant immediately before the particles collide.

(2)

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Question 4 continued

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Question 4 continued

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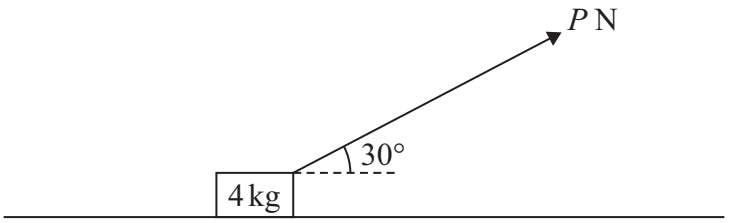

Figure 3

A box of mass 4 kg is placed on a rough horizontal surface.

A force of magnitude P newtons, acting at 30° to the horizontal, is applied to the box, as shown in Figure 3.

The coefficient of friction between the box and the surface is $\frac{2}{3}$

The box is modelled as a particle.

(a) Find the value of P when the box is on the point of sliding along the surface.

(6)

The value of P is now increased to 25 and the box moves along the surface.

Find

(b) the acceleration of the box,

(5)

(c) the speed of the box when it has moved 1.5 m.

(2)

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Question 5 continued

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Question 5 continued

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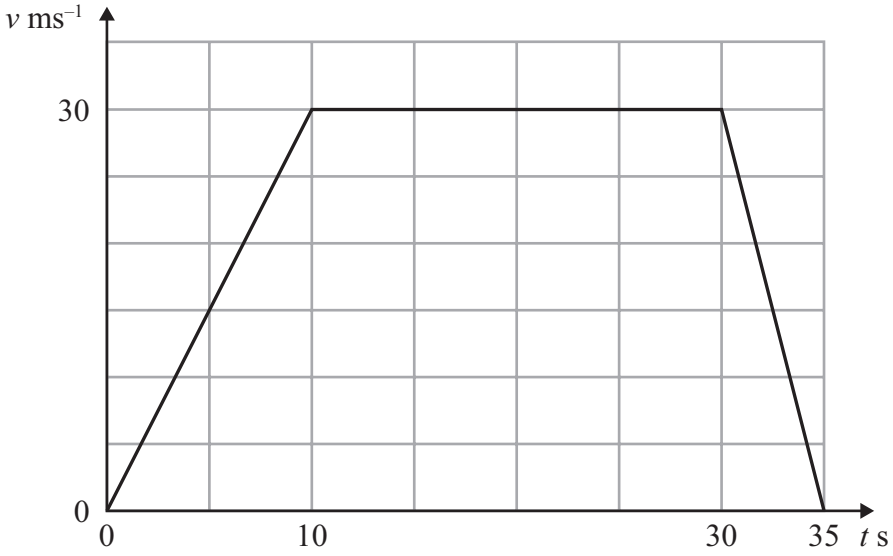

Figure 4

The point O lies on a straight horizontal road.
At time $t = 0$, a car leaves O and travels along the road.

The velocity-time graph in Figure 4 shows the velocity, $v\,\text{m s}^{-1}$, of the car at time t seconds for the first 35 seconds of its journey.

(a) Find

(i) the acceleration of the car for the period $0 \leqslant t \leqslant 10$

(ii) the deceleration of the car for the period $30 \leqslant t \leqslant 35$

(2)

(b) Sketch an acceleration-time graph for the car for the period $0 \leqslant t \leqslant 35$

(2)

(c) Find the distance travelled by the car for the period $0 \leqslant t \leqslant 35$

(2)

When $t = 5$, a motorcycle starts from rest at O.
The motorcycle travels along the same road as the car and in the same direction.

For the period $5 \leqslant t \leqslant 20$, the acceleration of the motorcycle is $A\,\text{m s}^{-2}$, where A is a positive constant.

The motorcycle catches up with the car when $t = 20$

(d) Find the value of A.

(4)

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Question 6 continued

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Question 6 continued

(Total for Question 6 is 10 marks)

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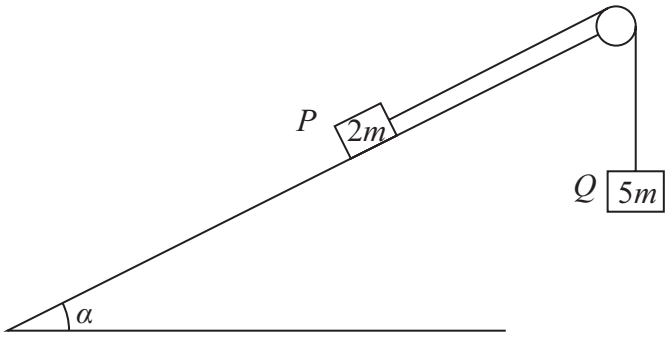

Figure 5

A block P of mass $2m$ is held at rest on a fixed rough plane.

The plane is inclined to the horizontal at an angle α, where $\tan\alpha = \frac{5}{12}$

One end of a light inextensible string is attached to P.
The string is parallel to a line of greatest slope of the plane and passes over a smooth light pulley which is fixed at the top of the plane.
The other end of the string is attached to a block Q of mass $5m$.
Block Q hangs vertically below the pulley, as shown in Figure 5.

The system is released from rest with the string taut and block P moves up the plane.

Immediately after the system is released, the tension in the string is T and the acceleration of the blocks is a.

The blocks are modelled as particles and air resistance is ignored.

(a) Write down an equation of motion for Q.

(2)

The coefficient of friction between P and the plane is $\frac{1}{8}$

(b) Find T in terms of m and g.

(7)

(c) State how the solution to part (b) uses the fact that the string is inextensible.

(1)

The magnitude of the force exerted on the pulley by the string is kmg.

(d) Find the value of k to 3 significant figures.

(4)

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Question 7 continued

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Question 7 continued

(Total for Question 7 is 14 marks)

TOTAL FOR PAPER IS 75 MARKS

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Mark Scheme (Results)

October 2025

International Advanced Level In Mechanics M1
WME01/01

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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 $\surd$ 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
- $\llcorner$ 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

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

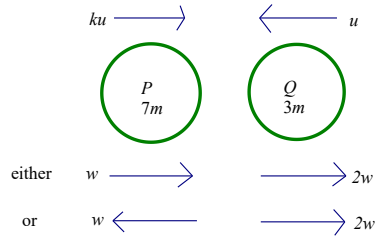
- Rules for M marks:
  - correct number of terms
  - dimensionally correct
  - all terms that need resolving (i.e. *multiplied* by cos or sin) are resolved
  - only terms that need resolving are resolved
  - +/– errors are condoned
  - sin/cos confusion is condoned
- Omission or extra g in a resolution 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

Mechanics Abbreviations

M(A)	Taking moments about A
N2L	Newton's Second Law (Equation of Motion)
NEL	Newton's Experimental Law (Newton's Law of Impact)
HL	Hooke's Law
SHM	Simple harmonic motion
PCLM	Principle of conservation of linear momentum
RHS	Right hand side
LHS	Left hand side

Question Number	Scheme	Marks	Notes
1a	M(C)	M1	Or equivalent to form an equation in *x* only.
			$\text{vert}: 240 = T_C + 90$ $\text{M}(A): 2T_C + 90(8-x) = 240\times 4$ $\text{M}(D): (6-x)T_C = 240(4-x)$ $\text{M}(B): 6T_C + 90x = 240\times 4$ $\text{M}(G): 2T_C = 90(4-x)$ with T_C eliminated to give an equation in *x* only.
	$240\times 2 = (6-x)\times 90$	A1	Correct unsimplified equation in *x* only.
	$x = \frac{2}{3}$ *	A1*	Obtain given answer from correct working, with at least one line of intermediate working, e.g. after $240\times 2 = (6-x)\times 90$, if they use M(C). N.B. Need '*x* ='
		[3]	
1b	M(*D*)	M1	Or equivalent to form an equation in *W* only. M0 if 183 is never used, including use of 182. M0 if 90 or 150 is used. N.B. Use of *Wg* is an A error.
			$\text{vert}: 240 + W = 183 + T_D$ $\text{M}(A): 2\times 183 + T_D \times \frac{22}{3} = 240\times 4$ $\text{M}(C): 2W + T_D \times \frac{16}{3} = 240\times 2$ $\text{M}(B): 6\times 183 + T_D \times \frac{2}{3} = 240\times 4 + 8W$ $\text{M}(G): 2\times 183 = T_D \times \frac{10}{3} + 4W$ with T_D (=81) eliminated to give an equation in *W* only.
	$240\times \frac{10}{3} + W\times \frac{22}{3} = 183\times \frac{16}{3}$	A1 A1	Unsimplified equation in *W* only with at most one error

			Correct unsimplified equation in *W* only
	(*W* =) 24	A1	Cao N.B. Allow decimals (3.33, 7.33 etc) in working.
			N.B. Allow use of $T_C < 183$ OR $T_C \,„\, 183$ for first 3 marks but must have equality for the final A1.
		[4]	
		(7)	

Question Number	Scheme	Marks	Notes
2a			
			N.B. Must be using correct pairings of masses and velocities for all M marks in this question.
	Use of $I = mv - mu$ for Q	M1	Dimensionally correct and subtraction seen or implied. (They are subtracting a negative, so they could go direct to "+") M0 for impulse-momentum for *P* or use of *m* for mass if not subsequently replaced. Condone sign errors. .
	$\frac{7}{2}mu = 3m\left(2w - \left(-u\right)\right)$	A1	Correct unsimplified equation in *u* and *w*
	$w = \frac{1}{12}u$	A1	0.083*u* or better N.B. Must be a single decimal or fraction
		[3]	
2b	Use of $I = mv - mu$ for *P* or equivalent	M1	Use impulse-momentum for *P* or CLM for one valid option with their *w* substituted, which must be a multiple of *u* but could also contain *k*'s if they've used CLM in (a). Allow an extra *g* throughout the CLM equation or *m* cancelled consistently. Condone sign errors.

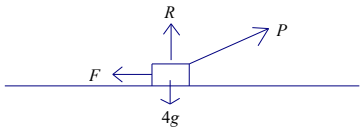
			M0 for impulse-momentum for Q or use of *m* for mass if not subsequently replaced.
	EITHER: (see diagram) $-\frac{7mu}{2}=7m\left(\frac{u}{12}-ku\right)$ or $7mku-3mu=\frac{7mu}{12}+\frac{6mu}{12}$ OR: (see diagram) $\frac{7mu}{2}=7m\left(\frac{u}{12}-\left(-ku\right)\right)$ or $7mku-3mu=\frac{-7mu}{12}+\frac{6mu}{12}$	A1ft	Correct unsimplified equation for *k* but allow uncancelled *m*'s. Follow their *w*
	EITHER: $k=\frac{7}{12}$	A1	0.58 or better (0.58333..) N.B. $k=\frac{7}{12}$ must be entered on ePEN for this A mark.
	Use of $I=mv-mu$ for *P* or equivalent	M1	Use impulse-momentum or CLM correctly for second valid option with their *w* substituted.- i.e. the velocity of *P* should have the opposite sign to that used in their first equation. Allow an extra *g* throughout the CLM. equation or *m* cancelled consistently. .
	OR: $k=\frac{5}{12}$	A1	0.42 or better (0.41666..) N.B. $k=\frac{5}{12}$ must be entered on ePEN for this A mark.
		[5]	
		(8)	

	Allow column vectors or i j form for vectors throughout.		
Question Number	**Scheme**	**Marks**	**Notes**
3a	Resultant force $=\left(-2\mathbf{i}+3\mathbf{j}+4\mathbf{i}+2\mathbf{j}\right)=\left(2\mathbf{i}+5\mathbf{j}\right)\left(\mathrm{N}\right)$	B1	Seen or implied
	Correct use of $\mathbf{F}=m\mathbf{a}$	M1	Must have added the forces
	Acceleration $=\left(\mathbf{i}+2.5\mathbf{j}\right)\left(\mathrm{m\,s^{-2}}\right)$	A1	Isw if they find the magnitude
		[3]	
3b	$\mathbf{v}=\left(3\mathbf{i}-4\mathbf{j}\right)+3\mathbf{a}$	M1	Use of $\mathbf{v}=\mathbf{u}+\mathbf{a}t$
	$\mathbf{v}=\left(3\mathbf{i}-4\mathbf{j}\right)+3\left(\mathbf{i}+2.5\mathbf{j}\right)$	A1ft	Correct unsimplified Follow their a
	Use of Pythagoras	DM1	Correct method to obtain the speed, dependent on M1
	$\left\|\mathbf{v}\right\|=\sqrt{6^2+3.5^2}=6.95\left(\mathrm{m\,s^{-1}}\right)$	A1	6.9 or better (6.94622……) Allow $\sqrt{\frac{193}{4}}$ oe
		[4]	
3c	Resultant force $=\left(\left(2+b\right)\mathbf{i}+\left(5+c\right)\mathbf{j}\right)\left(\mathrm{N}\right)$	B1	i's and j's must be collected but can be unsimplified, seen or implied.
	Correct use of direction to form equation in *b* and c only e.g $2+b=5+c$ or $2+b=\lambda$ and $5+c=\lambda$ with λ eliminated	M1	M0 if they use a specific numerical value for λ or they use $2+b=-(5+c)$
	$b-c=3$ *	A1*	Obtain given answer from correct working
		[3]	
3d	Use magnitude of resultant to form an equation in *b* and c	M1	Allow square roots
	$200=\left(2+b\right)^2+\left(5+c\right)^2$	A1ft	Correct unsimplified equation with no square roots. Follow their resultant.
	Form an equation in *b* or c only	DM1	e.g. $200=2\left(5+c\right)^2$ or $200=2\left(2+b\right)^2$

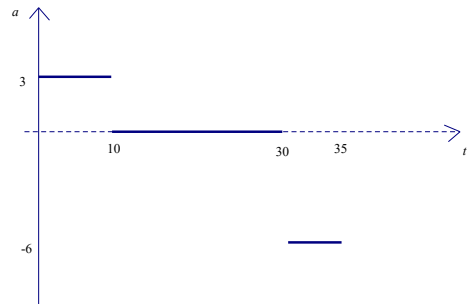
			dependent on M1
	ALT 1: Use magnitude of resultant to form equation in λ	M1	
	$200=\lambda^2+\lambda^2$	A1	
	Use either $\lambda=10$ or $\lambda=-10$ to find equations in *b* and c $2+b=10$ and $5+c=10$ Or $2+b=-10$ and $5+c=-10$	DM1	Dependent on M1
	$\mathbf{F}_3=(8\mathbf{i}+5\mathbf{j})\text{N}$ $\mathbf{F}_3=(-12\mathbf{i}-15\mathbf{j})\text{N}$	A1	Both forces, condone missing N's.
		[4]	
			N.B. If they go for $2+b=10$ and $5+c=10$ to obtain $(8\mathbf{i}+5\mathbf{j})\text{N}$ only, allow M1A1M1A0 for obtaining one force.
		(14)	

Question Number	Scheme	Marks	Notes
4a	Correct use of *suvat* to give an equation in *h* only.	M1	Complete method – e.g. they may find the time (25/49) first
	e.g. $0 = 5^2 - 2gh$ or $5^2 = 0 - 2gh$	A1	Correct unsimplified equation in *h* only
	1.3 or 1.28 (m)	A1	2 or 3 sf No isw if they add 10.
		[3]	
4b	Use *suvat* to form an expression for the distance travelled by either particle in terms of *T* or *t*. e.g. $\pm(5T - \frac{1}{2}gT^2)$ Case 1 (*P*) $\pm\left[7(T-1) - \frac{1}{2}g(T-1)^2\right]$ Case 1 (Q) OR $\pm\left[5(t+1) - \frac{1}{2}g(t+1)^2\right]$ Case 2 (*P*) $\pm(7t - \frac{1}{2}gt^2)$ Case 2 (Q)	M1	For Case 1, allow consistent use of *t* for *T* For Case 2, penalise incorrect use of *T*
	Use *suvat* to form a correct expression, in terms of the same variable, for the distance travelled by the other particle	M1	N.B. M0M1 on ePEN is not possible.
	$10 + 5T - \frac{1}{2}gT^2 = 7(T-1) - \frac{1}{2}g(T-1)^2$ Or $10 + 5(t+1) - \frac{1}{2}g(t+1)^2 = 7t - \frac{1}{2}gt^2$	A1	Correct unsimplified equation in *T* or their *t*
	$(T =)$ 1.9 or 1.86	A1	2 or 3 sf
		[4]	
	ALT 1 Find position and velocity of *P* at *t* = 1: 10.1 m above ground, moving downwards at 4.8 m s^{-1} then: $\pm(4.8t + \frac{1}{2}gt^2)$ (*P*) M1 $\pm(7t - \frac{1}{2}gt^2)$ (Q) M1		

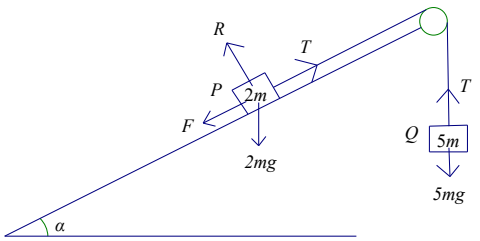
	$(4.8t+\frac{1}{2}gt^2)+(7t-\frac{1}{2}gt^2)=10.1$ **A1** $(T=)$ 1.9 or 1.86 **A1**		
	ALT 2 **Find position and velocity of Q at *t* = 0:** **11.9 m 'below' ground, moving upwards at 16.8** m s^{-1} **then:** $\pm(5T-\frac{1}{2}gT^2)$ **(*P*)** **M1** $\pm(16.8T-\frac{1}{2}gT^2)$ **(Q)** **M1** $16.8T-\frac{1}{2}gT^2-(5t-\frac{1}{2}gT^2)=21.9$ **A1**		
	$(T=)$ 1.9 or 1.86	**A1**	**2 or 3 sf**
4c	**e.g.** $v=-5+gT$ **or** $v=5-gT$	**M1**	**Complete method using *suvat* and their *T*** **M0 for** $v=5+gT$
	Speed of *P* = 13 or 13.2 $\left(\text{ms}^{-1}\right)$	**A1**	**2 or 3 sf** **Must be positive.**
		[2]	
		(9)	

Question Number	Scheme	Marks	Notes
5a			
	Resolve horizontally	M1	Need relevant terms. Condone sin/cos confusion and sign errors
	$P\cos 30° = F$	A1	Correct unsimplified equation
	Resolve vertically	M1	Need relevant terms. Condone sin/cos confusion and sign errors
	$P\sin 30° + R = 4g$	A1	Correct unsimplified equation
	$P\dfrac{\sqrt{3}}{2} = \dfrac{2}{3}R$ $\Rightarrow P\left(\dfrac{1}{2} + \dfrac{3\sqrt{3}}{4}\right) = 4g$	DM1	Use $F = \dfrac{2}{3}R$ to obtain an equation in P only, dependent on previous M marks
	$(P =)$ 22 or 21.8	A1	2 or 3 sf
		[6]	
5b	N.B. If they increase their value of P by 25, treat as an MR i.e. they can score all three M marks in (b) and M1A1ft in (c) if they get v = 4.7 or 4.74.		
	$25\sin 30° + R = 4g$ (R = 26.7)	M1	Need relevant terms. Condone sin/cos confusion and sign errors M0 if not using 25 and/or uses their R from (a) N.B. M1 for R = 26.7
	Equation of motion	M1	Need relevant terms. Condone sin/cos confusion and sign errors M0 if not using 25 and/or uses 2/3R for F, where R is their R from (a).

	$25\cos 30° - F = 4a$	A1	Correct unsimplified equation
	$25\cos 30° - \frac{2}{3}(4g - 25\sin 30°) = 4a$	DM1	Use $F = \frac{2}{3}R$ to obtain an equation in *a* only, dependent on both previous M marks
	0.96 or $0.963\left(\text{m s}^{-2}\right)$	A1	2 or 3 sf
		[5]	
5c	e.g. $v^2 = 2\times a\times 1.5$	M1	Complete method to find an equation in *v* only using their *a* which must be POSITIVE and not *g*
	1.7 or 1.70 $\left(\text{m s}^{-1}\right)$	A1 cso	2 or 3 sf Beware of a 'correct' answer from an incorrect value of *a*.
		[2]	
		(13)	

Question Number	Scheme	Marks	Notes
6a i	Acceleration = $3\left(\text{ms}^{-2}\right)$	B1	
ii	Decceleration = $6\left(\text{ms}^{-2}\right)$	B1	Must be positive (–) 6 is B0
		[2]	
6b		B1ft B1ft	Give BOD for the middle section. Any 2 horizontal lines correct 3 correct horizontal lines and no other solid lines, and 10, 30, 35, 3, -6 marked. Condone dotted vertical lines N.B. Follow their accelerations for one +ve and one -ve.
		[2]	
6c	Distance travelled $=\frac{(20+35)}{2}\times 30$ Or = $\frac{1}{2}\times 10\times 30+(20\times 30)+\frac{1}{2}\times 5\times 30$ Or $=\frac{1}{2}\times 3\times 10^2+(20\times 30)+\frac{1}{2}\times 6\times 5^2$	M1	Or equivalent method for total distance Unsimplified expression must be correct for this mark
	= 825 (m)	A1	Accept 830
		[2]	
6d	Distance travelled by motorcycle $=\frac{1}{2}\times A\times 15^2\left(=\frac{225A}{2}\right)$ or $\frac{1}{2}\times 15V$ seen	M1	Allow *a* for *A*. Condone 20 for 15
	Using equal distances travelled by both at *t* = 20 to set up an equation in *A* only (i.e. must also use *V* = 15*A* if necessary)	M1	Condone 20 for 15

	$\frac{225A}{2}=\frac{1}{2}\times10\times30+10\times30$ Or: $\frac{225A}{2}=\frac{(20+10)}{2}\times30$ Or: $\frac{1}{2}\times15V=\frac{(20+10)}{2}\times30$ and (V =) 60 = 15 A	A1	Correct unsimplified equation in *a* or *A* only
	(A =) 4	A1	
		[4]	
		(10)	

Question Number	Scheme	Marks	Notes
7			
	N.B. If *m*'s missing consistently, can score max (a)M1A0 (b)M1A0M1M1A0DM0A0 (d)M1A1DM0A0. For inconsistent omission of *m*'s, mark as per the scheme.(Omission of an *m* is an M error)		
7a	Equation of motion for Q:	M1	Need correct terms. Condone sign errors.
	$5mg - T = 5ma$	A1	Correct equation
		[2]	
7b	Resolve perpendicular to the plane	M1	Condone sine /cosine confusion N.B. $R = mg\cos\alpha$ is M0
	$R = 2mg\cos\alpha$	A1	Correct unsimplified.
	$F = \frac{1}{8} \times 2mg\cos\alpha$	M1	Use of $F = \frac{1}{8}R$
	Equation of motion for *P*:	M1	Need correct terms. Condone sign errors and sin/cos confusion.
	$T - F - 2mg\sin\alpha = 2ma$	A1	Correct equation. Condone combined equation: $5mg - F - 2mg\sin\alpha = 7ma$
	$\begin{cases} 10mg - 2T = 10ma \\ 5T - 5mg = 10ma \end{cases}$	DM1	Solve for *T*, dependent on first and third M marks. N.B. DM0 if they do not use the 2 equations that have earned marks.
	$T = \frac{15mg}{7}$	A1	Accept 2.1*mg* or better
		[7]	

7c	The acceleration of both blocks / particles is the same.	B1	Or equivalent. N.B. Accept: 'They have the same acceleration but not 'it (or the string) has the same acceleartion.' B0 if include additional incorrect statement e.g. same tension, string won't break
		[1]	
7d	Resolve to find force on pulley	M1	Complete method to obtain the resultant force, allow sin/cos confusion but must be correct numerical angle or correct in terms of α
	$2T\cos\left(\frac{90^\circ-\alpha}{2}\right)$	A1	Correct unsimplified expression
ALT 1	Use cosine rule to find force on pulley	M1	Complete method to obtain the resultant force. Allow WITHOUT ROOT
	$\sqrt{T^2+T^2-2\times T\times T\cos(90^\circ+\alpha)}$	A1	Correct unsimplified expression WITH ROOT but must be correct angle.
ALT 2	Use horiz and vert components and Pythagoras	M1	Complete method to obtain the resultant force, allow sin/cos confusion, Allow WITHOUT ROOT
	$\sqrt{(T\cos\alpha)^2+(T+T\sin\alpha)^2}$	A1	Correct unsimplified expression WITH ROOT
	N.B. For ALT 1 and 2, allow without root sign, if they equate it to $(kmg)^2$ oe		
	Substitute for *T* and trig. and solve for *T*, must take square root when appropriate, and must be a multiple of *mg*	DM1	Dependent on the previous M1

	$k = 3.57$ **to 3 sf**	**A1**	**3 sf only** $\left(\frac{90\sqrt{13}}{91}\right)$ **is A0** **3.57*mg* oe is A0**
		[4]	
		(14)	

Pearson Edexcel International Advanced Level

Thursday 23 October 2025

Afternoon (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 ▶

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P 8 7 4 3 9 A

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1 A particle of mass 4 kg is moving with velocity $(2\mathbf{i} + 3\mathbf{j})\,\text{m s}^{-1}$ when it receives an impulse of $(7\mathbf{i} - 5\mathbf{j})\,\text{N s}$.

Find the speed of the particle immediately after receiving the impulse.

(5)

(Total for Question 1 is 5 marks)

---

2 Three particles of masses m, $4m$ and km are placed at the points whose coordinates are $(-3, 2)$, $(4, 3)$ and $(6, -4)$ respectively.

The centre of mass of the three particles is at the point with coordinates $(c, 0)$.

Find

(a) the value of k,

(3)

(b) the value of c.

(3)

(Total for Question 2 is 6 marks)

---

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

At time t seconds ($t \geqslant 0$) a particle P has position vector $\mathbf{r}$ metres, with respect to a fixed origin O, where

$$\mathbf{r} = (16t - 3t^3)\mathbf{i} + (t^3 - t^2 + 2)\mathbf{j}$$

Find

(a) the velocity of P at the instant when it is moving parallel to the vector $\mathbf{j}$,

(5)

(b) the magnitude of the acceleration of P when $t = 4$

(4)

(Total for Question 3 is 9 marks)

4.

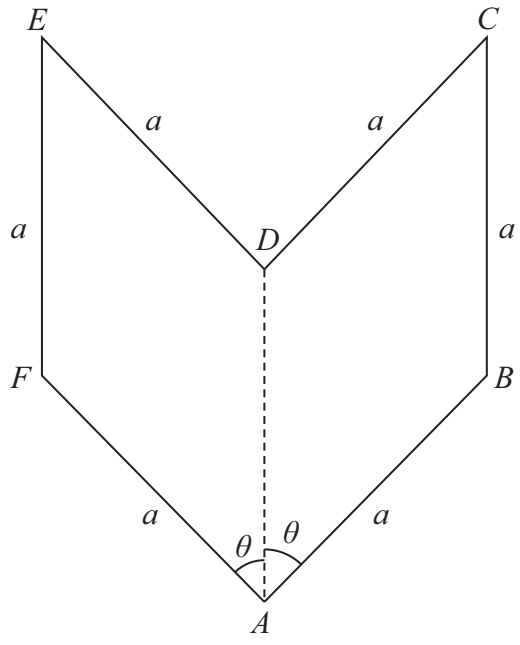

Figure 1

The uniform plane lamina $ABCDEF$ shown in Figure 1 is made from two identical rhombuses.

Each rhombus has sides of length a and angle BAD = angle $DAF = \theta$.

The centre of mass of the lamina is $0.9a$ from A.

(a) Show that $\cos\theta = 0.8$

(5)

The weight of the lamina is W.

A particle of weight kW is fixed to the lamina at the point A.

The lamina is freely suspended from B and hangs in equilibrium with DA horizontal.

(b) Find the value of k.

(4)

(Total for Question 4 is 9 marks)

5

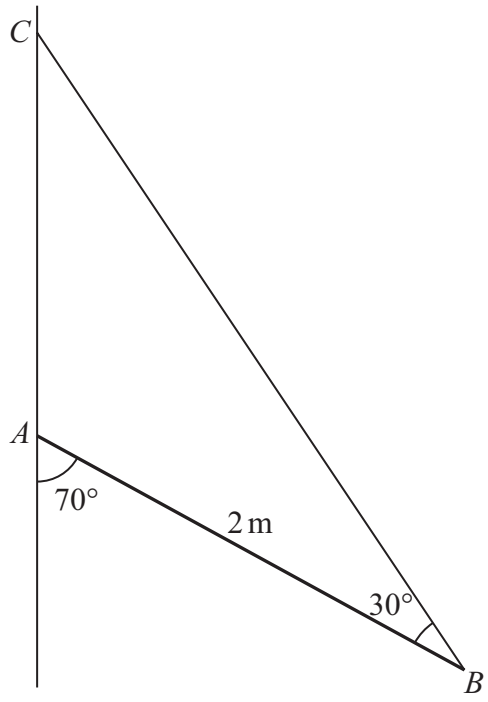

Figure 2

A uniform rod AB has mass 6 kg and length 2 m. The end A of the rod rests against a rough vertical wall.

One end of a light string is attached to the rod at B. The other end of the string is attached to the wall at C, which is vertically above A.

The angle between the rod and the string is 30° and the angle between the rod and the wall is 70°, as shown in Figure 2.

The rod is in a vertical plane perpendicular to the wall and rests in limiting equilibrium.

Find

(a) the tension in the string,

(4)

(b) the coefficient of friction between the rod and the wall,

(5)

(c) the direction of the force exerted on the rod by the wall at A.

(2)

(Total for Question 5 is 11 marks)

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

A particle P moves on the x-axis.

At time t seconds, $t \geqslant 0$

- the acceleration of P is $(2t - 3)\,\text{m s}^{-2}$ in the positive x direction
- the velocity of P is $v\,\text{m s}^{-1}$ in the positive x direction

When $t = 3$, $v = 2$

(a) Find v in terms of t.

(4)

The particle first comes to instantaneous rest at the point A and then comes to instantaneous rest again at the point B.

(b) Find the distance AB.

(6)

(Total for Question 6 is 10 marks)

---

7. A particle P is projected from a fixed point A with speed $12\,\text{m s}^{-1}$ at an angle α above the horizontal and moves freely under gravity.

As P passes through the point B on its path, P is moving with speed $8\,\text{m s}^{-1}$ at an angle β below the horizontal.

(a) By using the principle of the conservation of mechanical energy, find the vertical distance between A and B.

(4)

Particle P takes 1.5 seconds to travel from A to B.

(b) Find the size of angle α.

(3)

(c) Find the size of angle β.

(3)

(d) Find the length of time for which the speed of P is less than $8\,\text{m s}^{-1}$.

(4)

(Total for Question 7 is 14 marks)

---

8. Three particles A, B and C, each of mass m, lie at rest in a straight line L on a smooth horizontal surface, with B **between** A and C.

Particles A and B are projected directly **towards** each other with speeds $5u$ and $4u$ respectively.

At the same instant, particle C is projected directly **away** from B with speed $3u$.

In the subsequent motion, A, B and C move along L.

Particles A and B collide directly.

The coefficient of restitution between A and B is e.

(a) Find

(i) the speed of A immediately after the collision,

(ii) the speed of B immediately after the collision.

(7)

Given that the direction of motion of A is **reversed** in the collision between A and B, and that there is **no** collision between B and C,

(b) find the set of possible values of e.

(4)

(Total for Question 8 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 23 October 2025

Afternoon (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 $g = 9.8$ 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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Question 1 continued

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(Total for Question 1 is 5 marks)

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Question 2

Write the answer to Question 2 on these 2 pages

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Question 2 continued

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Question 3

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Question 3 continued

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Question 4

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Question 4 continued

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Question 4 continued

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Question 5

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Question 5 continued

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Question 6

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(Total for Question 6 is 10 marks)

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Question 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)

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Question 8

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Question 8 continued

Question 8 continued

(Total for Question 8 is 11 marks)

TOTAL FOR PAPER IS 75 MARKS

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Mark Scheme (Results)

October 2025

Pearson Edexcel International Advanced Level in Mechanics M2

WME02/01A

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October 2025
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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
- $\lfloor$ 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

Mechanics Abbreviations

M(A)	Taking moments about A
N2L	Newton's Second Law (Equation of Motion)
NEL	Newton's Experimental Law (Newton's Law of Impact)
HL	Hooke's Law
SHM	Simple harmonic motion
PCLM	Principle of conservation of linear momentum
RHS	Right hand side
LHS	Left hand side

Question Number	Scheme	Marks
1	Impulse-momentum equation	M1
	$(7\mathbf{i}-5\mathbf{j})=4\mathbf{v}-4(2\mathbf{i}+3\mathbf{j})$	A1
	$\mathbf{v}=\frac{15}{4}\mathbf{i}+\frac{7}{4}\mathbf{j}$	A1
	$\lvert\mathbf{v}\rvert=\frac{1}{4}\sqrt{15^2+7^2}$	M1
	$=\frac{1}{4}\sqrt{274}=4.1\ (\text{m s}^{-1})$	A1
		(5)
		(5 marks)
Notes		
N.B. Column vectors are acceptable throughout		
M1	Use of Impulse-Momentum principle, dimensionally correct, correct number of terms and must be a *difference* of momenta (condone subtraction in wrong order)	
A1	Correct equation oe	
A1	Correct velocity seen or implied	
M1	Use of Pythagoras' on their **v**	
A1	Cao from a correct **v**. 4.1 or better (4.138236…)	

Question Number	Scheme	Marks
2(a)	Moments about x-axis	M1
	$m\times 2+4m\times 3-km\times 4=0$	A1
	$k=3.5$	A1
		(3)
2(b)	Moments about y-axis $m\times -3+4m\times 4+km\times 6=(5+k)m\times c$	M1
	$m\times -3+4m\times 4+3.5m\times 6=8.5m\times c$	A1ft
	$c=4$	A1
		(3)
		(6 marks)

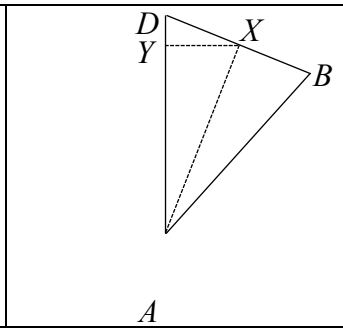
Notes	
(a) M1	All terms needed and no extras. Must be dimensionally consistent (allow with g in each term or consistent missing m). Condone sign errors.
A1	Correct unsimplified equation. Allow in vector form.
A1	oe
(b) M1	All terms needed and no extras (k does not need to be substituted). Must be dimensionally consistent (allow with g in each term or consistent missing m). Condone sign errors. Award if seen in part (a).
A1ft	Correct unsimplified equation with their value of k substituted. Award if seen in part (a). Allow in vector form.
A1	cao

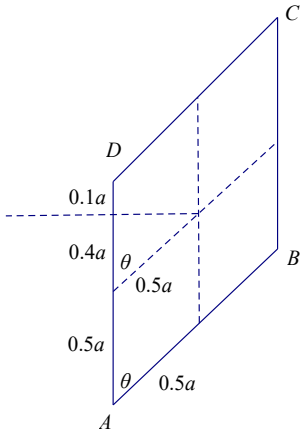
Question Number	Scheme	Marks

3(a)	Differentiate **r** w.r.t. t	M1
	$\left(\mathbf{v}=\frac{\mathrm{d}\mathbf{r}}{\mathrm{d}t}=\right)\quad\left(16-9t^2\right)\mathbf{i}+\left(3t^2-2t\right)\mathbf{j}$	A1
	Sets **i** component = 0: $16-9t^2=0$	M1
	$t=\frac{4}{3}\Rightarrow\mathbf{v}=\ldots$	dM1
	$\mathbf{v}=\left(3\times\frac{16}{9}-2\times\frac{4}{3}\right)\mathbf{j}=\frac{8}{3}\mathbf{j}$	A1
		(5)
3(b)	Differentiate **v** w.r.t. t	M1
	$\left(\mathbf{a}=\frac{\mathrm{d}\mathbf{v}}{\mathrm{d}t}=\right)\quad\left(-18t\right)\mathbf{i}+\left(6t-2\right)\mathbf{j}$	A1ft
	Substitutes $t = 4$ and finds magnitude	dM1
	$\lvert\mathbf{a}\rvert=\sqrt{72^2+22^2}=\sqrt{5668}=75$ (m s^{-2})	A1
		(4)
		(9 marks)

Notes (*N.B. Column vectors are acceptable throughout)*

(a) M1	Differentiates **r** w.r.t. t: at least one power decreasing by one in both **i** and **j** components.
A1	Correct vector
M1	Sets their **i** component equal to zero.
dM1	Solves for t **and** substitutes to find a velocity (or speed). Dependent on both previous M marks.
A1	Cao. Penalise extra solutions unless clearly discounted. Must be a vector. ISW if they go on to find a speed.
(b) M1	Differentiates **v** w.r.t. t: at least one power decreasing by one in both **i** and **j** components.
A1	Follow their **v** providing both **i** and **j** components are non-zero.
DM1	Substitutes $t = 4$ into their acceleration **and** uses Pythagoras' to find a magnitude. Dependent on previous M mark
A1	Cao. 75 or better (75.28612…) from correct working.

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td rowspan="4">4(a)</td><td>Vertical distance from A to C is $a+a\cos\theta$</td><td>B1</td></tr>
<tr><td>“Half the vertical height of the diagram”
Using the symmetry of the figure, the centres of mass of the rhombuses lie on a straight line passing through the centre of mass.</td><td>M1</td></tr>
<tr><td>$0.9a=\frac{1}{2}\left(a+a\cos\theta\right)$</td><td>A1
A1</td></tr>
<tr><td>$\cos\theta=0.8$ *</td><td>A1*</td></tr>
<tr><td></td><td>(5)</td></tr>
<tr><td rowspan="5">Alt1</td><td>Distance from A to centre of rhombus = $a\cos\frac{\theta}{2}$</td><td>B1</td></tr>
<tr><td>“Moments using CoM of two rhombuses”
Taking moments about an axis through A parallel to FB</td><td>M1</td></tr>
<tr><td>$\lambda.a\cos\frac{\theta}{2}.\cos\frac{\theta}{2}+\lambda.a\cos\frac{\theta}{2}\cos\frac{\theta}{2}=2\lambda\times0.9a$</td><td>A1
A1</td></tr>
<tr><td>$\cos\theta=2\cos^2\frac{\theta}{2}-1=0.8$ *</td><td>A1*</td></tr>
<tr><td></td><td>(5)</td></tr>
<tr><td rowspan="5">Alt2</td><td>Distance from A to centre of rhombus (= AX =) $a\cos\frac{\theta}{2}$</td><td>B1</td></tr>
<tr><td>“Vertical height of CoM rhombus”
Using the symmetry of the figure, the centres of mass of the rhombuses lie on a straight line passing through the centre of mass:
$AY=AX\cos\frac{\theta}{2}$
 
</td><td>M1</td></tr>
<tr><td>$a\cos\frac{\theta}{2}\times\cos\frac{\theta}{2}=0.9a$</td><td>A1
A1</td></tr>
<tr><td>$\cos\theta=2\cos^2\frac{\theta}{2}-1=0.8$ *</td><td>A1*</td></tr>
<tr><td></td><td>(5)</td></tr>
<tr><td rowspan="3">Alt3</td><td><table>
<tr><td>Shape</td><td>EFBC</td><td>EDC</td><td>FAB</td><td>lamina</td></tr>
<tr><td>Mass/Area</td><td>$2a^2\sin\theta$</td><td>$a^2\sin\theta\cos\theta$</td><td>$a^2\sin\theta\cos\theta$</td><td>$2a^2\sin\theta$</td></tr>
<tr><td>CoM</td><td>$a\cos\theta+\frac{a}{2}$</td><td>$a+\frac{2}{3}a\cos\theta$</td><td>$\frac{2}{3}a\cos\theta$</td><td>$0.9a$</td></tr>
</table></td><td>B1</td></tr>
<tr><td>Moments equation (“Rectangle minus triangle plus triangle”)</td><td>M1</td></tr>
</table>

<table>
<tr><td></td><td>$2a^2\sin\theta\left(a\cos\theta+\frac{a}{2}\right)-a^2\sin\theta\cos\theta\left(\frac{2}{3}a\cos\theta+a-\frac{2}{3}a\cos\theta\right)=2a^2\sin\theta\times0.9a$</td><td>A1
A1</td></tr>
<tr><td></td><td>$\cos\theta=0.8$ *</td><td>A1*</td></tr>
<tr><td></td><td></td><td>(5)</td></tr>
<tr><td>Alt4</td><td><table>
<tr><td>Shape</td><td>EDF & BCD</td><td>AFD & ADB</td><td>lamina</td></tr>
<tr><td>Mass/Area</td><td>$2\times\frac{1}{2}a^2\sin\theta$</td><td>$2\times\frac{1}{2}a^2\sin\theta$</td><td>$2a^2\sin\theta$</td></tr>
<tr><td>CoM</td><td>$\frac{2}{3}a(1+\cos\theta)$</td><td>$\frac{1}{3}a(1+\cos\theta)$</td><td>$0.9a$</td></tr>
</table></td><td>B1</td></tr>
<tr><td></td><td>Moments equation (“two upper triangles and two lower triangles”)</td><td>M1</td></tr>
<tr><td></td><td>$2\times\frac{1}{3}a(1+\cos\theta)\times\frac{1}{2}a^2\sin\theta+2\times\frac{2}{3}a(1+\cos\theta)\times\frac{1}{2}a^2\sin\theta=2a^2\sin\theta\times0.9a$</td><td>A1
A1</td></tr>
<tr><td></td><td>$\cos\theta=0.8$ *</td><td>A1*</td></tr>
<tr><td></td><td></td><td>(5)</td></tr>
<tr><td>Alt5</td><td>$AM=a\cos\theta$ (where M is the midpoint of BF)</td><td>B1</td></tr>
<tr><td></td><td>“Midpoint of midpoints”
CoM lies at midpoint of DM</td><td>M1</td></tr>
<tr><td></td><td>$0.9a=a\cos\theta+\frac{1}{2}(a-a\cos\theta)$</td><td>A1
A1</td></tr>
<tr><td></td><td>$\cos\theta=0.8$ *</td><td>A1*</td></tr>
<tr><td></td><td></td><td>(5)</td></tr>
<tr><td>Alt6</td><td>“Working out the heights and trigonometry”
 
</td><td></td></tr>
<tr><td></td><td>0.4a seen or implied</td><td>B1</td></tr>
<tr><td></td><td>Use of line of centres of rhombuses and trigonometry</td><td>M1</td></tr>
<tr><td></td><td>$\cos\theta=\frac{0.4a}{0.5a}$</td><td>A1
A1</td></tr>
<tr><td></td><td>$\cos\theta=0.8$ *</td><td>A1*</td></tr>
<tr><td></td><td></td><td>(5)</td></tr>
</table>

4(b)	Taking moments about *B*:	M1
	$kW\left(a\cos\theta\right)=W\left(0.9a-a\cos\theta\right)$	A1 A1
	$k=\frac{1}{8}$	A1
		(4)
Alt	Taking moments about *A*:	M1
	$0.9aW=\left(k+1\right)W\times a\cos\theta=\left(k+1\right)\times 0.8aW$	A1 A1
	$k=\frac{1}{8}$	A1
		(4)
		(9 marks)

Notes

N.B. Be aware that candidates may have worked on a diagram on the question paper and may use their own labelling.

(a) B1	$a+a\cos\theta$ seen
M1	Use of the symmetry of the figure for the height. Condone sin/cos confusion.
A1	Unsimplified equation with at most one error.
A1	Correct unsimplified equation.
A1*	Obtains given answer from correct exact working.
Alt1 B1	May be marked on a diagram
M1	Taking moments about an axis through *A* parallel to *FB*. Correct number of terms and dimensionally consistent. Condone sin/cos confusion. Any correct ratios in place of λ; may frequently see $a^2\sin\theta$.
A1	Unsimplified equation with at most one error.
A1	Correct unsimplified equation. $\left(\cos^2\frac{\theta}{2}=0.9\right)$
A1*	Obtains given answer from correct exact working.
Alt2 B1	May be marked on a diagram
M1	Use of the symmetry of the figure for the height. Condone sin/cos confusion.
A1	Unsimplified equation with at most one error.
A1	Correct unsimplified equation. $\left(\cos^2\frac{\theta}{2}=0.9\right)$
A1*	Obtains given answer from correct exact working.
Alt3 B1	Correct division of lamina with correct mass ratios Penalise errors in distance via the moments equation
M1	Moments equation about axis parallel to *FB*. Correct number of terms and dimensionally consistent. Condone sin/cos confusion.

A1	Unsimplified equation with at most one error.
A1	Correct unsimplified equation.
A1*	Obtains given answer from correct exact working.
Alt4 B1	Correct division of lamina with correct mass ratios Penalise errors in distance via the moments equation
M1	Moments equation about axis parallel to *FB*. Correct number of terms and dimensionally consistent. Condone sin/cos confusion.
A1	Unsimplified equation with at most one error.
A1	Correct unsimplified equation.
A1*	Obtains given answer from correct exact working.
Alt5 B1	May be marked on a diagram
M1	Use of the symmetry of the figure for the height. Condone sin/cos confusion.
A1	Unsimplified equation with at most one error.
A1	Correct unsimplified equation.
A1*	Obtains given answer from correct exact working.
Alt6 B1	May be on a diagram (seen or implied). Could be implied by use of 0.1*a*.
M1	Use of the symmetry of the figure: the CoM lies on a line joining the centres of the rhombuses. Condone sin/cos confusion.
A1	Unsimplified equation with at most one error.
A1	Correct unsimplified equation.
A1*	Obtains given answer from correct exact working.
(b) M1	Moments about *B*. Must have both terms but condone sign errors and sin/cos confusion.
A1	Unsimplified equation with at most one error.
A1	Correct unsimplified equation. $(0.8kW = 0.1W)$
A1	Cao
Alt M1	Moments about *A* and use of CoM on *FB*. Must have correct number of terms but condone sign errors and sin/cos confusion.
A1	Unsimplified equation with at most one error.
A1	Correct unsimplified equation.
A1	Cao
N.B.	If a candidate does not specify the point about which they are taking moments, do not condone a "mixed approach". E.g. "$kW\left(a\cos\theta\right)=0.9aW$" is M0

Question Number	Scheme	Marks

5(a)	Moments about *A*:	M1
	$6g(\times 1)\times \sin 70° = T\sin 30°\times 2$	A1 A1
	T = 55 or 55.3 (N)	A1
		(4)
5(b)	Resolve horizontally: $T\cos 50° = R(=35.5)$	B1
	Resolve vertically:	M1
	$T\sin 50° = 6g \pm F$	A1
	Use of $F = \mu R$ $\left(6g - T\sin 50° = \mu \times T\cos 50°\right)$	M1
	μ = 0.46	A1
		(5)
5(c)	$\tan\theta = \frac{"R"}{"F"}$	M1
	(θ =) 65° to the upward vertical oe (25° above the horizontal)	A1
		(2)
		(11 marks)

Notes	
(a) M1	A complete method to find *T*. Moments equations must have the correct number of terms and be dimensionally consistent (missing *g* is an A error). Condone sin/cos confusion and sign errors; allow incorrect angles.
A1	Unsimplified equation with at most one error.
A1	Correct unsimplified equation.
A1	2 or 3 sf only
(b) B1	Resolve horizontally. T does not need to be substituted but ft their value from (a).
M1	Resolve vertically: condone sign errors and sin/cos confusion but must use 40° or 50°
A1	Correct equation/ T does not need to be substituted but ft their value from (a).
M1	Use of $F = \mu R$. Must have found a value for *F* and *R*.
A1	0.46 or better (0.4638131241…)
Alt	**N.B.** For the first three marks if other methods attempted, e.g. resolve parallel and perpendicular to rod or take moments about B or C: B1 for first correct equation seen M1A1 for the "best" second equation seen N.B. M(B) $6g(\times 1)\times \sin 70° = R\times 2\times \cos 70° \pm F\times 2\times \sin 70°$
(c) M1	Correct use of trigonometry (E.g. $\tan\theta = \frac{R}{F}$ or $\frac{F}{R}$) with their numerical values (seen or implied).
A1	Correct angle and direction indicated (allow clear angle on a clear diagram) 65° or better (65.11751087…) or 25° or better (24.88248913…)

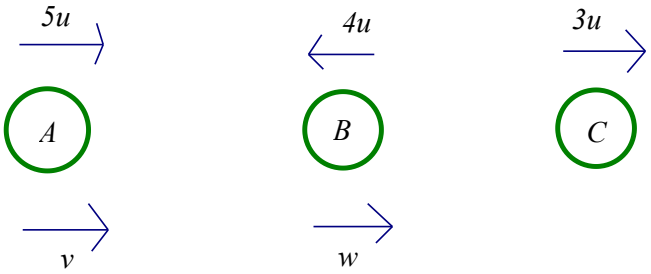
Question Number	Scheme	Marks
6(a)	Integrate *a* w.r.t. *t*	M1
	$(v=)\ t^2-3t\ \ (+c)$	A1
	Substitute to evaluate c: $t=3,\ v=2\ \Rightarrow c=2$	M1
	$v=t^2-3t+2$	A1
		(4)
6(b)	$v = 0 = t^2 - 3t + 2$ $(= (t-1)(t-2))$ $\Rightarrow t = \ldots$	M1
	$t = 1, 2$	A1
	$s=\int_1^2\left(t^2-3t+2\right)\mathrm{d}t$	M1
	$=\left[\frac{1}{3}t^3-\frac{3}{2}t^2+2t\right]_1^2$	A1ft
	$=\left[\frac{1}{3}(2)^3-\frac{3}{2}(2)^2+2(2)\right]-\left[\frac{1}{3}-\frac{3}{2}+2\right]$	dM1
	$\text{Distance}\ =\frac{1}{6}\ \text{(m)}$	A1
		(6)
		(10 marks)

Notes	
(a) M1	Integrate the given expression for *a*. Must see both powers increase by 1.
A1	Correct expression. Condone missing +c.
M1	Use of given values to find c (or definite integral with values substituted)
A1	Cao including "*v* ="
(b) M1	Set their *v* = 0 and solve for *t* to get two values.
A1	Cao
M1	Integrate their *v* (must have at least two terms). At least two powers increasing by 1.
A1ft	Condone without limits. Ft their *v* (at least two terms).
dM1	A correct method for the required distance, E.g. use of their values of *t* as limits. Dependent on previous M. Must see evidence of substitution: E.g. at least $\frac{2}{3}-\frac{5}{6}$ M0 for incorrect sums, E.g. $\int_0^1 \mathrm{d}t+\int_1^2 \mathrm{d}t$
A1	0.17 or better (do not accept e.g. 0.166). Must be positive.

Question Number	Scheme	Marks
7(a)	Conservation of Energy:	M1
	$\frac{1}{2}m\times 12^2 = \frac{1}{2}m\times 8^2 + mgh$	A1 A1
	(h =) 4.1 (m)	A1
		(4)
7(b)	Vertical distance:	M1
	$"4.1" = 12\sin\alpha\times 1.5 - \frac{g}{2}\times 1.5^2$	A1ft
	$\alpha = 57°$	A1
		(3)
7(c)	Equation in α and β only	M1
	Eg. Horizontally: $12\cos\alpha = 8\cos\beta$	Eg. Vertical and horizontal components: $\tan\beta = \frac{12\sin\alpha - 1.5g}{12\cos\alpha}\left(= -0.709....\right)$	A1ft
	$\beta = 35°$	A1
		(3)
7(d)	Max height, T	Times when v = 8	Times when h = 4.08	M1
	$2(1.5 - T)$	$T_2 - T_1$	$T_2 - T_1$	dM1
	$T = \frac{12\sin\alpha}{g}$	$0 = 8\sin\beta\, T - \frac{1}{2}gT^2$	$4.08 = 12\sin\alpha\, T - \frac{1}{2}gT^2$	A1ft
	0.94 (s)	A1
		(4)
		(14 marks)

Notes	
(a) M1	Energy equation with correct number of terms and dimensionally correct including mass. M0 if no energy equation used or for incorrect energy formulae.
A1	Unsimplified equation with at most one error.
A1	Correct unsimplified equation.
A1	4.1 or 4.08 only (2 or 3sf)
(b) M1	Complete method to find an equation in sin α only, using their h. This equation could be obtained by getting two equations in α and β, which don't require h, and eliminating β
A1ft	Correct equation, ft their h if used. ($\sin\alpha = 0.839$)
A1	57° or 57.1° (or 1.0 or 0.996 radians) [57.06178257…]
(c) M1	A method to reach an equation in α and β only. E.g. Equating horizontal speed in terms of α and β or finding the vertical velocity components at B, v_V, and then using $\tan\beta = \frac{\lvert v_V\rvert}{12\cos\alpha}$ or $\sin\beta = \frac{\lvert v_V\rvert}{8}$.
A1ft	A correct equation in α (need not be substituted) and β, ft their h and α
A1	35° or 35.4° (or 0.617 or 0.62 radians) [35.35311389…]

N.B.	v_V can be found in a number of ways [v_V = 4.628911565…] $v = u + at$: $v_V = 12\sin\alpha - 1.5g$ $v^2 = u^2 + 2as$: $v_V = \sqrt{(12\sin\alpha)^2 - 2g \times \text{their } h}$ $s = vt - \frac{1}{2}at^2$: $h = 1.5v_V + \frac{1}{2}g \times 1.5^2 \Rightarrow v_V = \frac{h - \frac{1}{2}g \times 1.5^2}{1.5} = \frac{2h}{3} - \frac{3g}{4}$ $s = \left(\frac{u+v}{2}\right)t$: $h = \left(\frac{12\sin\alpha + v_V}{2}\right) \times 1.5 \Rightarrow v_V = \frac{4}{h} - 12\sin\alpha$
(d) M1	Method to find an appropriate time(s), *T*, that could be used to find the required time: E.g.time to maximum height, times to height 4.08, times to speed being 8. M0 for total flight time unless they go on to use appropriately.
dM1	A correct overall method to use their *T* to find the required time.
A1ft	Correct equation for their *T*, ft their *h*, α, β
A1	0.94 or 0.945 obtained from correct working. [0.9446758295…]

Question Number	Scheme	Marks
8(a)		
	CLM:	M1
	$5mu-4mu=mv+mw \qquad (u=v+w)$	A1
	NEL:	M1
	$w-v=9ue$	A1
	Solve for v or w	DM1
	$w=\frac{u}{2}(9e+1)$	A1
	$v=\left\|\frac{u}{2}(1-9e)\right\|$	A1
		(7)
8(b)	Use of $v<0$ to find inequality involving e	M1
	$\frac{1}{9}<e$	A1
	Use of $w \leqslant 3u$	M1
	$\frac{1}{9}<e\leq\frac{5}{9}$	A1
		(4)

Notes	
(a) M1	Conservation of linear momentum. Needs all terms and dimensionally consistent but condone sign errors.
A1	Correct equation (m may be cancelled)
M1	Impact law. Condone sign errors but must not be reciprocal.
A1	Correct equation with directions consistent with momentum equation. **N.B.** Mark the equations even if inconsistent with any directions on their diagram
ddM1	Solve for v or w dependent on both previous M marks.
A1	Correct expression for speed of B after collision.
A1	Correct expression for speed of A; must include modulus as demand specifies speed.
(b) M1	Inequality considering direction of A reversed (i.e. their $v<0$)
A1	Correct lower inequality. Must be strict inequality.
M1	Second inequality requiring speed of B to be less than or equal to the speed of C but condone strict inequality ($w<3u$)
A1	cao

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 23 October 2025

Afternoon (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 $g = 9.8\,\text{m}\,\text{s}^{-2}$, 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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Pearson

1.

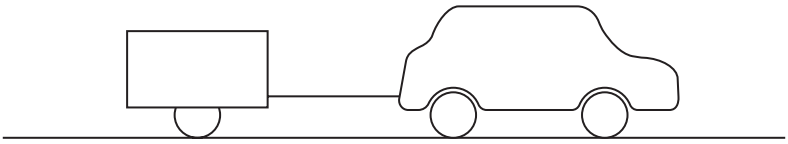

Figure 1

A car of mass 500 kg is towing a trailer of mass 150 kg along a straight horizontal road. The trailer is attached to the car by a towbar, as shown in Figure 1.

The towbar is parallel to the direction of motion of the car and the trailer.

The towbar is modelled as a light rod.

The resistance to the motion of the car is modelled as a constant force of magnitude 350 N.

The resistance to the motion of the trailer is modelled as a constant force of magnitude 200 N.

The engine of the car is working at a constant rate of 10.5 kW.

At the instant when the car and the trailer are moving with speed 14 m s^{-1}, the acceleration of the car is a m s^{-2} and the tension in the towbar is T newtons.

Using the model,

(a) find the value of a,

(4)

(b) find the value of T.

(3)

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Question 1 continued

(Total for Question 1 is 7 marks)

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2. [*In this question,* **i** *and* **j** *are perpendicular horizontal unit vectors.*]

A particle P of mass 2 kg is moving on a smooth horizontal plane with velocity $4\mathbf{i}\,\text{m s}^{-1}$

The particle receives a horizontal impulse of magnitude $\sqrt{29}$ Ns.

Immediately **after** receiving the impulse, the velocity of P is $(3\mathbf{i} + \lambda\mathbf{j})\,\text{m s}^{-1}$, where λ is a positive constant.

(a) Find the value of λ

(4)

(b) Find the size of the angle between the direction of motion of P immediately **before** receiving the impulse and the direction of the impulse.

(3)

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Question 2 continued

(Total for Question 2 is 7 marks)

3. [*In this question, the perpendicular unit vectors* **i** *and* **j** *are in a horizontal plane.*]

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

A particle Q is moving on a smooth horizontal plane.

At time t seconds, $t \geqslant 0$, the position vector of Q, relative to a fixed origin, is **r** metres and the velocity of Q is $\mathbf{v}\,\text{m s}^{-1}$

It is given that $\mathbf{v} = (2t + 3)\mathbf{i} + (t^2 - 5t - 15)\mathbf{j}$

(a) Find the acceleration of Q when $t = 4$

(2)

When $t = 1$, $\mathbf{r} = 6\mathbf{i} - 2\mathbf{j}$

(b) Find an exact expression for **r** in terms of t, **i** and **j**

(4)

When $t = T$, particle Q is moving in the direction of the vector $5\mathbf{i} - 3\mathbf{j}$

(c) Find the exact speed of Q when $t = T$

(5)

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Question 3 continued

Question 3 continued

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Question 3 continued

(Total for Question 3 is 11 marks)

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4. In this question you may assume, without proof, that the distance of the centre of mass of a uniform semicircular lamina of radius r from its diameter is $\frac{4r}{3\pi}$

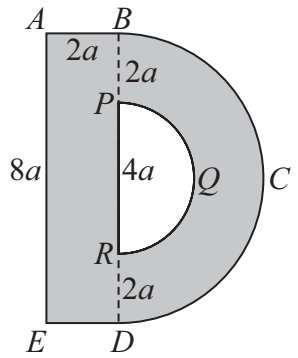

Figure 2

The uniform lamina $ABDE$ is a rectangle with $AB = 2a$ and $AE = 8a$.

The uniform lamina BCD is a semicircle with diameter $BD = 8a$.

The points P and R lie on BD with $BP = RD = 2a$.

The uniform lamina PQR is a semicircle with diameter $PR = 4a$.

The mass per unit area of the lamina $ABDE$ is equal to the mass per unit area of the lamina BCD.

The uniform template $ABCDE$, shown shaded in Figure 2, is formed by joining the lamina $ABDE$ to the lamina BCD and removing the lamina PQR.

The distance of the centre of mass of the template **from *BD*** is d.

(a) Show that $d = \frac{32a}{3(8+3\pi)}$

(5)

The template is free to rotate in a vertical plane about a smooth horizontal axis through B and hangs freely in equilibrium with BD at an angle $\phi°$ to the downward vertical.

(b) Find the value of ϕ.

(3)

The weight of the template is $15W$. A particle of weight kW is attached to the template at E.

The template is again free to rotate in a vertical plane about a smooth horizontal axis through B. The template is held in equilibrium, with BD vertical, by a horizontal force of magnitude W which is applied to the template at E and acts towards D.

(c) Find the value of k.

(4)

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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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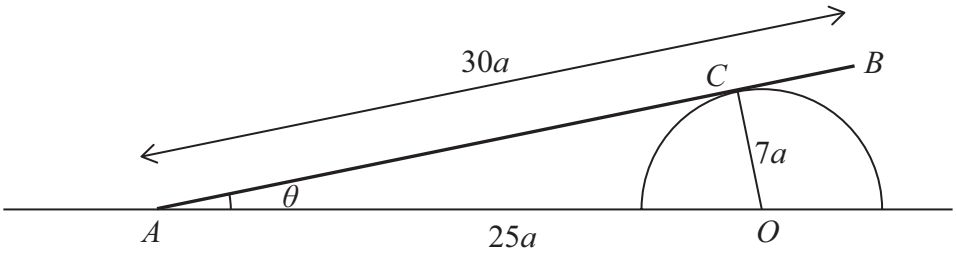

Figure 3

A smooth solid hemisphere is fixed with its plane face in contact with rough horizontal ground. The hemisphere has centre O and radius $7a$

A uniform rod AB, of length $30a$ and weight W, rests in limiting equilibrium on the hemisphere with end A on the ground. The rod is in contact with the hemisphere at the point C. The rod is at an angle θ to the ground, as shown in Figure 3.

Points A, C, B and O all lie in the same vertical plane.

Given that $AO = 25a$

(a) show that $AC = 24a$

(1)

(b) Show that the magnitude of the normal reaction on the rod at C is $\frac{3}{5}W$

(3)

The coefficient of friction between the rod and the ground at A is μ

(c) Find the value of μ

(6)

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Question 5 continued

Question 5 continued

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Question 5 continued

(Total for Question 5 is 10 marks)

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6. Two particles, P of mass $9m$ and Q of mass $3m$, are at rest on a smooth horizontal surface.

Particle P is projected with speed $4u$ towards Q and P collides with Q.

The coefficient of restitution between the particles is e.

(a) Show that the speed of Q immediately after the collision is $3u(1 + e)$.

(5)

The total kinetic energy lost in the collision between P and Q is kmu^2

Given that $e = \frac{2}{3}$

(b) find the value of k.

(4)

After being struck by P, particle Q goes on to hit a fixed vertical wall. The wall is perpendicular to the direction of motion of Q.

In the collision with the wall, Q receives an impulse of magnitude $21mu$.

(c) Find the coefficient of restitution between Q and the wall.

(3)

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Question 6 continued

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Question 6 continued

(Total for Question 6 is 12 marks)

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7.

Figure 4

A rough straight ramp is fixed at an angle α to horizontal ground, where $\tan\alpha = \frac{5}{12}$

The point A is at the bottom of the ramp and the point B is at the top of the ramp. Points A and B are on a line of greatest slope of the ramp, with $AB = 5\,\text{m}$, as shown in the sketch in Figure 4.

A particle of mass $0.5\,\text{kg}$ is projected up the ramp from A, along the line AB, with speed $U\,\text{m s}^{-1}$. At the instant when it reaches B, the speed of the particle is $26\,\text{m s}^{-1}$

The coefficient of friction between the particle and the ramp is $\frac{1}{3}$

(a) Find the work done against friction as the particle moves from A to B.

(3)

(b) Use the work–energy principle to find the value of U.

(4)

After leaving the ramp at B, the particle moves freely under gravity.

The particle is above the level of B for T seconds.

(c) Find the value of T.

(3)

The particle hits the ground for the first time at the point C.

(d) Find the distance AC.

(6)

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Question 7 continued

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Question 7 continued

(Total for Question 7 is 16 marks)

TOTAL FOR PAPER IS 75 MARKS

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Mark Scheme (Results)

October 2025

Pearson Edexcel International Advanced Level in Mechanics M2

WME02/01

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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 $\surd$ 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

   • 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)*

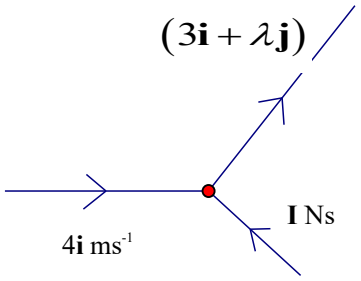
- Rules for M marks:
    - correct number of terms
    - dimensionally correct
    - all terms that need resolving (i.e. *multiplied* by cos or sin) are resolved
    - only terms that need resolving are resolved
    - +/− errors are condoned
    - sin/cos confusion is condoned
- Omission or extra g in 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

Mechanics Abbreviations

M(A)	Taking moments about A
N2L	Newton's Second Law (Equation of Motion)
NEL	Newton's Experimental Law (Newton's Law of Impact)
HL	Hooke's Law
SHM	Simple harmonic motion
PCLM	Principle of conservation of linear momentum
RHS	Right hand side
LHS	Left hand side

Question Number		Mark	Note
	Use the mass to determine which part of the system is being considered.		
1a	Equation of motion for the car and trailer or for each **with** T eliminated	M1	Need all terms. Dimensionally correct. M0 if they use power as a force. Condone sign errors.
	$F-350-200=(500+150)a$	A1	Correct unsimplified equation in F and a
	Use of $(F=)\ \frac{10500}{14}\ (=750)$ seen	M1	Independent M0 for just $14F = 10500$, with no subsequent working.
	$a=\frac{4}{13}$	A1	Accept 0.31 or better. 0.30769……
		[4]	
1b	Equation of motion for the car or the trailer to give an equation in T and a only.	M1	Need all relevant terms. Dimensionally correct. M0 if they use power as a force. Condone sign errors.
	$T-200=150\times\ '\frac{4}{13}'$ or $750-350-T=500\times\ '\frac{4}{13}'$	A1**ft**	Correct unsimplified equation, follow their a.
	$T=\frac{3200}{13}$	A1	Accept 250 or better 246.15338…….
		[3]	
		(7)	

Question Number		Mark	Note
2a			
	Impulse momentum equation	M1	Must be subtracting but condone subtraction in the wrong order Condone poor notation e.g. $\sqrt{29}=2(3\mathbf{i}+\lambda\mathbf{j})-2(4\mathbf{i})\left(=2(-\mathbf{i}+\lambda\mathbf{j})\right)$
	$(\mathbf{I}=)\ 2(3\mathbf{i}+\lambda\mathbf{j})-2(4\mathbf{i})\left(=2(-\mathbf{i}+\lambda\mathbf{j})\right)$	A1	Correct unsimplified expression for **I** Accept $2(\mathbf{i}-\lambda\mathbf{j})$
	Correct use of magnitude for their impulse e.g. $29=4(1+\lambda^2)$	M1	Allow with square roots on both sides
	$\lambda=2.5$	A1	Or equivalent. Must be positive.
		[4]	
2b	Correct use of trig or scalar product to find ratio for a relevant angle, for $4\mathbf{i}$ and their **I** e.g. $\tan\theta=\pm\frac{2}{2\lambda}$ or $\pm\frac{2\lambda}{2}$ or equivalent sin or cos equation.	M1	M0 if they use $(3\mathbf{i}+\lambda\mathbf{j})$ M0 for $\tan^{-1}\frac{2}{5}-\tan^{-1}4$ or similar
	Correct ratio for a relevant angle e.g. $\tan\theta=\pm\frac{2}{5}$ or $\pm\frac{5}{2}$ or equivalent sin or cos equation e.g. $\cos\theta=\frac{-2}{\sqrt{29}}$	A1ft	Follow their λ
	$111.801409...°$ or 1.9513027…. radians	A1	Accept $110°$ or 2, 2.0 radians or better
		[3]	
		(7)	

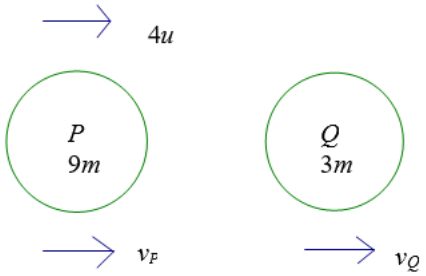
Question Number		Mark	Note
	Accept column vectors throughout apart from in the answer to part (b).		
3a	Use of $\mathbf{a}=\frac{\mathrm{d}\mathbf{v}}{\mathrm{d}t}$ $\left(\mathbf{a}=2\mathbf{i}+(2t-5)\mathbf{j}\right)$	M1	At least two powers of *t* going down by 1.
	$t=4\Rightarrow\mathbf{a}=2\mathbf{i}+3\mathbf{j}\left(\mathrm{m\,s^{-2}}\right)$	A1	Isw if they find the magnitude.
		[2]	
3b	Use $\mathbf{r}=\int\mathbf{v}\,\mathrm{d}t$	M1	At least two powers of *t* going up by 1
	$\mathbf{r}=\left(t^2+3t+A\right)\mathbf{i}+\left(\frac{1}{3}t^3-\frac{5}{2}t^2-15t+B\right)\mathbf{j}$	A1	Allow without constant of integration
	Use of $t=1$, $\mathbf{r}=6\mathbf{i}-2\mathbf{j}$ to **find** the (vector) constant of integration	M1	$\left(1+3+A=6,\quad\frac{1}{3}-\frac{5}{2}-15+B=-2\right)$ Must find *A* and *B*.
	$\left(t^2+3t+2\right)\mathbf{i}+\left(\frac{1}{3}t^3-\frac{5}{2}t^2-15t+\frac{91}{6}\right)\mathbf{j}$	A1	Cao (exact)
		[4]	
3c	Use the velocity and the direction to form an equation in *T*.	M1	Condone if 5 and -3 on the wrong sides of the equation.
	$-3\times(2T+3)=5\times\left(T^2-5T-15\right)$ oe	A1	Correct unsimplified equation in *T* or *t*
	$5T^2-19T-66=0\quad\left((5T+11)(T-6)=0\right)$ $\Rightarrow\quad T=6$	**D**M1	Simplify and solve for *T*, dependent on M1.
	Use of Pythagoras with their *T*: $\left(v=\sqrt{(2\times6+3)^2+\left(6^2-5\times6-15\right)^2}\right)$	M1	Independent but not available if they have more than one positive *T* value.
	$v=\sqrt{306}\left(=3\sqrt{34}\right)\left(\mathrm{m\,s^{-1}}\right)$	A1	Must be exact, accept either. Isw if they go on to give a decimal.
		[5]	
		(11)	

Question Number		Mark	Note
4a	<table><tr><td></td><td>*ABDE*</td><td>*BCD*</td><td>*PQR*</td><td>template</td></tr><tr><td>Mass</td><td>16</td><td>8π</td><td>2π</td><td>$6\pi+16$</td></tr><tr><td>From *BD*</td><td>$-a$</td><td>$\frac{16a}{3\pi}$</td><td>$\frac{8a}{3\pi}$</td><td>(*d*)</td></tr></table>	B1 B1	Correct mass ratios Correct distances from *BD* or from a parallel axis (Condone sign error)
	Moments about *BD*, using their table **N.B**. c of m of 'RH part' = $\frac{112a}{18\pi}$ then $\left(\frac{112a}{18\pi}\times 6\pi\right)-16a=(6\pi+16)d$	M1	Allow use of a parallel axis. Dimensionally consistent terms. All terms required. Correct pairings Condone sign error(s)
	$-16a+8\pi\times\frac{16a}{3\pi}-2\pi\times\frac{8a}{3\pi}=(6\pi+16)d$	A1	Correct unsimplified equation for their parallel axis.
	$d=\frac{64a}{3(16+6\pi)}=\frac{32a}{3(8+3\pi)}$ *	A1*	Obtain **given answer** from full and correct working. Need *d* = not $\bar{x}$
		[5]	
4b	Vertical distance of c of m from *B* = 4*a*	B1	Seen or implied
	Use of trigonometry to obtain a relevant angle $\tan\phi=\frac{32a}{3(8+3\pi)\times 4a}$ e.g. $\left(=\frac{8}{3(8+3\pi)}\right)\ (=0.153....)$	M1	M0 if they don't use 4*a*
	$\phi=8.7$	A1	8.7 or better (8.700966…)
		[3]	
4c	Moments about *B* or any other complete method to obtain in equation in *k*, *W* and *a* only. e.g. resolve horizontally (*X* = *W*) and	M1	All terms required. Terms dimensionally consistent. Condone sign

	vertically ($Y = (15 + k)\,W$) and Moments about another point.		errors.
	$\frac{32}{3(8+3\pi)} a \times 15W - 2akW = 8a \times W$	A1 A1	Unsimplified equation with at most one error Correct unsimplified equation
	$(k) = \frac{48-12\pi}{8+3\pi}$ or equivalent single fraction	A1	0.59 or better (0.59116…..)
		[4]	
		(12)	

Question Number		Mark	Note
5a	Correct use of Pythagoras e.g. $AC = \sqrt{(25a)^2 - (7a)^2} = 24a$ *	B1*	Allow quotation of the Pythagorean triple without detailed working. Need '*AC* =' B0 if error(s) in working e.g. $\sqrt{576a}$
		[1]	
5b	Moments about *A* or equivalent complete method.	M1	Dimensionally consistent. Condone sine/cosine confusion. Allow M1A0A0 if *a*'s never appear. M0 if they use 25*a* instead of 24*a*
	$W \times 15a \times \cos\theta = 24aN$	A1	Correct unsimplified equation
	$N = \frac{15}{25}W = \frac{3}{5}W$ *	A1*	Obtain **given answer** from correct working. Must see use of $(\cos\theta =)\frac{24}{25}$
		[3]	
5c	Resolve vertically:	M1	First equation (enter first on ePEN). Condone sine/cosine confusion. Condone sign error.
	$R_A + N\cos\theta = W \left(R_A = \frac{53}{125}W \right)$	A1	Correct unsimplified equation
	Resolve horizontally:	M1	Second equation (enter second on ePEN). Condone sine/cosine confusion. Condone sign error.
	$F_A = N\sin\theta \left(= \frac{21}{125}W \right)$	A1	Correct unsimplified equation
	Alternatives for either of the above equations: Resolve perpendicular to the rod: $N + R_A\cos\theta = W\cos\theta + F_A\sin\theta$ Resolve parallel to the rod: $W\sin\theta = F_A\cos\theta + R_A\sin\theta$ M(C): $9a \times W\cos\theta + 24a \times F_A\sin\theta = 24a \times R_A\cos\theta$		

	M(*B*): $6aN+30a\times R_A\cos\theta=30a\times F_A\sin\theta+15a\times W\cos\theta$ M(*G*): $15a\times F_A\sin\theta+9aN=15a\times R_A\cos\theta$		
	Use $F_A=\mu R_A$ to obtain an equation in μ only.	**D**M1	Substitute their values correctly, dependent on both M's, to obtain an equation in μ only. This mark is only available if they use the equations for which they have been awarded marks.
	$\mu=\frac{21}{53}$ or an equivalent fraction	A1	Accept 0.4, 0.40 or better (0.39622….)
		[6]	
		(10)	

Question Number		Mark	Note
6a			
	Use of CLM	M1	Need all terms. Dimensionally consistent Must be using the correct masses.
	$9m\times 4u = 9mv_P + 3mv_Q$	A1	Correct unsimplified equation
	Impact Law	M1	Used the correct way round $\left(v_{\text{sep}} = e\times v_{\text{app}}\right)$
	$v_Q - v_P = 4ue$	A1	Correct unsimplified equation
	Obtain $\left(v_Q\right) = 3u\left(1+e\right)$ *	A1*	Obtain given answer correctly with at least one line of intermediate working.
		[5]	
6b	$v_P = u\left(3-e\right)\left(=\frac{7}{3}u\right)$ or negative of these	B1	Seen or implied
	KE lost $=\frac{1}{2}.9m.\left(4u\right)^2 - \frac{1}{2}.9m.\left(v_P\right)^2 - \frac{1}{2}.3m.\left(v_Q\right)^2$	M1	Correct form for KE. Need all terms. Condone subtraction the wrong way round i.e. all signs reversed.
	$=\frac{1}{2}.9m.\left(4u\right)^2 - \frac{1}{2}.9m.\left(\frac{7u}{3}\right)^2 - \frac{1}{2}.3m.\left(5u\right)^2$ $(=72mu^2 - 24.5mu^2 - 37.5mu^2)$ $(=18mu^2(1-e^2))$	A1ft	Correct unsimplified expression in *m* and *u* only Follow their v_P
	$(k=)10$	A1	cao
		[4]	

6c	$w = 5uf$ or $-5uf$	B1	Or equivalent. Seen or implied Condone a sign error here.
	$21mu = 3m \times 5u - 3m \times w$ $(w = -2u)$	M1	Impulse momentum equation. Dimensionally correct. Must be using 3*m*. Condone sign error and in terms of e.
	$(f =) \frac{2}{5}$ oe	A1**cso**	
		[3]	
		(12)	

Question Number		Mark	Note
7a	$F_{\max} = \frac{1}{3} \times 0.5g \times \frac{12}{13}$	M1	Use of $F = \mu R$. Allow $\cos\alpha$ Condone sine/cosine confusion
	Work done $= F_{\max} \times 5$	DM1	For their $F_{\max}$ Dependent on previous M1
	Work done = 7.5 (J)	A1	7.5(J) or 7.54 (J) or $\frac{10g}{13}$ Not $\frac{98}{13}$ (follows substitution for g).
		[3]	
7b	Work-energy equation	M1	Need all terms. Condone sign errors and sine/cosine confusion.
	$\frac{1}{4}U^2 = \frac{1}{4}.26^2 + \frac{1}{2}g.5\sin\alpha + their\ \text{WD}$	A1ft A1ft	Unsimplified equation with at most one error Correct unsimplified equation
	(U =) 27	A1	27 or 27.3 (2 sf or 3 sf)
		[4]	
7c	Use of $v = u + at$	M1	Complete method using *suvat*
	$-26\sin\alpha = 26\sin\alpha - gT \quad (20 = gT)$ **OR** $0 = 26\sin\alpha \times T - \frac{1}{2}gT^2$ **OR** $T = 2 \times \frac{26\sin\alpha}{g}$	A1	Correct unsimplified equation in T or t.
	(T =) 2.0	A1	2, 2.0 or 2.04 (2sf or 3sf)
		[3]	
7d	Use of $s = ut + \frac{1}{2}gt^2$	M1	Complete method for time to ground using *suvat*
	$-5\sin\alpha = 26\sin\alpha t - \frac{1}{2}gt^2$	A1	Unsimplified equation with at most one error

	$(t = 2.2177...)$	A1	Correct unsimplified equation
	ALT 1: time up + time down	M1	Complete method using *suvat*
	$\frac{26\sin\alpha}{g} + \frac{2}{g}\sqrt{\left(\frac{(26\sin\alpha)^2}{2g} + 5\sin\alpha\right)}$ =(1.0204 + 1.1973)	A1 A1	Unsimplified equation with at most one error Correct unsimplified equation
	Horizontal distance, $X = 26\cos\alpha \times t$ (53.22)	**D**M1	Use of $u\cos\alpha t$ or equivalent, dependent on M1.
	Total distance $= 5\cos\alpha + 26\cos\alpha \times t$	M1	Use of: their $X + 5\cos\alpha$
	$= 58\ (\text{m})$	A1	58 or 57.8 (2sf or 3sf)
		[6]	
		(16)	

Pearson Edexcel International Advanced Level

Thursday 9 October 2025

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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1.

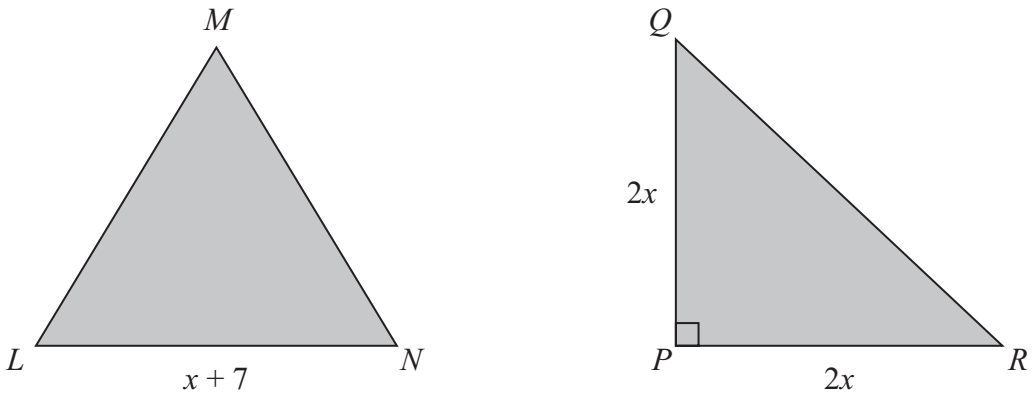

Figure 1

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 a triangle *LMN* and a sketch of a triangle *PQR*.

Triangle *LMN* is an equilateral triangle with sides $(x + 7)$ cm.

Triangle *PQR* is a right-angled isosceles triangle with $PQ = PR = 2x$ cm and angle $QPR = 90°$

(a) Find, in its simplest form in terms of x, the length QR.

(2)

Given that the perimeter of triangle *LMN* is equal to the perimeter of triangle *PQR*,

(b) find the value of x, writing your answer in the form $a\sqrt{2} + b$, where a and b are integers.

(5)

(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

$$y = x(x + 3)(x - 2)$$

(a) Find, in simplest form, $\frac{dy}{dx}$

(3)

(b) Hence find the range of values for x such that

$$\frac{dy}{dx} \geqslant 2$$

(4)

(Total for Question 2 is 7 marks)

---

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

Solve the equation

$$2y^2 + 1 = \frac{15}{y^2}$$

(5)

(Total for Question 3 is 5 marks)

4.

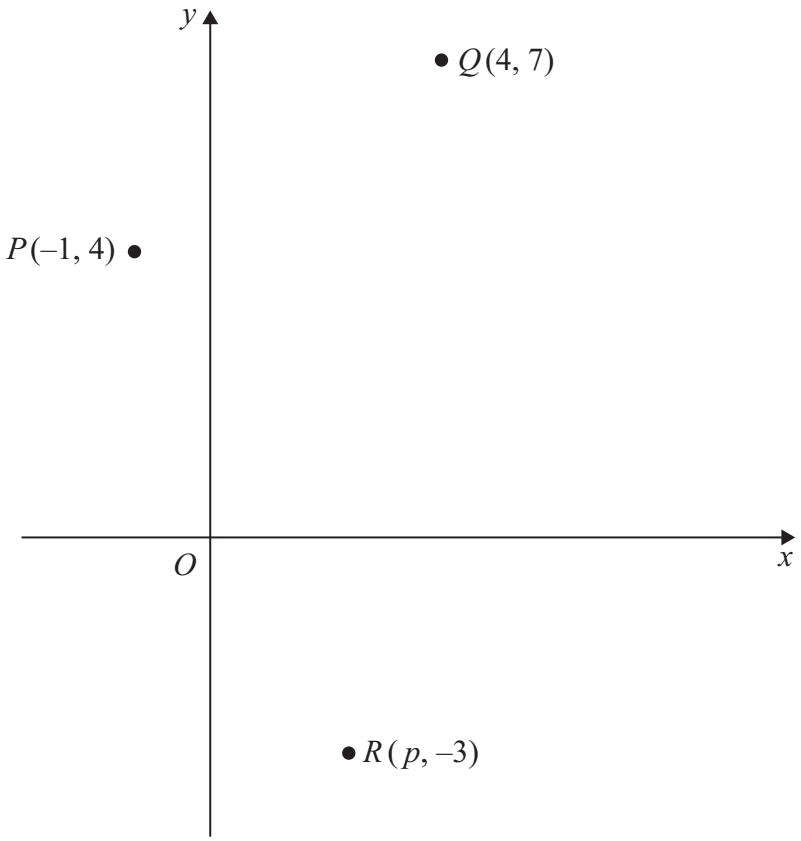

Figure 2

Figure 2 shows the points P, Q and R.

Points P and Q have coordinates $(-1, 4)$ and $(4, 7)$ respectively.

(a) Find an equation for the straight line passing through points P and Q.

Give your answer in the form $ax + by + c = 0$ where a, b and c are integers.

(3)

The point R has coordinates $(p, -3)$, where p is a positive constant.

Given that angle $QPR = 90°$,

(b) find the value of p.

(*Solutions relying on calculator technology are not acceptable.*)

(3)

(Total for Question 4 is 6 marks)

5. Find

$$\int \frac{4\sqrt{x} - 3}{2x^2} \mathrm{d}x \qquad x > 0$$

writing the answer in its simplest form.

(5)

(Total for Question 5 is 5 marks)

---

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

The equation

$$k(3x^2 + 8x + 9) = 2 - 6x$$

where k is a real constant, has no real roots.

Find the range of possible values for k.

(7)

(Total for Question 6 is 7 marks)

7.

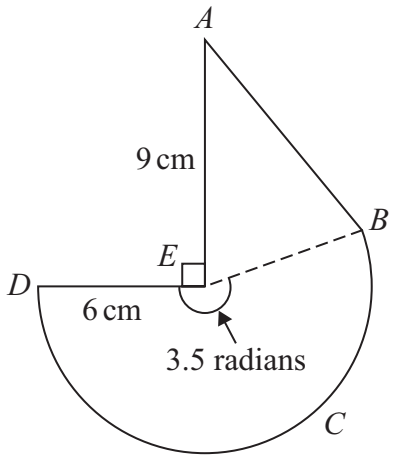

Diagram not drawn to scale

Figure 3

In this question you must show detailed reasoning.

Figure 3 shows the design for a company logo.

The design consists of a triangle *ABE* joined to a sector *BCDE* of a circle with radius 6 cm and centre *E*.
The line *AE* is perpendicular to the line *DE* and the length of *AE* is 9 cm.

The size of angle *DEB* is 3.5 radians, as shown in Figure 3.

(a) Find the length of the arc *BCD*.

(2)

Find, to one decimal place,

(b) the perimeter of the logo,

(3)

(c) the area of the logo.

(4)

(Total for Question 7 is 9 marks)

8.

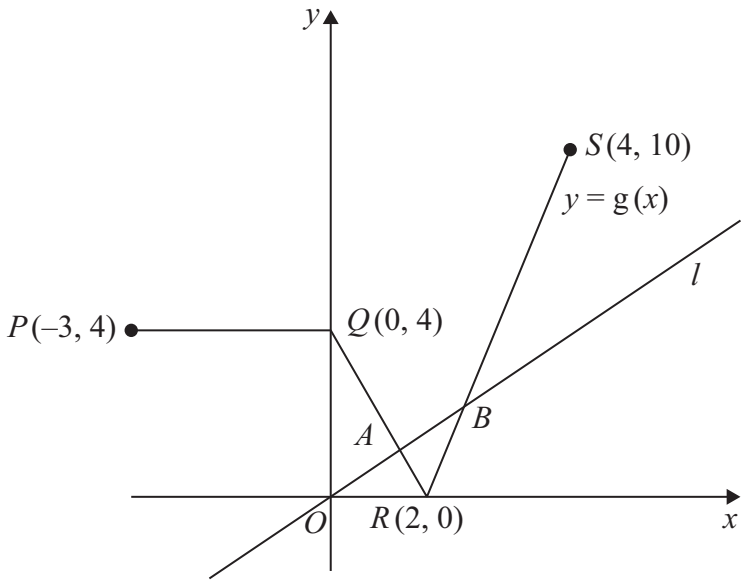

Figure 4

Figure 4 shows a sketch of the graph of $y = g(x)$, $-3 \leqslant x \leqslant 4$ and part of the line l with equation $y = \frac{1}{2}x$

The graph of $y = g(x)$ consists of three line segments, from $P(-3, 4)$ to $Q(0, 4)$, from $Q(0, 4)$ to $R(2, 0)$ and from $R(2, 0)$ to $S(4, 10)$.

The line l intersects $y = g(x)$ at the points A and B as shown in Figure 4.

(a) Use algebra to find the x coordinate of the point A and the x coordinate of the point B.
Show each step of your working and give your answers as exact fractions.

(6)

(b) Sketch the graph with equation

$$y = \frac{3}{2}g(x) \qquad -3 \leqslant x \leqslant 4$$

On your sketch show the coordinates of the points to which P, Q, R and S are transformed.

(2)

(Total for Question 8 is 8 marks)

9. The curve C has equation $y = f(x)$, $x > 0$ where

$$f'(x) = 30 + \frac{6 - 5x^2}{\sqrt{x}}$$

Given that the point $P(4, -8)$ lies on C,

(a) find the equation of the normal to C at P, giving your answer in the form $y = mx + c$, where m and c are constants.

(4)

(b) Find $f(x)$, giving each term in its simplest form.

(5)

(Total for Question 9 is 9 marks)

---

10. (a) On the axes in the answer book sketch and clearly label the graphs of

(i) $y = x(a - x)$

(ii) $y = x^2(b - x)$

where a and b are positive constants $b > a$

Show clearly the coordinates of all the points where the curves cross or meet the coordinate axes.

(5)

(b) Show that the x-coordinates of the points of intersection of

$$y = x(4 - x) \quad \text{and} \quad y = x^2(7 - x)$$

are given by the solutions to the equation

$$x(x^2 - 8x + 4) = 0$$

(2)

The point A lies on both of the curves and the x and y coordinates of A are both positive.

(c) Find the exact coordinates of A, leaving the answer in the form $\left(p + q\sqrt{3},\ r + s\sqrt{3}\right)$, where p, q, r and s are integers.

(*Solutions relying on calculator technology are not acceptable.*)

(5)

(Total for Question 10 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

Thursday 9 October 2025

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

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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 7 marks)

Question 2

Write the answer to Question 2 on these 2 pages

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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 7 marks)

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Question 3

Write the answer to Question 3 on these 2 pages

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Question 3 continued

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(Total for Question 3 is 5 marks)

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Question 4

Write the answer to Question 4 on these 2 pages

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Question 4 continued

This is the end of Question 4 answer space. Please turn the page for Question 5 answer space.

(Total for Question 4 is 6 marks)

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Question 5

Write the answer to Question 5 on these 2 pages

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Question 5 continued

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(Total for Question 5 is 5 marks)

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Question 6

Write the answer to Question 6 on these 2 pages

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Question 6 continued

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(Total for Question 6 is 7 marks)

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Question 7

Write the answer to Question 7 on these 2 pages

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Question 7 continued

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(Total for Question 7 is 9 marks)

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Question 8

Write the answer to Question 8 on these 4 pages

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Question 8 continued

Question 8 continued

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Question 8 continued

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(Total for Question 8 is 8 marks)

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Question 9

Write the answer to Question 9 on these 2 pages

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Question 9 continued

This is the end of Question 9 answer space. Please turn the page for Question 10 answer space.

(Total for Question 9 is 9 marks)

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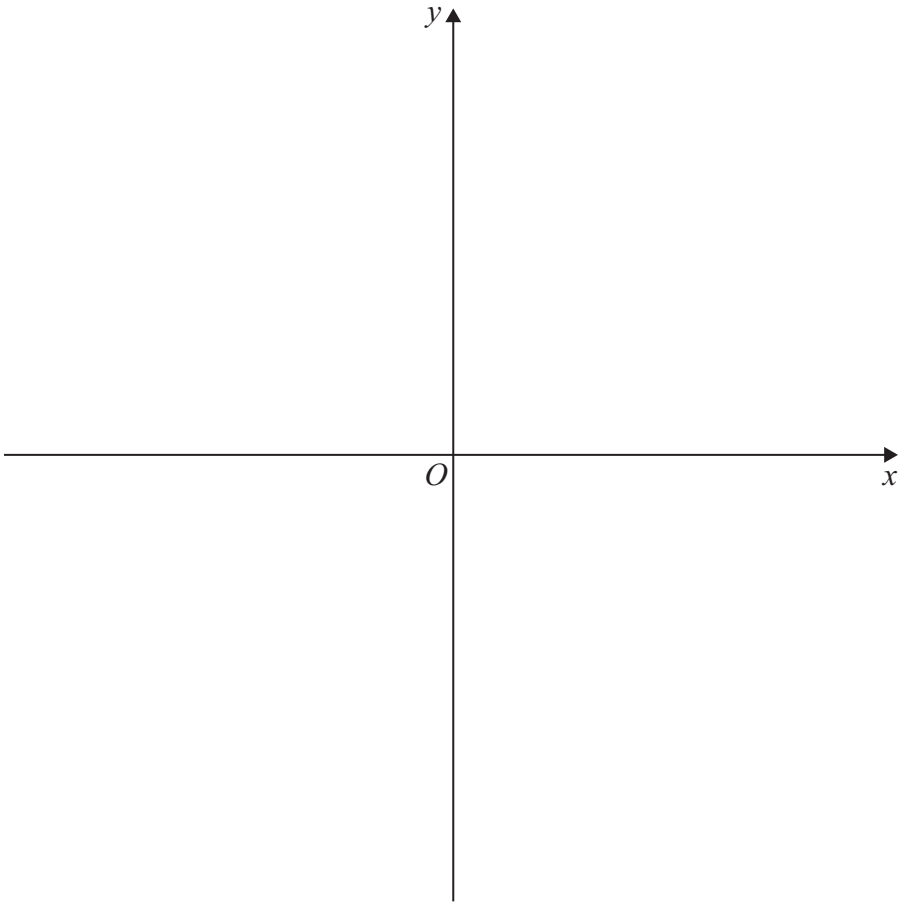
Question 10

Write the answer to Question 10 on these 3 pages



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Question 10 continued

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Question 10 continued

(Total for Question 10 is 12 marks)

TOTAL FOR PAPER IS 75 MARKS

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Mark Scheme (Results)

October 2025

International Advanced Level in Pure Mathematics P1

WMA11/01A

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications are awarded by Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk. 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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October 2025
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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
   - $\sqsubset$ 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 $x = \ldots$

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

2. Formula

Attempt to use correct formula (with values for a, b and c)

3. Completing the square

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

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	Notes	Marks
1(a)	$\{QR^2 =\}(2x)^2+(2x)^2$ Valid attempt at Pythagoras' Theorem. Condone omission of brackets e.g., $\{QR =\}\sqrt{2x^2+2x^2}$ If no sum seen only accept $\{QR^2 =\}8x^2$ or $\{QR =\}\sqrt{8x^2}$ or correct answer $\{QR =\}2\sqrt{2}x$ or $\sqrt{8}x$. If trig, must see a correct statement e.g., $\frac{2x}{QR}=\sin 45(^\circ)$		**M1**
	$\{QR =\}2\sqrt{2}x$ or $\sqrt{8}x$ not e.g., $\sqrt{8x^2}$ Allow e.g., $2x\sqrt{2},\ x\sqrt{8}$. Must be seen in part (a) and do not condone $\pm$ but allow all remaining marks to be scored		**A1**
			(2)
(b)	Question has: "Solutions relying on calculator technology are not acceptable"		
	$3(x+7)=4x+'2\sqrt{2}x'$ Sets perimeters equal e.g., $x+7+x+7+x+7=2x+2x+'2\sqrt{2}x'$ Allow kx or $kx^{\frac{1}{2}}$ or kx^2 or for $'2\sqrt{2}x'$ Allow the odd slip if the intention is clear e.g. $3(x+7)\rightarrow 3x+7$		**M1**
	$\Rightarrow(1+2\sqrt{2})x=21$ Collects terms in *x* and reaches $Ax=B$ where *A* is a rational number + a surd and *B* is a rational number. Could be implied by $x=$ an intermediate answer Must have had kx for $'2\sqrt{2}x'$		**dM1**
	Correct **intermediate** answer $x=\frac{21}{(1+2\sqrt{2})}$ or $x=\frac{21}{(1+\sqrt{8})}$ Implied by $-3+6\sqrt{2}$ provided there is some relevant minimal algebra		**A1**
	$\Rightarrow x=\frac{21}{(2\sqrt{2}+1)}\times\frac{(2\sqrt{2}-1)}{(2\sqrt{2}-1)}$ Any correct method seen to rationalise an expression of form $\frac{D}{C}$ where C is a rational number + a surd and *D* is a rational number. What is shown above is sufficient. Can be implied but not by just a calculator answer.		**M1**
	$\Rightarrow\{x =\}6\sqrt{2}-3$	$6\sqrt{2}-3$ or $-3+6\sqrt{2}$	**A1**

	Squaring both sides - example: $3(x+7)=4x+2\sqrt{2}x$ (M1) $\Rightarrow 2\sqrt{2}\,x=21-x\Rightarrow\left(2\sqrt{2}\,x\right)^2=(21-x)^2\Rightarrow 8x^2=441-42x+x^2\Rightarrow 7x^2+42x-441=0$ Squares and obtains a 3TQ (dM1) Correct 3TQ (A1) $\Rightarrow x^2+6x-63=0\Rightarrow x=\dfrac{-6\pm\sqrt{6^2-4(1)(-63)}}{2(1)}$ Solves via valid non-calculator method (M1) $\Rightarrow x=\frac{-6\pm\sqrt{288}}{2}\Rightarrow x=-3+6\sqrt{2}$ This answer only (A1)	**(5)**
		Total 7

Question Number	Scheme	Notes	Marks
2	Question has: "Solutions relying on calculator technology are not acceptable"		
(a)	$\{y=\}\, x(x+3)(x-2) = x^3 + x^2 - 6x$	Correct expansion. Terms collected. Implied by a correct answer	**B1**
	$\left\{\frac{\mathrm{d}y}{\mathrm{d}x}=\right\} 3x^2 + 2x - 6$ M1: For reducing the power of x by one for at least one term Indices may not be processed. Allow if $\ldots x^n \rightarrow \ldots x^{n-1}$ seen anywhere in an attempt at the product rule which may be partial A1: Correct expression as shown (terms in any order) Must be seen in part (a).		**M1** **A1**
			(3)
(b)	$\frac{\mathrm{d}y}{\mathrm{d}x} = 3x^2 + 2x - 6 \geq 2 \Rightarrow$ $3x^2 + 2x - 8 = 0 \Rightarrow (3x-4)(x+2) = 0 \Rightarrow \{x=\} -2, \frac{4}{3}$	M1: Sets their quadratic = 2 (or uses any inequality sign) and attempts to find the critical values by solving a 3TQ (not a 2TQ) via a valid non-calculator method. M0 if 0 is used instead of 2. Roots may be complex. A1: Critical values of $-2,\ \frac{4}{3}$	**M1** **A1**
	$x \leq -2,\quad x \geq \frac{4}{3}$ M1: Selects the outside region appropriately for their real critical values. Do not condone e.g., $-2 \geq x \geq \frac{4}{3}$ Can follow previous M0 provided they have solved a 2 or 3 term quadratic with a positive x^2 coefficient, possibly by calculator (if so, must be correct roots for their equation - to 3sf if necessary). Allow if the work shows that they have solved e.g., $3x^2 + 2x - 6 = 0 \quad \left\{\Rightarrow x = \frac{-1 \pm \sqrt{19}}{3}\right\}$ but do not accept using these roots from $3x^2 + 2x - 8 = 0$ or e.g., $3x^2 + 2x - 6 \geq 2$ May have strict inequalities or one strict, one non-strict. A1: Correct region. Any appropriate notation. Condone "and" but not $\cap$.		**M1** **A1**

	Must be using x for both parts of the region not e.g., $x_1 \leq -2, \quad x_2 \geq \frac{4}{3}$ ISW once a correct answer is seen even if an incorrectly modified answer follows. Note that 0011 or 0010 are possible. Answer only is no marks but e.g., $3x^2 + 2x - 6 \geq 2, \quad x \leq -2, \quad x \geq \frac{4}{3}$ is 0011	
		(4)
		Total 7

Question Number	Scheme	Notes	Marks
3	Question has: "Solutions relying on calculator technology are not acceptable" Note that the "= 0" may be implied by solutions		
	$2y^2+1=\dfrac{15}{y^2} \Rightarrow 2y^4+y^2-15=0$	M1: Multiplies through by y^2 and forms a 3TQ equation in y^2 May be written as e.g., $2\left(y^2\right)^2+y^2=15$ A1: Any correct 3 term equation May have replaced y^2 with e.g., x	**M1** **A1**
	$\Rightarrow \left(2y^2-5\right)\left(y^2+3\right)=0 \Rightarrow \left\{y^2=\right\}\ldots$	Solves an equation which could be written in the form $ay^4+by^2+c=0$, $a,\ b,\ c\neq 0$ by a valid non-calculator method (see guidance) and finds at least one real value for y^2. May have replaced y^2 with e.g., x Do not condone if solutions are wrongly labelled e.g., as $y=\ldots$ instead of $y^2=\ldots$	**dM1**
	$\Rightarrow \{y=\} \pm \dfrac{\sqrt{10}}{2}$ or $\pm\sqrt{\dfrac{5}{2}}$ A1: One correct solution from a correct 3TQ. Note that e.g., $\Rightarrow \left(2y^2-5\right)\left(y^2-3\right)=0 \Rightarrow \{y=\} \dfrac{\sqrt{10}}{2}$ still scores this mark. Accept awrt ± 1.58 A1: Both correct exact solutions from a correct 3TQ. Ignore any of $\pm\sqrt{-3}$ or $\pm\sqrt{3}\,\mathrm{i}$ but A0 if **any (**real or complex) wrong solution is offered. Do not condone if clearly $\dfrac{\sqrt{5}}{2}$ but apply BOD if marginal. May not be labelled but final A0 if e.g., x = ... unless defined earlier	**A1** **A1**

	Alternative: $2y^2+1-\frac{15}{y^2}=0\Rightarrow\left(2y-\frac{5}{y}\right)\left(y+\frac{3}{y}\right)=0$ M1: Factorises allowing for sign/coefficient errors only A1: Correct factorisation $2y-\frac{5}{y}=0\Rightarrow 2y^2-5=0\Rightarrow y^2=\frac{5}{2};\qquad y=\pm\sqrt{\frac{5}{2}}\text{ or }\pm\frac{\sqrt{10}}{2}$ dM1: Proceeds with sign/coefficient errors only to a real value for y^2. Do not condone if this is mis-labelled e.g., as $y=...$ if should be $y^2=...$ A1A1: as above	
		(5)
		Total 5

Question Number	Scheme	Notes	Marks
4	$P(-1, 4),\quad Q(4, 7),\quad R(p, -3)$		
(a)	{Gradient PQ =} $\dfrac{y_1 - y_2}{x_1 - x_2} = \dfrac{7-4}{4-(-1)}\left\{= \dfrac{3}{5}\right\}$ Correct attempt at gradient of PQ which may be unsimplified. There must be no evidence of obtaining this fortuitously e.g. by use of an incorrect formula. See below for methods involving simultaneous equations.		**B1**
	$y-4=\dfrac{3}{5}(x-(-1))$ or $4=\dfrac{3}{5}(-1)+c,\ \Rightarrow c=...\left\{\dfrac{23}{5}\right\}\Rightarrow y=...$ $y-7=\dfrac{3}{5}(x-4)$ or $7=\dfrac{3}{5}(4)+c,\quad \Rightarrow c=...\left\{\dfrac{23}{5}\right\}\Rightarrow y=...$ Obtains a consistent equation of the line for their gradient using point P or Q. Allow this mark with any gradient If $y=mx+c$ must correctly substitute, reach $c=...$ and form equation unless "$y=mx+c$" seen. **Score the first two marks together** for $\dfrac{y-4}{7-4}=\dfrac{x-(-1)}{4-(-1)}$ or $\dfrac{y-7}{7-4}=\dfrac{x-4}{4-(-1)}$ or $4=-m+c,\ 7=4m+c\Rightarrow m=\dfrac{3}{5},\ c=\dfrac{23}{5}\Rightarrow y=\dfrac{3}{5}x+\dfrac{23}{5}$ Allow simultaneous equations to be solved by calculator		**M1**
	$\Rightarrow 3x-5y+23=0$ or an integer multiple e.g., $-3x+5y-23=0$ Allow terms in any order but all on one side with = 0 Only allow e.g., $a=-3,\ b=5,\ c=-23$ if $ax+by+c=0$ is seen		**A1**
			(3)
(b)	Question has: "Solutions relying on calculator technology are not acceptable"		
	e.g., Gradient PR = "$-\dfrac{5}{3}$" $\Rightarrow \dfrac{-7}{p+1}=$ "$-\dfrac{5}{3}$" Correctly takes negative reciprocal of a positive value $\neq 1$ and forms a correct consistent ft linear equation in p (or other variable) by an appropriate method. **OR** e.g., $(p+1)^2+7^2+5^2+3^2=(p-4)^2+10^2$ Alternatively, uses Pythagoras correctly to obtain a correct implied linear equation. Note that it is possible to form an equation using trigonometry. If so it must be consistent and correct and must not have any trig expressions. **OR** e.g, $4=-\frac{5}{3}(-1)+c,\ -3=-\frac{5}{3}p+c\Rightarrow 7=\frac{5}{3}+\frac{5}{3}p$ or $c=\frac{7}{3}\Rightarrow -3=-\frac{5}{3}p+\frac{7}{3}$ Award for appropriate simultaneous equations using P and R and the correct negative reciprocal of their positive gradient. Must also combine their equations correctly for their gradient which can be implied by $\frac{16}{5}$ with no wrong working, provided there has been some working which might e.g., be just writing down the simultaneous equations		**M1**
	e.g., $5p+5=21\Rightarrow p=\dfrac{16}{5}$ or $2p+84=116-8p\Rightarrow 10p=32\Rightarrow p=\dfrac{16}{5}$		**dM1** **A1**

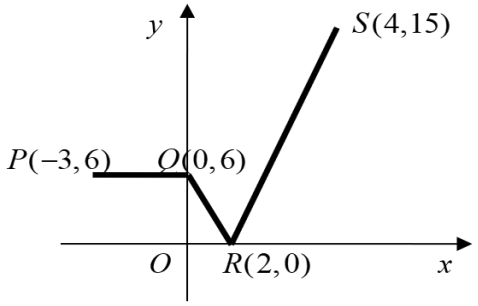
	dM1: Solves linear equation in p. This is not implied by just $p=\frac{16}{5}$ - must see a previous linear equation or $\frac{-7}{p+1}=\text{"}-\frac{5}{3}\text{"}$ (Condone using another variable) A1: $p=\frac{16}{5}$, $3\frac{1}{5}$ or 3.2 Accept just $\frac{16}{5}$ but not if labelled as x = ... etc.	
		(3)
		Total 6

Question Number	Scheme	Notes	Marks
5	$\frac{4\sqrt{x}-3}{2x^2}=\frac{4\sqrt{x}}{2x^2}-\frac{3}{2x^2}=2x^{-\frac{3}{2}}-\frac{3}{2}x^{-2}$	M1: Writes as a sum of **two** terms. Award for $...x^p \pm ...x^q$ with $p \neq q$ **and** one of p or q correct (indices processed). Allow if one of p or q = 0 A1: $2x^{-\frac{3}{2}}-\frac{3}{2}x^{-2}$ oe - coefficients could be unsimplified but indices must be processed	**M1** **A1**
	$\int \frac{4\sqrt{x}-3}{2x^2}\,dx=-4x^{-\frac{1}{2}}+\frac{3}{2}x^{-1}+c$ dM1: Raises a power of x by one. Allow if this is done on a term individually. Powers may be unprocessed A1: For one correct term either $-4x^{-\frac{1}{2}}$ or $+\frac{3}{2}x^{-1}$ which may be left unsimplified but powers processed A1: Fully correct and simplified including an arbitrary constant e.g. $-4x^{-\frac{1}{2}}+\frac{3}{2}x^{-1}+c$ Accept equivalent answers such as $-\frac{4}{\sqrt{x}}+\frac{3}{2x}+c$ but ISW once a correct expression has been seen. Ignore spurious integral signs, "dx", or if labelled as derivative		**dM1** **A1** **A1**
			(5)
			Total 5

Question Number	Scheme	Notes	Marks
6	Question has: "Solutions relying on calculator technology are not acceptable"		
	$k\left(3x^2+8x+9\right)=2-6x \Rightarrow$ $3kx^2+(8k+6)x+9k-2=0$	Expresses equation correctly as a three term quadratic or states the correct *a*, *b* and *c* Accept $3kx^2+8kx+6x+9k-2=0$ with LHS terms in any order Could be implied by attempt at discriminant	**B1**
	$(8k+6)^2-4(3k)(9k-2)$ $\Rightarrow -44k^2+120k+36$ $\left\{\Rightarrow 11k^2-30k-9\right\}$ M1: Uses b^2-4ac correctly allowing for $a=\pm 3k, b=\pm 8k\pm 6$ and $c=\pm 9k\pm 2$ or $c=\pm 9k$. No need to expand for the M mark. If e.g., $a=3kx^2$ is used then the '*x*'s must disappear later. Could be seen within use of quadratic formula/CTS. May see e.g. $b^2...4ac$ with = or any inequality sign for ... A1: Any correct three term quadratic expression for b^2-4ac (may be under root sign)		**M1** **A1**
	e.g., $(11k+3)(k-3)=0 \Rightarrow k=3,-\frac{3}{11}$	dM1: For an attempt at finding the critical values via a valid non-calculator method. Must see the precise 3TQ that is then solved (see guidance). May have complex roots. Requires previous M mark. A1: Correct critical values. Could be labelled with *x* = ... or unlabelled	**dM1** **A1**
	$k<-\frac{3}{11},\ k>3$ M1: Chooses outside region appropriately for their real critical values. Must not be fortuitous from e.g., two errors that correct themselves. Signs may non-strict or one strict, one non-strict. Requires **FIRST** M mark. May use e.g., *x* Do not condone e.g., $-\frac{3}{11}>k>3$ A1: Correct region - any suitable notation but must be using *k* only. Do not condone $k_1<-\frac{3}{11},\ k_2>3$ ISW once a correct answer is seen even if an incorrectly modified answer follows. Condone "and" but not $\cap$ Note that e.g.,1110011 is possible		**M1** **A1**
			(7)
			Total 7

Question Number	Scheme	Notes	Marks
7	Ignore units **in parts (b) and (c).** There is no credit for quoting correct formulae and then mis-applying. Question says "...you must show detailed reasoning"		
(a)	$r\theta = 6\times 3.5 = 21\,\mathbf{cm}$ M1: Any correct numerical expression or value for the arc length A1: 21**cm** only but allow e.g., 21.0 cm or 210 mm. Not awrt. **Units required**.		**M1** **A1**
			(2)
(b)	$AB^2 = 9^2 + 6^2 - 2\times 9\times 6\cos\left(\frac{3}{2}\pi - 3.5\right)$ $\{= 79.115..., \quad AB = 8.89...\}$	Correct expression for, or equation involving, AB^2 or AB - but allow with any angle in the cosine rule, even if it is negative or has come from mixed units. Not implied by a wrong value if there is no work - only accept awrt 78 or 79 (or 8.8 or 8.9) provided no incorrect method seen. Approaches that do not use the cosine rule must validly reach $AB^2 = \text{awrt } 78 \text{ or } 79$ OR $AB = \text{awrt } 8.8 \text{ or } 8.9$	**M1**
	$P = 6+9+"21"+AB = ...$	Obtains a value using 6 + 9 + their (a) + their AB	**dM1**
	$P = 44.9$	awrt 44.9	**A1**
			(3)
(c)	{Area triangle ABE =} $\frac{1}{2}\times 6\times 9\sin\left(\frac{3}{2}\pi - 3.5\right)$ or e.g., $\frac{1}{2}\times 9\times 6\cos(3.5-\pi)$ $\{= 25.284...\}$	**Fully correct** numerical expression or value for the area of ABE If angle is a decimal must be awrt 1.2 (1.212...) or if degrees awrt 69° (69.46...) Implied by awrt 25 (25.28433..) provided no incorrect method seen Alternative multi-step approaches where the work is not clear must validly reach Area ABE = awrt 25	**M1**
	{Area sector $BCDE$=} $\frac{1}{2}\times 6^2\times 3.5\{= 63\}$	Any correct expression or value for sector area	**B1**
	$\frac{1}{2}\times 6\times 9\sin\left(\frac{3}{2}\pi - 3.5\right) + \frac{1}{2}\times 6^2\times 3.5 = 88.3$	dM1: Obtains a **value** for sector + triangle. Sector must be $\frac{1}{2}\times 6^2\times 3.5\{= 63\}$ or $6^2\times 3.5\{= 126\}$ oe	**dM1** **A1**

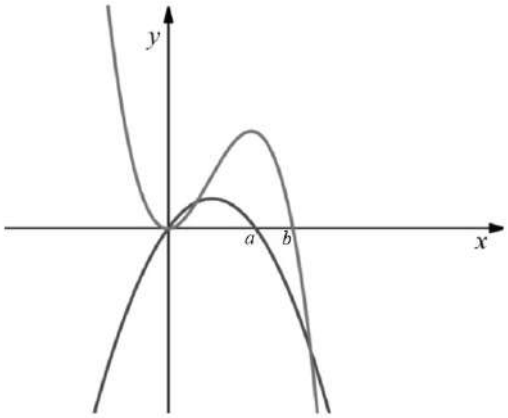
		A1: Awrt 88.3	
			(4)
			Total 9

Question Number	Scheme	Notes	Marks
8(a)	Ignore any *y* coordinates given and any labelling of points Note that coordinate pairs are $A\left(\frac{8}{5}, \frac{4}{5}\right)$ & $B\left(\frac{20}{9}, \frac{10}{9}\right)$		
	$\frac{1}{2}x = -2x + 4$	Sets $\frac{1}{2}x = ax + 4$ where $a < 0$	**1st M1**
	$\frac{1}{2}x = -2x + 4 \left\{\Rightarrow \frac{5}{2}x = 4 \Rightarrow\right\} \{x =\} \frac{8}{5}$ oe	dM1: Sets $\frac{1}{2}x = -2x + 4$ and obtains a value for *x* (which could be decimal) A1: Correct value. Must be a fraction	**dM1 A1**
	$\frac{1}{2}x = 5x - 10$	Sets $\frac{1}{2}x = 5x + b$ where $b < 0$	**3rd M1**
	$\frac{1}{2}x = 5x - 10 \left\{\Rightarrow \frac{9}{2}x = 10 \Rightarrow\right\} \{x =\} \frac{20}{9}$ oe	dM1: Sets $\frac{1}{2}x = 5x - 10$ and obtains a value for *x* (which could be decimal) A1: Correct value. Must be a fraction	**dM1 A1**
	There is no credit for answers only - some algebraic working must be seen.		
			(6)
(b)	 Do not be concerned with scaling e.g., if *P* is closer to the origin than *R* etc. There is no credit for the correct points but no sketch. May use P', Q', R' & S' or other letters - ignore any labels used for the points. Ignore any intersections with $y = \frac{1}{2}x$ or e.g., $y = \frac{3}{4}x$ shown	A sketch graph going from L to R made up of 3 straight line segments with two points positioned and labelled appropriately (*P* scores if it is in Q2, *Q* on positive *y*-axis, *R* on positive *x*-axis, *S* in Q1 but graph might not be the correct shape) May use numbers on axes rather than coordinates. Letters are not required. Coordinates may be indicated separately (e.g., following just having the letters on the sketch) but anything marked on sketch take precedence.	**B1**
		Fully valid sketch: same shape (horizontal line in Q2 to *y*-axis, then V with its vertex on the *x*-axis in Q1 but condone *S* being below *P* & *Q* and ignore the relative gradients of *QR* and *RS*) with all 4 points correct. May use numbers on axes rather than coordinates. Letters are not required. Coordinates may be	**dB1**

		indicated separately but any marked on sketch take precedence.	
			(2)
			Total 8

Question Number	Scheme	Notes	Marks
9	Question parts are marked separately throughout this paper (except for Q10) e.g., there are no marks in (b) for integration that is clearly an answer to (a).		
(a)	$f'(x)=30+\frac{6-5x^2}{\sqrt{x}}$ $\{f'(4)=\}30+\frac{6-5\times4^2}{\sqrt{4}}=-7$	M1: Attempts $f'(4)$ and achieves a value. Allow slips in substitution but if only a value is given it must be -7 A1: Correct value. May be implied later if uncalculated	**M1** **A1**
	$y+8=\frac{1}{7}(x-4)$ or $y=mx+c:-8=\frac{1}{7}(4)+c\Rightarrow c=...\left\{-\frac{60}{7}\right\}\Rightarrow y=...$	Uses the correct negative reciprocal of their $f'(4)\neq 0$ or 1 correctly with (4, –8) to obtain a straight line equation. If $y=mx+c$ must correctly substitute, reach $c=...$ and form equation unless "$y=mx+c$" seen Allow this mark if they use their $f''(4)$	**M1**
	$\Rightarrow y=\frac{1}{7}x-\frac{60}{7}$	$y=\frac{1}{7}x-\frac{60}{7}$. This form only with exact values. Allow if *y* on one side and the two other terms on the other side.	**A1**
			(4)
(b)	$f'(x)=30+\frac{6-5x^2}{\sqrt{x}}=30+6x^{-\frac{1}{2}}-5x^{\frac{3}{2}}\Rightarrow$ $\{f(x)=\}30x+12x^{\frac{1}{2}}-2x^{\frac{5}{2}}(+c)$	M1: For $30\rightarrow 30x$ or raises the power of $...x^{-\frac{1}{2}}$ or $...x^{\frac{3}{2}}$ by 1 A1: Two correct terms A1: Correct expression. $\{f(x)=\}30x+12x^{\frac{1}{2}}-2x^{\frac{5}{2}}(+c)$ No constant required. May be unsimplified but indices must be processed	**M1** **A1** **A1**
	If parts/substitution are used then award the M for $30\rightarrow 30x$ otherwise integration must be completed and a correct form achieved to score any marks.		
	$-8=30(4)+12(4)^{\frac{1}{2}}-2(4)^{\frac{5}{2}}+c\Rightarrow c=...$ Substitutes (4, –8) correctly into their f(*x*) and finds value of c Allow slips after substitution but must not e.g., mix up *x* and *y* You make have to check for consistency if there is minimal working		**dM1**

	$\{f(x) \text{ or } y =\}\quad 30x+12x^{\frac{1}{2}}-2x^{\frac{5}{2}}-88$	Correct and simplified four term expression. A0 if stops at $c=-88$. Do not need to see $f(x)=...$ Condone if e.g., a spurious integration sign remains	**A1**
			(5)
			Total 9

Question Number	Scheme	Notes	Marks
10	For this question, mark the parts together so e.g., marks for (b) and (c) may be scored for appropriate work in (a).		
(a)	$y = x(a-x), \quad y = x^2(b-x), \quad b > a > 0$  Ignore any labelling of the graphs with the equations. Work on the sketch takes precedence. If coordinates are given separately they must be identified e.g., labelled *P*, *Q* on the sketch and given in the answer space. Give BOD as a "slip of the pen" if curvature poor at the ends of the graphs. Allow asymmetry of the quadratic. Note that the vertex of the parabola could be above the maximum of the cubic.	For any **negative** quadratic curve (i.e., not an inverted V shape)	**1st B1**
		For **any** quadratic curve that intersects the *x*-axis at the origin and *a*, with *a* indicated on the positive *x*-axis. If coordinates, must be the right way round unless axis labelled	**2nd B1**
		For any **negative** cubic shaped curve (min then max - not point of inflection)	**3rd B1**
		For a **negative** cubic shaped curve with a minimum turning point at the origin	**4th B1**
		A completely correct diagram. Cubic crossing the positive *x*-axis at *b* to the right of *a*. If coordinates, must be the right way round unless axis labelled. The curves do not need to intersect in Q4 and do not be concerned about the relative gradients. Ignore any coords for intersections if given.	**5th B1**
			(5)

Question Number	Scheme	Notes	Marks
10(b)	$\{x(4-x)=x^2(7-x)\Rightarrow\}\ 4x-x^2=7x^2-x^3$ $\{x(4-x)=x^2(7-x)\Rightarrow\}\ x(4-x)=x(7x-x^2)$	Sets $x(4-x)=x^2(7-x)$ and multiplies out both brackets to achieve a correct form or factorises RHS to correct form	**M1**
	$\{\Rightarrow x^3-8x^2+4x=0\}\Rightarrow x\left(x^2-8x+4\right)=0$ Proceeds to the given answer with no errors seen. No intermediate step is required. Accept e.g., $0=\left(4+x^2-8x\right)x$ but must have 0 = or = 0 and be fully factorised		**A1***
			(2)
(c)	Question has: "Solutions relying on calculator technology are not acceptable"		
	$x^2-8x+4=0\Rightarrow x=\dfrac{-(-8)\pm\sqrt{8^2-4(1)(4)}}{2(1)}\Rightarrow x=4\pm2\sqrt{3}$ M1: Attempts to solve $x^2-8x+4=0$ by valid non-calculator means (not factorisation). May be complex if using CTS but see guidance. A1: $\{x=\}\ 4\pm2\sqrt{3}$ but allow $\{x=\}\ 4\pm\sqrt{12}$ and may just give one solution. Fraction must have been dealt with.		**M1** **A1**
	$x=4-2\sqrt{3}\ \ y=x(4-x)=2\sqrt{3}\left(4-2\sqrt{3}\right)=-12+8\sqrt{3}$		
	M1: Chooses either of their $x=4\pm2\sqrt{3}$ (rational number + surd) and uses $y=x(4-x)$ or $y=x^2(7-x)$ to obtain a value (rational number + surd). Method may not be shown - if so value must be correct for their *x*. If working is shown allow slips such as $\left(4-2\sqrt{3}\right)\left(4-4-2\sqrt{3}\right)=\ldots$ or $\left(4-2\sqrt{3}\right)\left(-2\sqrt{3}\right)=\ldots$ May be seen on the graph in (a). Note also that $x=4+2\sqrt{3}\Rightarrow y=-12-8\sqrt{3}$		**M1**
	dM1: **Shows a method** of finding *y* (achieving rational number + surd) from the **correct** $x=4-2\sqrt{3}$ (may use both) E.g. $\left(4-2\sqrt{3}\right)\left(2\sqrt{3}\right)=\ldots$ or $\left(4-2\sqrt{3}\right)\left(4-\left(4-2\sqrt{3}\right)\right)=\ldots$ Must start with a correct expression so do not condone starting with $\left(4-2\sqrt{3}\right)\left(4-4-2\sqrt{3}\right)$ or $\left(4-2\sqrt{3}\right)\left(-2\sqrt{3}\right)$ However, $\left(4-2\sqrt{3}\right)^2\left(3+2\sqrt{3}\right)$ requires the correct $\left(28-16\sqrt{3}\right)\left(3+2\sqrt{3}\right)$ or $2\sqrt{3}\left(4-2\sqrt{3}\right)$ seen Requires previous M mark		**dM1**
	$\left(4-2\sqrt{3},-12+8\sqrt{3}\right)$ Correct coordinates in this form. Accept $x=-2\sqrt{3}+4,\ \ y=8\sqrt{3}-12$		**A1**

	If both are given then the correct solution must be identified e.g., $A\left(4-2\sqrt{3},-12+8\sqrt{3}\right)$ and note that the other intersection is $\left(4+2\sqrt{3},-12-8\sqrt{3}\right)$ which can be ignored if the correct point is identified. $p=4,\ q=-2,\ r=-12,\ s=8$ is A0 without sight of $\left(p+q\sqrt{3},\ r+s\sqrt{3}\right)$ Note that 00111, 00110 and 00100 are possible.	
		(5)
		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

Thursday 9 October 2025

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 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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P 7 8 8 4 8 A 0 1 3 2

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1. The curve C has equation

$$y = 6x^2 + 3\sqrt{x} + \frac{5}{8} \qquad x > 0$$

(a) Find $\frac{dy}{dx}$ writing the answer in simplest form.

(3)

The point $P\left(\frac{1}{4}, \frac{5}{2}\right)$ lies on C.

(b) Find the equation of the tangent to C at P, writing your answer in the form $y = mx + c$ where m and c are integers.

(3)

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Question 1 continued

(Total for Question 1 is 6 marks)

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2. Find

$$\int (x-3)^2(2x+5)\,\mathrm{d}x$$

writing the answer in simplest form.

(5)

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Question 2 continued

(Total for Question 2 is 5 marks)

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3. The sides of a triangle are in the ratio $2 : 4 : 5$

(a) Find the size of the **largest** angle of the triangle, in degrees, to one decimal place.

(2)

Given that the area of the triangle is $140\,cm^2$

(b) find the length of the **shortest** side, in cm, to one decimal place.

(3)

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Question 3 continued

(Total for Question 3 is 5 marks)

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4. **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

$$3^{2p-5} = \frac{1}{9}\sqrt{27}$$

(3)

(ii) Find the real roots of the equation

$$x^2 + 1 = \frac{36}{x^2 - 4}$$

(4)

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Question 4 continued

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Question 4 continued

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Question 4 continued

(Total for Question 4 is 7 marks)

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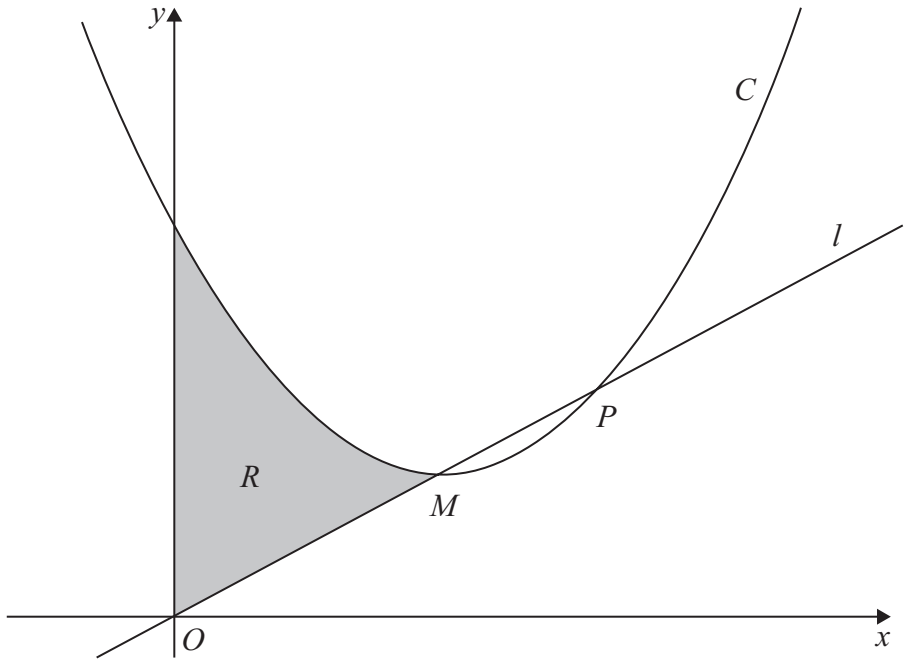

Figure 1

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

(a) Express $2x^2 - 16x + 50$ in the form

$$a(x + b)^2 + c$$

where a, b and c are constants to be found.

(3)

Figure 1 shows a sketch of the curve C with equation $y = 2x^2 - 16x + 50$

Given that in Figure 1

- M is the minimum point on C
- line l passes through the origin and intersects C at the points M and P

(b) find, using algebra and showing your working, the x coordinate of P.

(5)

The region R is shown shaded in Figure 1.

(c) Use inequalities to fully define R.

(2)

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Question 5 continued

Question 5 continued

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Question 5 continued

(Total for Question 5 is 10 marks)

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6. (a) Sketch the graph of the curve C with equation

$$y = \frac{4k}{x - 2k}$$

where k is a positive constant.

On your sketch show

- the coordinates of any points where C cuts the coordinate axes
- the equation of the vertical asymptote to C

(4)

The straight line l has equation

$$y = 6 - 2x$$

Given that there is at least one point of intersection between l and C,

(b) find the range of possible values of k.

(5)

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Question 6 continued

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Question 6 continued

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Question 6 continued

(Total for Question 6 is 9 marks)

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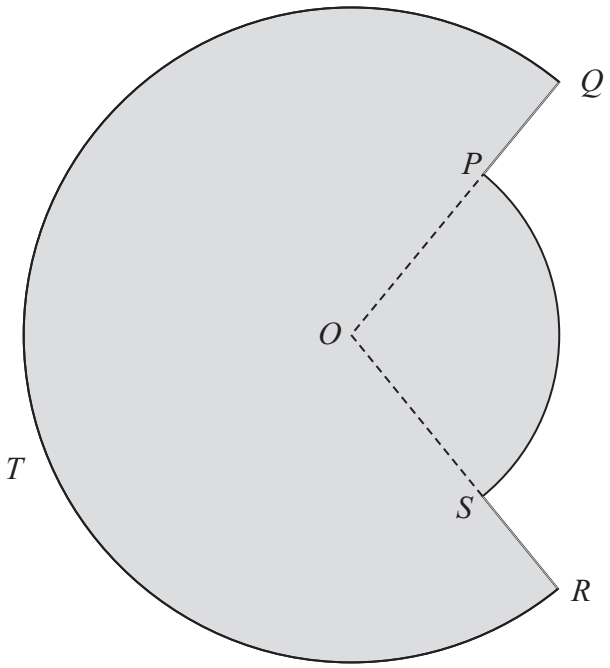

Figure 2

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

Figure 2 shows the plan view of a design for a swimming pool.

The design consists of a sector POS of a circle centre O joined to a major sector $QORTQ$ of a different circle, also with centre O.

Given that

- angle POS is 1.65 radians
- the area of sector POS is $30\,m^2$
- $PQ = 2.8\,m$

(a) show that, to 3 significant figures, $OQ = 8.83\,m$

(3)

(b) Find the total surface area of the swimming pool in m^2 to the nearest integer.

(3)

(c) Find the total perimeter of the swimming pool in metres to 2 significant figures.

(3)

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Question 7 continued

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Question 7 continued

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Question 7 continued

(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.

A curve has equation $y = f(x)$, $x > 0$

Given that

- $f'(x) = 2x + \frac{8}{x^2} + k$, where k is a constant
- the equation of the tangent to the curve at $x = \sqrt{2}$ is $y = 5x - 3\sqrt{2}$

(a) find the exact value of k.

(2)

(b) Find an equation of the normal to the curve at $x = \sqrt{2}$

(2)

(c) Find $f(x)$, writing your answer in simplest form.

(4)

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Question 8 continued

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Question 8 continued

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Question 8 continued

(Total for Question 8 is 8 marks)

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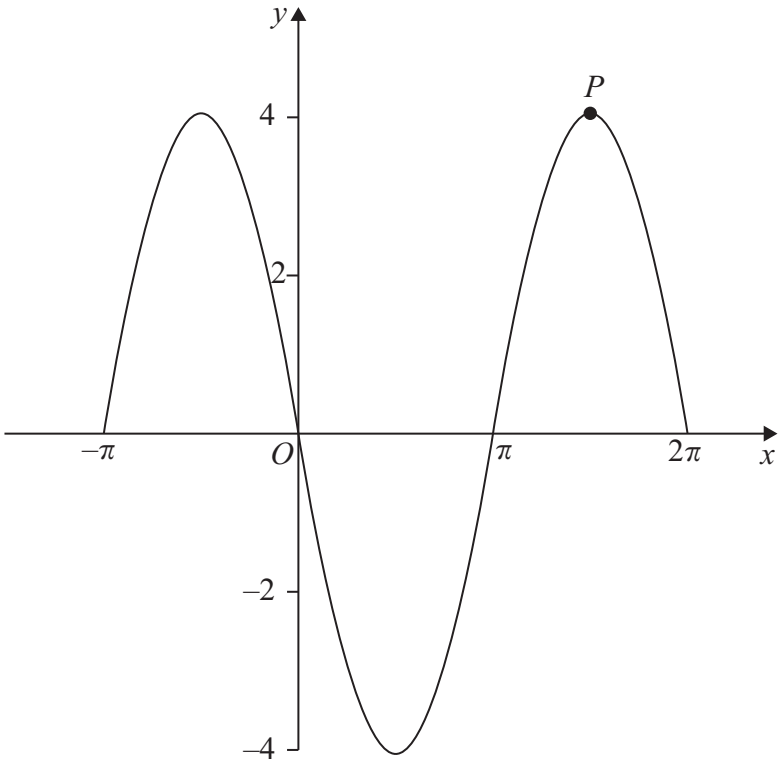

Figure 3

Figure 3 shows a sketch of part of the graph of the trigonometric function with equation $y = \mathrm{f}(x)$

(a) Write down an expression for $\mathrm{f}(x)$

(2)

The point P lies on $y = \mathrm{f}(x)$ and is shown in Figure 3.

(b) State the coordinates of the point to which P is transformed when the graph of $y = \mathrm{f}(x)$ is transformed to the graph with equation

(i) $y = \mathrm{f}\left(x - \frac{\pi}{6}\right)$

(2)

(ii) $y = -\frac{1}{2}\mathrm{f}(x)$

(2)

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Question 9 continued

(Total for Question 9 is 6 marks)

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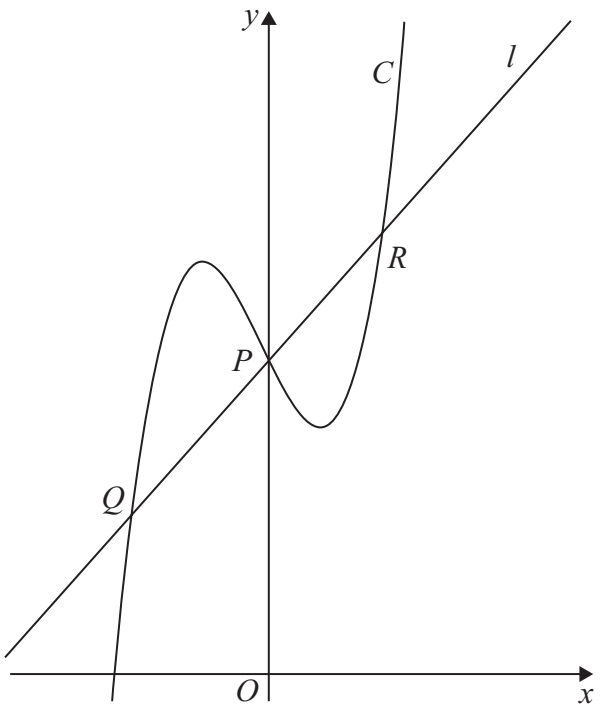

Figure 4

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

Figure 4 shows a sketch of the curve C with equation

$$y = 2x^3 + \frac{1}{2}x^2 - 2x + 5$$

The line l is the normal to C at the point P where $x = 0$

The line l also intersects C at points Q and R as shown in Figure 4.

(a) Find, using algebra, the x coordinate of point Q.

(6)

The point T lies on C.

Given that

- the tangent to C at T is parallel to l
- the x coordinate of T is positive

(b) find, using algebra, the exact x coordinate of T.

(4)

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Question 10 continued

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Question 10 continued

(Total for Question 10 is 10 marks)

TOTAL FOR PAPER IS 75 MARKS

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Pearson

Mark Scheme (Results)

October 2025

International Advanced Level in Pure Mathematics P1

WMA11/01

Edexcel and BTEC Qualifications

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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: 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

- ⌐ 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 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 = ...

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

2. Formula

Attempt to use correct formula (with values for a, b and c)

3. Completing the square

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

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)	$y = 6x^2 + 3\sqrt{x} + \frac{5}{8}$	
	$\left(\frac{dy}{dx} =\right) 12x + \frac{3}{2}x^{-\frac{1}{2}}$	M1 A1 A1
		(3)

Notes

(a)

M1: Attempts to differentiate achieving one correct index or for $\frac{5}{8} \to 0$

Award for $6x^2 \to ...x$ or $3\sqrt{x} \to ...x^{-\frac{1}{2}}$ (oe) or for $\frac{5}{8} \to 0$

Allow indices to be unprocessed for this mark e.g. $6x^2 \to ...x^{2-1}$ or $3\sqrt{x} \to ...x^{\frac{1}{2}-1}$

A1: One correct simplified algebraic term. E.g. $12x$ or $\frac{3}{2}x^{-\frac{1}{2}}$ oe e.g. $\frac{3}{2\sqrt{x}}, \frac{1.5}{x^{\frac{1}{2}}}$

Condone $12x^1$ for $12x$ for this mark.

Do not allow $3\times\frac{1}{2}x^{-\frac{1}{2}}$ for $\frac{3}{2}x^{-\frac{1}{2}}$

Award as soon as a correct simplified term is seen.

A1: $\left(\frac{dy}{dx}\right) = 12x + \frac{3}{2}x^{-\frac{1}{2}}$ or simplified equivalent such as $12x + \frac{1.5}{\sqrt{x}}$.

Do **not** allow $12x^1$ for $12x$ for this mark.

There is no need for "$\frac{dy}{dx} =$" so just look for the correct expression and apply isw once a correct answer is seen.

$\left(\frac{dy}{dx}\right) = 12x + \frac{3}{2}x^{-\frac{1}{2}} + c$ scores A0 here as does $\left(\frac{dy}{dx}\right) = 12x + \frac{3}{2}x^{-\frac{1}{2}} + 0$

(b)	$x=\frac{1}{4}\Rightarrow \frac{\mathrm{d}y}{\mathrm{d}x}=12\times\frac{1}{4}+\frac{3}{2}\times\sqrt{\left(\frac{4}{1}\right)}=...\left(6\right)$	M1
	$\left(\frac{1}{4},\frac{5}{2}\right)\Rightarrow y-\frac{5}{2}="6"\left(x-\frac{1}{4}\right)$ or e.g. $y="6"x+c\Rightarrow\frac{5}{2}=6\times\frac{1}{4}+c\Rightarrow c=...$	**d**M1
	$\Rightarrow y=6x+1$	A1
		(3)
		(6 marks)

Notes

(b)

M1: Substitutes $x=\frac{1}{4}$ into their $\frac{\mathrm{d}y}{\mathrm{d}x}$ and finds its value. Their $\frac{\mathrm{d}y}{\mathrm{d}x}$ cannot be the same as "y".

Score for sight of $x=\frac{1}{4}$ substituted consistently into their $\frac{\mathrm{d}y}{\mathrm{d}x}$ followed by a value **or** it may be implied by a correct value for their $\frac{\mathrm{d}y}{\mathrm{d}x}$ if no substitution is seen.

Condone a miscopy of their $\frac{\mathrm{d}y}{\mathrm{d}x}$ if the intention is clear.

Do **not** award this mark for work such as

$$\left(\frac{\mathrm{d}y}{\mathrm{d}x}\right)=12x+\frac{3}{2}x^{-\frac{1}{2}}+c=12\left(\frac{1}{4}\right)+\frac{3}{2}\left(\frac{1}{4}\right)^{-\frac{1}{2}}+c=0\left(\text{or}\frac{5}{2}\right)\Rightarrow c=...$$

dM1: Correct method for finding the equation of the tangent (not the normal). Look for the correct use of their non-zero $\frac{\mathrm{d}y}{\mathrm{d}x}$ at $x=\frac{1}{4}$ and the point $\left(\frac{1}{4},\frac{5}{2}\right)$ with the values correctly placed.

If the form $y=mx+c$ is used they must proceed as far as $c=...$ e.g. $\frac{5}{2}="6"\frac{1}{4}+c\Rightarrow c=...$

Depends on the first method mark.

A1: $y=6x+1$ Cso

Note if they do not use part (a) for part (b) e.g. just use a calculator they will need to obtain a gradient of 6 for the first mark, then apply the scheme.

Question Number	Scheme	Marks
2.	$\int (x-3)^2(2x+5)\,\mathrm{d}x$	
	$(x-3)^2(2x+5)=\left(x^2-6x+9\right)(2x+5)=...$ or e.g. $(x-3)^2(2x+5)=(x-3)\left(2x^2-x-15\right)=...$	M1
	$=2x^3-7x^2-12x+45$	A1
	$\int (x-3)^2(2x+5)\,\mathrm{d}x=\frac{1}{2}x^4-\frac{7}{3}x^3-6x^2+45x+c$	M1 A1ft A1
		(5 marks)

Notes

M1: Attempts to multiply out. Look for an attempt to multiply two brackets together to form a quadratic before the result is combined with the third bracket.
Condone slips e.g. $(x-3)^2=x^2\pm 9$ and it may be left unsimplified but it must lead to an expression that could be simplified to the form ax^3+bx^2+cx+d where $a,b,c,d\neq 0$
Condone an answer appearing without an intermediate step only if it is of the form (or can be expressed in the form) $2x^3+px^2+qx\pm 45$ where $p,q\neq 0$

A1: For $2x^3-7x^2-12x+45$ but allow this unsimplified with the terms uncollected e.g. $2x^3+5x^2-12x^2-30x+18x+45$ and award this mark as soon as a correct expression is seen. Inclusion of "+ c" here scores A0 but the final mark is still available.

So $(x-3)^2(2x+5)=2x^3-7x^2-12x+45+c$ is A0 but

$\int (x-3)^2(2x+5)\,\mathrm{d}x=\int\left(2x^3-7x^2-12x+45\right)\mathrm{d}x+c$ is ok for A1

M1: For an attempt to integrate any 2 terms with **different powers** of their simplified or unsimplified expression by increasing the power of x by 1 following an attempt to expand all 3 brackets.
It is for any 2 of, $...x^3\rightarrow ...x^4$, $...x^2\rightarrow ...x^3$, $...x\rightarrow ...x^2$, $k\rightarrow kx$
Allow indices to be unprocessed e.g. $...x^3\rightarrow ...x^{3+1}$
There must have been an attempt to **expand all 3 brackets** so do not award for e.g.
$(x-3)^2=x^2-6x+9\rightarrow\frac{x^3}{3}-3x^2+9x$
or e.g. $(x-3)^2(2x+5)\rightarrow(x-3)^2\left(x^2+5x\right)$ or $(x-3)^2(2x+5)\rightarrow\frac{1}{3}(x-3)^3(2x+5)$

A1ft: For 2 **different** correctly integrated and simplified terms with **different powers** with indices processed.
Follow through on any **two different terms** with **different powers** of their simplified or unsimplified expansion.

A1: $\frac{1}{2}x^4 - \frac{7}{3}x^3 - 6x^2 + 45x + c$ or exact simplified equivalent including the + *c* all on one line.

Apply isw once a correct expression, including "+ *c*" is seen.

Condone the presence of spurious integral signs and/or d*x*'s.

Alternative attempts to integrate such as integration by parts or by substitution – send to review.

Question Number	Scheme	Marks
3(a)	$5^2 = 2^2 + 4^2 - 2\times 2\times 4\cos"\theta"$ or e.g. $(5x)^2 = (2x)^2 + (4x)^2 - 2\times 2x\times 4x\cos"\theta"$ or $\cos"\theta" = \dfrac{2^2+4^2-5^2}{2\times 2\times 4}$ or e.g. $\cos"\theta" = \dfrac{(2x)^2+(4x)^2-(5x)^2}{2\times(2x)\times(4x)}$	M1
	$\Rightarrow \theta = 108.2°$	A1
		(2)
Alternative using the cosine rule for a different angle and then the sine rule		
	e.g. $2^2 = 4^2 + 5^2 - 2\times 4\times 5\cos"A" \Rightarrow \cos"A" = \dfrac{4^2+5^2-2^2}{2\times 4\times 5}$ $\Rightarrow A = 22.33...°$ $\dfrac{2}{\sin 22.33...} = \dfrac{5}{\sin"\theta"}$	M1
	$\Rightarrow \sin"\theta" = \dfrac{5\sin 22.33...}{2} \Rightarrow \theta = 108.2°$	A1

(a) Notes

Note that some candidates may use equivalent correct ratios

e.g. $1:2:\frac{5}{2}$ **or** $x:2x:\frac{5}{2}x$ **or** $\frac{2}{11}:\frac{4}{11}:\frac{5}{11}$ **or** $\frac{2}{11}x:\frac{4}{11}x:\frac{5}{11}x$

M1: Attempts to use the cosine rule with the sides 2, 4 and 5 or e.g. $2x$, $4x$ and $5x$ or e.g. x, $2x$ and $2.5x$ **in the correct positions for the largest angle**.

Condone missing brackets e.g. $2x^2$ rather than $(2x)^2$ as long as the intention is clear.

If they start with a rearranged rule, the values or expressions must be in the correct positions.

A1: $\theta =$ awrt $108.2°$ (Degrees symbol not required)

Allow missing brackets to be recovered e.g. $\cos"\theta°" = \dfrac{2x^2+4x^2-5x^2}{2\times 2x\times 4x} \Rightarrow \theta = 108.2°$

Note that attempts to find any of the other angles, correct or incorrect, can be ignored if the largest angle is found correctly.

Alternative:

M1: Attempts to use the cosine rule with the sides 2, 4 and 5 or e.g. $2x$, $4x$ and $5x$ in the correct positions for their angle and then attempts to use the sine rule with their angle and the largest angle in the correct positions.

Note that they may also find the other smaller angle using the sine rule (or cosine rule) and then subtract the 2 smaller angles from 180°

A1: $\theta =$ awrt $108.2°$ (Degrees symbol not required)

Note that this method is likely to lead to the acute angle (71.79…°) and scores A0

Allow missing brackets to be recovered as above.

(b)	$A=\frac{1}{2}ab\sin C \Rightarrow 140=\frac{1}{2}2x\times 4x\sin"108.2°"$ or e.g. $A=\frac{1}{2}ab\sin C \Rightarrow 140=\frac{1}{2}2a\times\frac{5}{2}a\sin"22.33...°"$	B1ft
	$x^2=\frac{280}{8\sin("108.2°")}=36.8...\Rightarrow x=...$	M1
	Shortest side $=2\times\sqrt{36.8...}=12.1$ (cm)	A1
		(3)
		(5 marks)

(b) Notes

B1ft: Sets up a correct area equation in one variable e.g. x. using $A=\frac{1}{2}ab\sin C$ with A = 140 and with the sides and angle in the correct positions. Follow through on their $108.2°$ and they must have a value i.e. not just "C".

It is for e.g. $140=\frac{1}{2}\times 2x\times 4x\sin"108.2°"$ or with some letter other than "x" but note that $140=\frac{1}{2}\times x\times 2x\sin"108.2°"\Rightarrow x=...$ is also acceptable as the correct ratio is being used and leads directly to the length of the shortest side.

or if they didn't find the largest angle in part (a), it is for setting up the correct corresponding equation for their angle.

M1: Full use of $A=...x^2\sin C$ with A = 140 leading to a value for x (or any other letter) that involves taking the **square root** of their variable.

Note some candidates may use the exact value for $\sin C$ e.g. $\frac{\sqrt{231}}{16}$

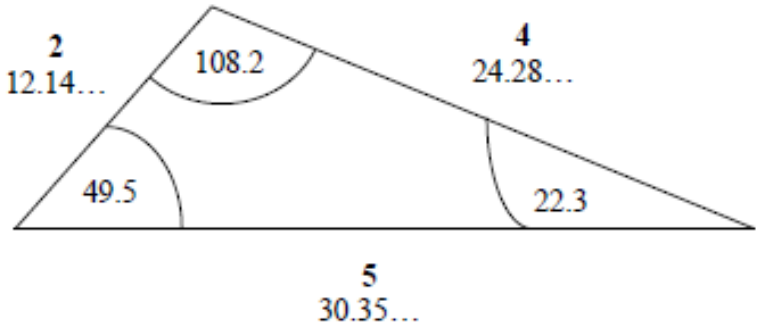
You do not need to be concerned about the order of operations as long as it involves taking the square root to find "x".

Condone errors in sides and/or angles used.

A1: awrt 12.1 (cm). Units are not required but if they are given they must be correct.

Q3 values for reference

NB scale factor $"x"=\sqrt{\frac{80\sqrt{231}}{33}}=\sqrt{36.845...}=6.0700...$



Question Number	Scheme	Marks
4(i)	**Examples:** lhs: $3^{2p-5}=3^{2p}\times3^{-5}$ or $\dfrac{3^{2p}}{3^5}$ or $\dfrac{3^{2p}}{243}$ or $3^{2p}=\left(3^{p}\right)^2$ or $9^{\frac{1}{2}(2p-5)}$ or $9^{p-\frac{5}{2}}$ rhs: $\dfrac{1}{9}=\dfrac{1}{3^2}$ or 9^{-1}, $\sqrt{27}=3\sqrt{3}$ or $3^{\frac{3}{2}}$, $\dfrac{1}{9}\sqrt{27}=\dfrac{\sqrt{3}}{3}$	M1
	Examples:	**d**M1 A1
	$3^{2p-5}=\dfrac{1}{9}\sqrt{27}\Rightarrow 3^{2p-5}=3^{-0.5}\Rightarrow 2p-5=-0.5\Rightarrow p=2.25$	
	$3^{2p-5}=\dfrac{1}{9}\sqrt{27}\Rightarrow \dfrac{3^{2p}}{3^5}=3^{-0.5}\Rightarrow 3^{2p}=3^{4.5}\Rightarrow 2p=4.5\Rightarrow p=2.25$	
	$3^{2p-5}=\dfrac{1}{9}\sqrt{27}\Rightarrow 3^{2p}\times3^{-5}=\dfrac{1}{9}\sqrt{27}\Rightarrow 9^{p}=81\sqrt{3}\Rightarrow p=2.25$	
	$3^{2p-5}=\dfrac{1}{9}\sqrt{27}\Rightarrow 3^{2p-5}=\dfrac{1}{3}\sqrt{3}\Rightarrow 3\times3^{2p-5}=\sqrt{3}\Rightarrow 3^{2p-4}=3^{0.5}$ $\Rightarrow 2p-4=0.5\Rightarrow p=2.25$	
	$3^{2p-5}=\dfrac{1}{9}\sqrt{27}\Rightarrow 9^{p-\frac{5}{2}}=9^{-1}\times9^{\frac{3}{4}}\Rightarrow p-\dfrac{5}{2}=-\dfrac{1}{4}\Rightarrow p=2.25$	
		(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 using a correct law of indices on the lhs or rhs of the equation. This may be seen in isolation i.e. not necessarily within the equation.
See scheme for some examples.

dM1: Reaches a value for p condoning arithmetic slips but with no incorrect index work e.g.
$\dfrac{1}{9}\times3^{\frac{3}{2}}=\left(\dfrac{1}{3}\right)^{\frac{3}{2}}$ or e.g. $3\times3^{\frac{1}{2}}=9^{\frac{1}{2}}$.
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 $p=2.25$ o.e. e.g. $\dfrac{9}{4}$, $2\dfrac{1}{4}$ following award of both Method marks.

Correct answer with no working scores no marks in (i)

(ii)	$x^2+1=\dfrac{36}{x^2-4}\Rightarrow\left(x^2+1\right)\left(x^2-4\right)=36\Rightarrow x^4-4x^2+x^2-4=36$	M1
	$\Rightarrow x^4-3x^2-40=0$ or e.g. $\Rightarrow x^4-3x^2=40$	A1
	$\left(x^2-8\right)\left(x^2+5\right)=0\Rightarrow x^2=...$	**d**M1
	$x=\pm2\sqrt{2}$	A1
		(4)
		(7 marks)

Notes

M1: Attempts to cross multiply and expand to obtain a polynomial equation in x or another variable if a substitution is used e.g. $y=x^2\Rightarrow y+1=\dfrac{36}{y-4}\Rightarrow\left(y+1\right)\left(y-4\right)=36\Rightarrow y^2-4y+y-4=36$

A1: Correct 3 term quadratic equation in x^2. The terms do not have to all be on the same side but must be collected so e.g. $x^4-3x^2=40$ is acceptable.
If the terms are all one side, the "= 0" may be implied by their attempt to solve.
May also be implied by a substitution e.g.
$y=x^2\Rightarrow y+1=\dfrac{36}{y-4}\Rightarrow\left(y+1\right)\left(y-4\right)=36\Rightarrow y^2-4y+y-4=36\Rightarrow y^2-3y=40$

dM1: Attempts to solve 3TQ in x^2 by any **non-calculator** means leading to values for x^2
This may be implied by substitution e.g. $y=x^2\Rightarrow y^2-3y-40=0\Rightarrow\left(y-8\right)\left(y+5\right)=0\Rightarrow y=...$
This may also be implied by their values for x e.g. $\left(x^2-8\right)\left(x^2+5\right)=0\Rightarrow x=\pm2\sqrt{2}$
Note that e.g. $x^4-3x^2-40=0\Rightarrow\left(x-8\right)\left(x+5\right)=0\Rightarrow x=8,-5$ scores dM0
but $x^4-3x^2-40=0\Rightarrow\left(x-8\right)\left(x+5\right)=0\Rightarrow x^2=8,-5$ scores dM1 by implication.

A1: $x=\pm2\sqrt{2}$ o.e. e.g. $\pm\sqrt{8}$ and no other values. Do **not** allow decimal values.
Do not isw if they obtain e.g. $x=\pm\sqrt{8}$ and then $x=\pm4$ score A0
Similarly if they obtain $x=\pm2\sqrt{2}$ and then declare e.g. therefore $x=2\sqrt{2}$ score A0
Must clearly be identified as values of x not any other variable e.g. y or t.

Question Number	Scheme	Marks
5(a)	$2x^2-16x+50\equiv 2\left(x^2-8x+25\right)\equiv 2(x\pm...)^2\pm...$	B1
	$\equiv 2(x-4)^2+18$	M1 A1
		(3)

Notes

(a)

B1: Writes $2x^2-16x+50$ in the form $2(x\pm...)^2\pm...$ or e.g. $2\left[(x\pm...)^2\pm...\right]$

M1: For $2(x-4)^2\pm...$ or e.g. $2\left[(x-4)^2\pm...\right]$. Allow e.g. $-\frac{16}{4}$ or $-\frac{8}{2}$ for -4

A1: For $2(x-4)^2+18$

Condone any spurious " = 0" e.g. $2(x-4)^2+18=0$

(b)	Eqn of l is $y = "\frac{18}{4}"x$ **or** $y = 2x^2 - 16x + 50 \Rightarrow \frac{dy}{dx} = 4x - 16$ At M $4x - 16 = 0 \Rightarrow x = 4$, $y = 18 \Rightarrow y = \frac{18}{4}x$	M1 B1 on ePEN
	$2x^2 - 16x + 50 = \frac{9}{2}x \Rightarrow 4x^2 - 41x + 100 = 0$ or e.g. $2x^2 + 50 = \frac{41}{2}x$	M1 A1
	$4x^2 - 41x + 100 = 0 \Rightarrow (x-4)(4x-25) = 0 \Rightarrow x = ...$	**dd**M1
	$x = \frac{25}{4}$ o.e.	A1
		(5)

Notes

(b)

M1: Deduces that equation of l is $y = "\frac{18}{4}"x$ o.e. Follow through on $y = "\frac{c}{-b}"x$ from (a)

Alternatively finds the coordinates of M (p, q) by using calculus and forms the equation $y = \frac{q}{p}x$

M1: Equates $y = 2x^2 - 16x + 50$ and their l of the form $y = \pm mx$ and collects terms to form a 3 term quadratic equation. Condone a miscopy of $y = 2x^2 - 16x + 50$ as long as the intention is clear.

A1: Correct 3 term quadratic equation. The terms do not have to all be on the same side but must be collected so e.g. $2x^2 + 50 = \frac{41}{2}x$ is acceptable.
If the terms are all one side, the "= 0" may be implied by their attempt to solve.

ddM1: Correct **non calculator** method of solving their 3TQ.
Depends on both previous method marks.
Do not allow for quoting the quadratic formula quoted followed by values e.g.

$$4x^2 - 41x + 100 = 0 \Rightarrow x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{25}{4},\ 4$$

But allow e.g. $4x^2 - 41x + 100 = 0 \Rightarrow x = \frac{41 \pm \sqrt{41^2 - 4 \times 4 \times 100}}{2 \times 4}$

Do not allow obvious use of a calculator where the factors do not correspond with their 3TQ

e.g. $4x^2 - 41x + 100 = 0 \Rightarrow \left(x - \frac{25}{4}\right)(x-4) = 0 \Rightarrow x = \frac{25}{4},\ 4$

or e.g. $2x^2 - \frac{41}{2}x + 50 = 0 \Rightarrow (4x-25)(x-4) = 0 \Rightarrow x = \frac{25}{4},\ 4$

or e.g. $4x^2 - 41x + 100 = 0 \Rightarrow (4x-25)(4x-16) = 0 \Rightarrow x = \frac{25}{4},\ 4$

but allow e.g. $4x^2 - 41x + 100 = 0 \Rightarrow 4\left(x - \frac{25}{4}\right)(x-4) = 0 \Rightarrow x = \frac{25}{4},\ 4$

and allow e.g. $4x^2-41x+100=0 \Rightarrow (4x-25)(4x-16)=(4x-25)(x-4)=0 \Rightarrow x=\frac{25}{4}$, 4

A1: $x=\frac{25}{4}$ only. If $x = 4$ is also seen, it must clearly be rejected or the $x=\frac{25}{4}$ clearly selected.
Ignore any attempts to find y.

(c)	$y \le 2x^2-16x+50, \quad y \ge "\frac{9}{2}x"$	B1ft
	Fully defined region E.g. $\frac{9}{2}x \le y \le 2x^2-16x+50$ and $0 \le x \le 4$	B1ft
		(2)
		(10 marks)

Notes

Some candidates are answering (c) at the bottom of the first page of the question so please check there.

Allow use of f(x) for y.

Do not allow use of R for y e.g. $R \le 2x^2-16x+50$ or e.g. $y >$ line

B1ft: Uses C and l with inequalities in the correct directions and ignore any other inequalities for this mark.
Allow strict or non-strict inequalities and condone a mix of both for this mark.
Follow through on their equation for l and their possibly incorrect completed square form for C.

Examples:

$y < 2x^2-16x+50$ and $y \ge "\frac{9}{2}x"$ or e.g. $"\frac{9}{2}x" < y < 2x^2-16x+50$

B1ft: Correct and fully **consistently** defined region and no incorrect inequalities.
Follow through on their equation for l and their possibly incorrect completed square form for C.
For the restriction on x, allow e.g. $0 < x < 4$ or written separately as e.g. $x > 0$, $x < 4$ and allow $0 < x < a$ where $a < \frac{25}{4}$

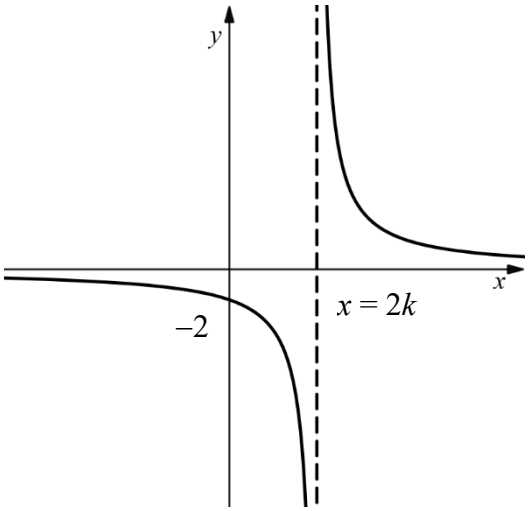
If extra inequalities are given that do not contradict then they can be ignored (see example below)

Examples of full marks in (c):

$y \le 2x^2-16x+50, \quad y \ge "\frac{9}{2}x", \quad x \ge 0, \quad x \le 4$

$"\frac{9}{2}x" < y < 2x^2-16x+50, \quad 0 < x < 4$

$"\frac{9}{2}x" < y, \; y < 2x^2-16x+50, \quad 0 < x, \; x < 6.25, \; y > 0$

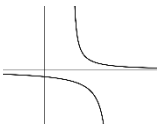
Question Number	Scheme		Marks
6(a)		Shape in quadrant 1	M1
		Fully correct shape and position	A1
		Cuts the y-axis at -2	B1
		Vertical asymptote at $x = 2k$	B1
			(4)

(a) Notes

Marks cannot be scored without a sketch.

M1: Correct shape in quadrant one for the right hand branch. It must not cross either axis but be tolerant of functions that don't go down as far as the x-axis and do extend as far left as the y-axis.
Condone curves that touch the x or y-axis as long as they do not cross the axis.
Ignore any asymptotes, correct or incorrect, for this mark.

A1: Correct shape and position (for whole curve). Be tolerant of slips of the pen but the intention should be clear. Look for the curve in quadrants 1, 3 and 4 with a vertical asymptote in quadrant 1 and 4. The left hand branch must extend into quadrant 3 and should not intentionally dip away from the x-axis to e.g. create an intentional maximum.
There should be no horizontal asymptotes other than the x-axis.

Do not allow this mark if the branches clearly overlap vertically. E.g. 

B1: Cuts or touches the negative y-axis **once** at -2
Must be in the correct position but allow as -2 or $y = -2$ and condone $(-2, 0)$ as long as it is in the correct place. Condone missing brackets e.g. $0, -2$
Allow to appear away from the sketch but it must be fully correct e.g. $(0, -2)$
If there is any ambiguity, the sketch takes precedence.

B1: For **one** vertical asymptote to the right of the y-axis marked $x = 2k$
It must be labelled as an equation and not just a value on the y-axis and it must correspond with the sketch.
The asymptote does not need to be drawn as a dotted line but the curve must be asymptotic to the correct line for either branch.
Allow $x = 2k$ to appear away from the sketch but it must be correct and correspond with the sketch. If there is any ambiguity, the sketch takes precedence.

6(b)	$\frac{4k}{x-2k}=6-2x \Rightarrow 4k=6x-12k-2x^2+4kx$ o.e.	M1 A1
	$2x^2-(4k+6)x+16k=0 \Rightarrow b^2-4ac=(4k+6)^2-4\times 2\times 16k$	**d**M1
	$4k^2-20k+9=0 \Rightarrow (2k-1)(2k-9)=0 \Rightarrow k=\frac{1}{2},\frac{9}{2}$ so $0<k\leq\frac{1}{2}, k\geq\frac{9}{2}$	**dd**M1 A1
		(5)
		(9 marks)

(b) Notes

M1: Equates curve with given line and attempts to form a quadratic equation.
The terms do not need to be collected.
Look for $\frac{4k}{x-2k}=6-2x$ cross multiplies (condoning slips) and proceeds to a quadratic equation.

A1: Correct quadratic equation with brackets expanded which may be unsimplified e.g.
$\frac{4k}{x-2k}=6-2x \Rightarrow 4k=6x-12k-2x^2+4kx$

dM1: Correct attempt to find the discriminant b^2-4ac for their $ax^2+bx+c=0$ with both *b* and *c* expressions in terms of *k*. May be seen embedded in an attempt at the quadratic formula.
It is dependent upon the previous Method mark.

ddM1: Solves their 3 term quadratic equation/inequality in *k* resulting from $b^2-4ac...0$ **and** chooses the **outside region** for their critical values.
Allow calculator solutions for solving their 3TQ and condone factors that are inconsistent with their equation so just look for the correct or correct ft roots with an attempt at the outside regions e.g. condone $4k^2-20k+9=0 \Rightarrow \left(k-\frac{1}{2}\right)\left(k-\frac{9}{2}\right)=0 \Rightarrow k=\frac{1}{2},\frac{9}{2} \Rightarrow k<\frac{1}{2}, k>\frac{9}{2}$

The roots may be embedded so allow e.g. $4k^2-20k+9=0 \Rightarrow k\leq\frac{1}{2}, k\geq\frac{9}{2}$ to imply this mark.

Condone the boundaries not being included in the inequality and condone the omission of $k>0$
Condone the use of *x* rather than *k*.
It is dependent upon both previous Method marks.

A1: CSO $0<k\leq\frac{1}{2}, k\geq\frac{9}{2}$ o.e. Must be in terms of *k*.

The following are acceptable:

$0 < k \leq \frac{1}{2}, k \geq \frac{9}{2}$	$0 < k \leq \frac{1}{2}$ and $k \geq \frac{9}{2}$	$0 < k \leq \frac{1}{2}$ or $k \geq \frac{9}{2}$	$0 < k \leq \frac{1}{2} \cup k \geq \frac{9}{2}$
$\left(0, \frac{1}{2}\right], \left[\frac{9}{2}, \infty\right)$	$\left\{k : 0 < k \leq \frac{1}{2}, k \geq \frac{9}{2}\right\}$		

But do **not** allow $0 < k \leq \frac{1}{2} \cap k \geq \frac{9}{2}$.

Do not isw and mark their final answer.

Question Number	Scheme	Marks
7(a)	$\frac{1}{2}r^2\times1.65=30\Rightarrow r^2=\ldots$ or $r=\ldots$	M1
	$r=6.03$	A1
	$\left(OQ=\right)6.03+2.8=8.83\,(\text{m})$*	A1*
		(3)
	(a) Alternative	
	$\frac{1}{2}(OQ-2.8)^2\times1.65=30\Rightarrow(OQ-2.8)^2=\ldots$ or $(OQ-2.8)=\ldots$	M1
	$(OQ-2.8)=6.030\ldots$	A1
	$\left(OQ=\right)6.03+2.8=8.83\,(\text{m})$*	A1*

Notes

(a)

M1: Uses $\frac{1}{2}r^2\times1.65=30$ in an attempt to find a value for r^2 or r (where r is OP)

A1: $"r"=6.03\ldots$ or exact $\sqrt{\frac{400}{11}}$ or $\frac{20}{\sqrt{11}}$ or $\frac{20\sqrt{11}}{11}$ or $\sqrt{36.36\ldots}$

A1*: $\left(OQ=\right)6.03\left(\text{or e.g.}\frac{20\sqrt{11}}{11}\text{ or }\sqrt{36.36\ldots}\right)+2.8=8.83\,(\text{m})$

Must be 8.83 not awrt 8.83

The "$OQ=$" is not required.

There must be some indication that they are adding $6.03\left(\text{or e.g.}\frac{20\sqrt{11}}{11}\right)$ to 2.8

There is no requirement for units but if any are given they must be correct.

Allow equivalent **correct** work in degrees e.g. $1.65\,\text{rads}=1.65\times\frac{180}{\pi}°$ etc.

Alternative:

M1: Uses $\frac{1}{2}(OQ-2.8)^2\times1.65=30$ in an attempt to find a value for $(OQ-2.8)^2$ or $(OQ-2.8)$

A1: $(OQ-2.8)=6.03\ldots$ or exact $\sqrt{\frac{400}{11}}$ or $\frac{20}{\sqrt{11}}$ or $\frac{20\sqrt{11}}{11}$ or $\sqrt{36.36\ldots}$

A1*: $OQ=6.03\left(\text{or e.g.}\frac{20\sqrt{11}}{11}\right)+2.8=8.83\,(\text{m})$

Must be 8.83 not awrt 8.83

No requirement for units but if any are given they must be correct.

Note that any attempts to verify the result in (a) would need a complete argument e.g. attempts to find the area for 2 suitable values of OQ such as 8.835 and 8.825 for M1, A1 for both areas evaluated correctly and A1 for fully reasoning that OQ is 8.83 to 2dp.

(b)	Attempts $\frac{1}{2}\times 8.83^2\times(2\pi-1.65)=(180.\_\_)$	M1
	Total area = $\frac{1}{2}\times 8.83^2\times(2\pi-1.65)+30=...$	dM1
	awrt 210 (m^2) or 211 (m^2)	A1
		(3)
(c)	"6.03"$\times 1.65=(9.95)$ **or** $8.83\times(2\pi-1.65)=(40.91)$	M1
	Full method for perimeter = "6.03"$\times 1.65+8.83\times(2\pi-1.65)+2.8\times 2$	dM1
	= awrt 56 (m)	A1
		(3)
		(9 marks)

Notes

Allow equivalent correct work in degrees.

(b)

M1: Attempts $\frac{1}{2}\times 8.83^2\times(2\pi-1.65)$ or equivalent e.g. $\pi\times 8.83^2-\frac{1}{2}\times 8.83^2\times 1.65$

May be implied by awrt 180 or awrt 181 provided no incorrect working is seen.

dM1: Attempts $\frac{1}{2}\times 8.83^2\times(2\pi-1.65)+30=...$

Adds 30 to a correct attempt at the area of the major sector of the larger circle.

A1: awrt 210 (m^2) or awrt 211 (m^2)

No requirement for units but if any are given they must be correct.

Correct answer only scores no marks.

(c)

M1: Attempts "6.03"$\times 1.65$ which may be implied by awrt 9.95 or 3sf accuracy for their 6.03 provided no incorrect working is seen.

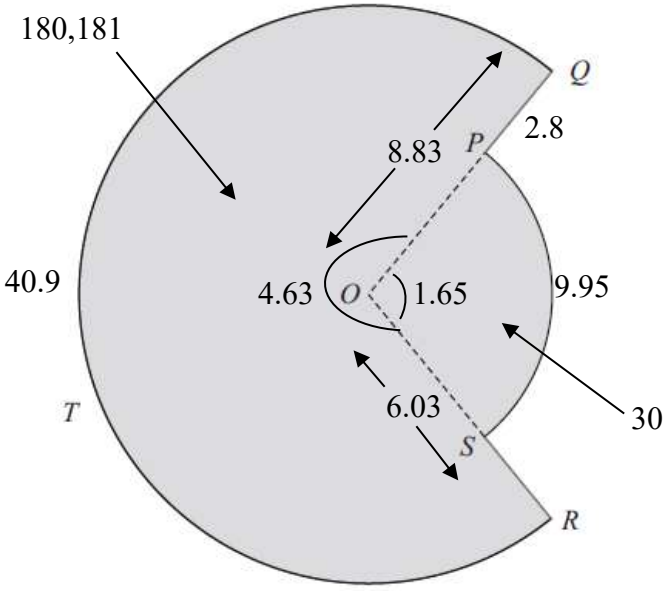
OR

Attempts $8.83\times(2\pi-1.65)$ which may be implied by awrt 40.9 provided no incorrect working is seen.

dM1: Full method for perimeter = "6.03"$\times 1.65+8.83\times(2\pi-1.65)+2.8\times 2$

A1: awrt 56 (m) . No requirement for units but if any are given they must be correct.

Correct answer only scores no marks.



Question Number	Scheme	Marks
8(a)	$f'\left(\sqrt{2}\right)=5 \Rightarrow\ 2\sqrt{2}+\frac{8}{2}+k=5 \Rightarrow k=...$	M1
	$1-2\sqrt{2}$	A1
		(2)
(b)	$x=\sqrt{2} \Rightarrow y=5\sqrt{2}-3\sqrt{2}\left(=2\sqrt{2}\right)$ So $y-"2\sqrt{2}"=-\frac{1}{5}\left(x-\sqrt{2}\right)$ **or** $y=-\frac{1}{5}x+c \Rightarrow "2\sqrt{2}"=-\frac{1}{5}\sqrt{2}+c \Rightarrow c=...$ $\Rightarrow y=-\frac{1}{5}x+\frac{11\sqrt{2}}{5}$	M1A1
		(2)

Notes

Mark all parts together.

(a)

M1: Substitutes $x=\sqrt{2}$ into $f'(x)$, sets = 5 and solves for *k*.

Condone slips in evaluating $f'\left(\sqrt{2}\right)$ as long as the intention is clear.

A1: Correct exact value $k=1-2\sqrt{2}$ oe e.g. $1-\sqrt{8}$

(b)

M1: Correct attempt at the equation of the normal using a gradient of $-\frac{1}{5}$, $x=\sqrt{2}$ and y from substituting $x=\sqrt{2}$ into $y=5x-3\sqrt{2}$

If they use $y = mx + c$ then they must reach as far as $c = \ldots$

A1: Correct equation in any form e.g. $y-2\sqrt{2}=-\frac{1}{5}\left(x-\sqrt{2}\right)$ or $5y+x=11\sqrt{2}$ or $y=-\frac{1}{5}x+\frac{11\sqrt{2}}{5}$

Apply isw as soon as a correct equation is seen.

(c)	$f'(x) = 2x + \frac{8}{x^2} + k \Rightarrow \quad \left(f(x) =\right) x^2 - \frac{8}{x} + kx \left(+c\right)$	M1A1ft
	$\left(\sqrt{2}, 2\sqrt{2}\right) \Rightarrow 2\sqrt{2} = 2 - \frac{8}{\sqrt{2}} + \left(1 - 2\sqrt{2}\right)\sqrt{2} + c \Rightarrow c = ...\left(2 + 5\sqrt{2}\right)$	dM1
	$\left(f(x) =\right) x^2 - \frac{8}{x} + \left(1 - 2\sqrt{2}\right)x + 2 + 5\sqrt{2}$	A1
		(4)
		(8 marks)

Notes

Mark all parts together.

(c)

M1: Integrates with two terms having a correct index. Allow indices unprocessed.

It is for 2 from: $2x \rightarrow ...x^2 \left(\text{or } x^{1+1}\right)$, $\frac{8}{x^2} \rightarrow \frac{...}{x} \left(\text{or } ...x^{-1} \text{ or } ...x^{-2+1}\right)$, $k \rightarrow ...x \left(\text{or } ...x^{0+1}\right)$

A1ft: Correct integration in any form with indices processed.

$\left(f(x)\right) = x^2 - \frac{8}{x} + kx \left(+c\right)$ but follow through on their k which may be a decimal and allow the letter k. $"f(x) ="$ is **not** required and "+ c" is **not** required.

Brackets are required around their $1 - 2\sqrt{2}$ but they may be implied by their attempt to find "c" so you may need to check their calculation for c.

dM1: Uses $x = \sqrt{2}$ and their attempt at y using $x = \sqrt{2}$ in $y = 5x - 3\sqrt{2}$ in their integrated function and finds the value of c.

A1: Correct simplified exact expression $\left(f(x) =\right) x^2 - \frac{8}{x} + \left(1 - 2\sqrt{2}\right)x + 2 + 5\sqrt{2}$ or e.g.

$\left(f(x) =\right) x^2 - \frac{8}{x} + x - 2\sqrt{2}x + 2 + 5\sqrt{2}$. $"f(x) ="$ is **not** required.

Brackets are required around their $1 - 2\sqrt{2}$ if written as in the first example above.

Do not allow $1x^2$ or e.g. $\frac{2}{2}x^2$ for x^2 but allow $\sqrt{8}$ for $2\sqrt{2}$.

Apply isw once a correct function is seen.

Question Number	Scheme	Marks
9(a)	$(f(x)=)-4\sin x$ or equivalent such as $(f(x)=)4\cos\left(x+\frac{\pi}{2}\right)$	M1 A1
		(2)
(b)(i)	$\left(\frac{5\pi}{3}, 4\right)$	B1, B1
		(2)
(ii)	$\left(\frac{3\pi}{2}, -2\right)$	B1, B1
		(2)
		(6 marks)

Notes

Do <u>not</u> allow the use of degrees in this question.

If there is more than one answer for any part, score the final attempt.

Remember to check for answers written in the question.

(a)

M1: For any sine or cosine curve with an amplitude of 4 and a period of 2π and which passes through the origin. E.g. $(f(x)=)\pm 4\sin(\pm x)$, $(f(x)=)\pm 4\cos\left(x\pm\frac{\pi}{2}\right)$

Condone the use of θ for this mark and "f(x) =" (or "$f(\theta)=$") is not required.

Do not allow ambiguous expressions e.g. $(f(x)=)-4f(\sin x)$

A1: Completely correct expression in terms of x e.g. $(f(x)=)-4\sin x$ or equivalent such as $(f(x)=)4\cos\left(x+\frac{\pi}{2}\right)$, $(f(x)=)4\sin(x+\pi)$, $4\sin(-x)$

"f(x) =" is not required.

(b)

Allow answers to be written as coordinates or as $x = \ldots$, $y = \ldots$

If more than one answer is given, mark their final answer.

Condone missing brackets e.g. $\frac{5\pi}{3}, 4$ and condone punctuation other than a comma e.g. $\left(\frac{5\pi}{3}; 4\right)$

The x coordinates must be written as single fractions but allow equivalents e.g. $\frac{10\pi}{6}$ for $\frac{5\pi}{3}$

The y coordinate must be written as single number so do not allow 0 – 2 for –2

Do **not** allow coordinates the wrong way round e.g. $\left(4, \frac{5\pi}{3}\right)$ or $\left(-2, \frac{3\pi}{2}\right)$

(b) (i)

B1: One correct coordinate from $x=\frac{5\pi}{3}$ or $y=4$

B1: $\left(\frac{5\pi}{3}, 4\right)$ or $x=\frac{5\pi}{3}$ and $y=4$

(b) (ii)

B1: One correct coordinate from $x = \frac{3\pi}{2}$ or $y = -2$

B1: $\left(\frac{3\pi}{2}, -2\right)$ or $x = \frac{3\pi}{2}$ and $y = -2$

Question Number	Scheme	Marks
10(a)	$y=2x^3+\frac{1}{2}x^2-2x+5 \Rightarrow \frac{dy}{dx}=6x^2+x-2$ so at $x=0$, $\frac{dy}{dx}=-2$	M1
	Equation of normal at P is $y=\frac{1}{2}x+5$	A1
	Q is where $y=2x^3+\frac{1}{2}x^2-2x+5$ meets $y=\frac{1}{2}x+5$ $2x^3+\frac{1}{2}x^2-2x+5=\frac{1}{2}x+5 \Rightarrow 4x^3+x^2-5x=0$	**d**M1 A1
	$\Rightarrow x\left(4x^2+x-5\right)=0 \Rightarrow x(4x+5)(x-1)=0 \Rightarrow x=-\frac{5}{4}$	**dd**M1 A1
		(6)

Notes

(a)

M1: Attempts to find the gradient of the curve at P.

It is for attempting to find the value of $\frac{dy}{dx}$ when $x=0$

There must be some evidence of differentiating e.g. $2x^3 \to ...x^2$ or $\frac{1}{2}x^2 \to ...x$

or $-2x \to -2$ or $5 \to 0$ followed by the substitution of $x=0$ which may be implied.

Alternatively deduces that the gradient of the curve at P is -2

A1: Equation of normal at P is $y=\frac{1}{2}x+5$ oe e.g. $y-5=\frac{1}{2}(x-0)$

dM1: Sets $2x^3+\frac{1}{2}x^2-2x+5=kx+5$ where k is not their gradient of the tangent at P and collects terms to one side. Must be $kx+5$ but condone a miscopy of the equation of C.

A1: Correct cubic equation with terms collected and all on one side e.g. $4x^3+x^2-5x=0$ or equivalent e.g. $2x^3+\frac{1}{2}x^2-\frac{5}{2}x=0$. The "= 0" may be implied by their attempt to solve.

ddM1: Cancels or factorises out an x term from an equation of the form $ax^3+bx^2+cx=0$, $a,b,c \neq 0$ and solves resulting 3TQ by any means including a calculator.

Condone factors that are inconsistent with their 3TQ so just look for the correct or correct ft roots.

Allow e.g. $4x^3+x^2-5x=0 \Rightarrow x(4x+5)(x-1)=0 \Rightarrow x=...$

Do **not** allow e.g. $4x^3+x^2-5x=0 \Rightarrow x=\frac{-1\pm\sqrt{1^2-4(4)(-5)}}{2\times 4}=...$

If roots of the 3TQ are just written down you may need to check.

They cannot just write down the roots of the cubic equation. Decimals should be correct to 2 sf or truncated to 2sf.

Depends on the previous method mark.

A1: $x=-\frac{5}{4}$ oe only. Ignore any attempts to find the y coordinate and ignore any incorrect attempts at finding the other x coordinate provided $x=-\frac{5}{4}$ is selected.

Question Number	Scheme	Marks
Note: full marks are available for those with an incorrect $\frac{\mathrm{d}y}{\mathrm{d}x}$ that still leads to a gradient at P of -2		

Beware in part (a) that it is possible to reach the correct answer fortuitously as follows:

$$y = 2x^3 + \tfrac{1}{2}x^2 - 2x + 5 \Rightarrow \frac{\mathrm{d}y}{\mathrm{d}x} = 6x^2 + x - 2$$

$$\frac{\mathrm{d}y}{\mathrm{d}x} = 0 \Rightarrow 6x^2 + x - 2 = 0 \Rightarrow x = \frac{1}{2}, -\frac{2}{3}$$

And then incorrectly assuming the gradient of the normal to C at P is $\frac{1}{2}$ and that l has the equation $y = \tfrac{1}{2}x + 5$

This will generally score no marks in (a) it is entirely fortuitous.

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

(b)	Sets $\frac{dy}{dx} = 6x^2 + x - 2 = \frac{1}{2}$	M1
	$12x^2 + 2x - 5 = 0$	A1
	$x = \frac{-2 \pm \sqrt{4 + 240}}{24}$	dM1
	$x = \frac{-1 + \sqrt{61}}{12}$	A1
		(4)
		(10 marks)

Notes

(b)

M1: Sets their $\frac{dy}{dx}$ of the form $ax^2 + bx - 2,\ a, b \neq 0$ equal to $\frac{1}{2}$

A1: Correct 3 term equation $12x^2 + 2x - 5 = 0$ or equivalent e.g. $6x^2 + x - \frac{5}{2} = 0$

The constant terms must be collected but the terms do not need to be all on one side so allow e.g. $12x^2 + 2x = 5$

dM1: Correct attempt to solve a 3TQ resulting from $ax^2 + bx - 2 = \frac{1}{2}$.

Allow calculator solutions for solving their 3TQ and condone factors that are inconsistent with their equation so just look for the correct or correct ft roots.
Note that only the positive solution may be seen which is acceptable.
If values are just written down you may need to check. Decimals should be correct to 2 sf or truncated to 2sf.

A1: $x = \frac{-1 + \sqrt{61}}{12}$ only.

Pearson Edexcel International Advanced Level

Wednesday 15 October 2025

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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P 8 7 4 3 4 A

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

A sequence u_1, u_2, u_3, is defined by

$$u_1 = 1$$

$$u_{n+1} = k - \frac{8}{u_n} \qquad n \geqslant 1$$

where k is a constant.

(a) Write down expressions for u_2 and u_3 in terms of k.

(2)

Given that $u_3 = 6$

(b) find the possible values of k.

(3)

(Total for Question 1 is 5 marks)

2. Find the first 3 terms in ascending powers of x of

$$\left(2 - \frac{x}{2}\right)^6$$

giving each term in its simplest form.

(4)

(Total for Question 2 is 4 marks)

3.

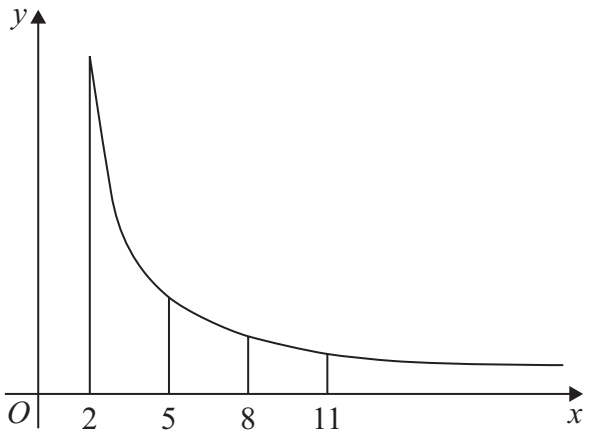

Figure 1

Figure 1 shows a sketch of part of the graph of $y = \dfrac{12}{\sqrt{x^2 - 2}} \quad x \geqslant 2$

The table below gives values of y rounded to 3 decimal places.

x	2	5	8	11
y	8.485	2.502	1.524	1.100

(a) Use the trapezium rule with all the values of y from the table to find an approximate value, to 2 decimal places, for

$$\int_2^{11} \frac{12}{\sqrt{x^2 - 2}} \, \mathrm{d}x$$

(3)

(b) Use your answer to part (a) to estimate a value for

$$\int_2^{11} \left(1 + \frac{6}{\sqrt{x^2 - 2}} \right) \mathrm{d}x$$

(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.

$$f(x) = 13 + 3x + (x + 2)(x + k)^2 \qquad \text{where } k \text{ is a constant}$$

Given that $(x + 3)$ is a factor of $f(x)$,

(a) (i) show that a possible value of k is 5

(ii) find the other possible value of k.

(3)

Given that $k = 5$

(b) (i) write $f(x)$ as the product of two algebraic factors

(ii) show that the equation $f(x) = 0$ has only one real solution.

(6)

(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.

(i) Given that

$$\log_a x + \log_a 3 = \log_a 27 - 1 \qquad \text{where } a \text{ is a positive constant}$$

find, in its simplest form, an expression for x in terms of a.

(4)

(ii) Solve the equation

$$(\log_5 y)^2 - 7(\log_5 y) + 12 = 0$$

showing each step of your working.

(4)

(Total for Question 5 is 8 marks)

---

6. A circle C has equation $x^2 + y^2 - 6x - 14y + k = 0$ where k is constant.

(a) Find the coordinates of the centre of C.

(2)

(b) Find the radius of C when $k = -32$

(2)

(c) Find the range of values of k for which C lies completely within the first quadrant.

(4)

(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) Solve, for $0 \leqslant \theta < 180°$, the equation

$$7\sin 2\theta = 5\cos 2\theta$$

giving your answers, in degrees, to one decimal place.

(4)

(ii) Solve, for $0 \leqslant x < 2\pi$, the equation

$$24\tan x = 5\cos x$$

giving your answers, in radians, to 3 decimal places.

(5)

(Total for Question 7 is 9 marks)

---

8. A curve has equation $y = (x + 2)^2(4 - x)$

The finite region R is bounded by the curve and the x-axis.

(a) Using algebraic integration and showing each step of your working, find the exact area of R.

(5)

(b) Using the answer to part (a) and explaining your reasoning, find the area of the finite region bounded by the curve with equation $y = (3x + 6)^2\left(2 - \frac{1}{2}x\right)$ and the x-axis.

(2)

(Total for Question 8 is 7 marks)

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

(i) A car has five gears. Given that

- the maximum speed of the car in first gear is $22\,\text{km}\,\text{h}^{-1}$
- the maximum speed in each successive gear forms a geometric sequence
- the maximum speed of the car in fifth gear is $130\,\text{km}\,\text{h}^{-1}$

find the maximum speed of the car in second gear, giving your answer, in $\text{km}\,\text{h}^{-1}$, to one decimal place.

(4)

(ii) The first two terms of an arithmetic sequence are 208 and 207.2

Given that S_n is the sum to n terms,

(a) find the maximum value of S_n

(4)

(b) Hence or otherwise state the smallest value of N such that $S_N < 0$

(1)

(Total for Question 9 is 9 marks)

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

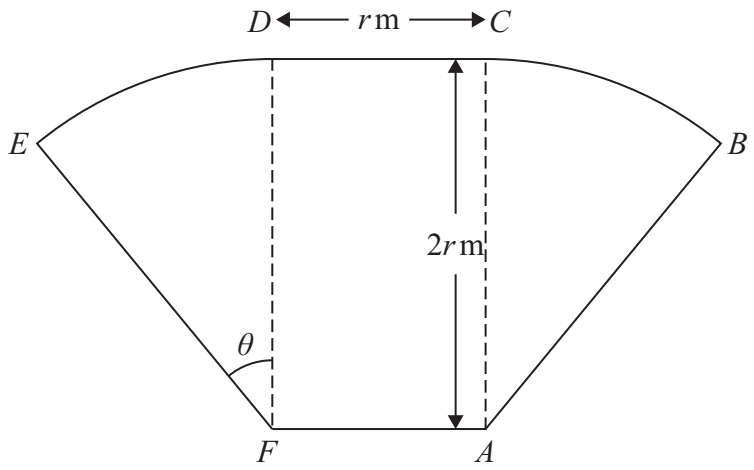

Figure 2

Figure 2 shows the plan view of the design for a stage at a trade fair.

The shape of the stage *ABCDEFA*, consists of a rectangle *ACDF* joined to two congruent sectors of circles. *ABC* is a sector of a circle centre *A* and *FDE* is a sector of a circle centre *F*.

Given that $AC = 2r$ metres, $CD = r$ metres, angle $DFE = \theta$ radians and the area of the stage is $30\,\text{m}^2$,

(a) show that the perimeter, *P* metres, of the stage, is given by

$$P = 4r + \frac{30}{r}$$

(4)

(b) Use calculus to find the minimum value for *P*, giving your answer in the form $a\sqrt{b}$, where *a* and *b* are integers to be found.

(4)

(c) Justify that the value of *P* found in part (b) is the minimum.

(2)

(Total for Question 10 is 10 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 15 October 2025

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

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 5 marks)

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Question 2

Write the answer to Question 2 on these 2 pages

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 4 marks)

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Question 3

Write the answer to Question 3 on these 2 pages

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Question 3 continued

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

(Total for Question 3 is 6 marks)

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Question 4

Write the answer to Question 4 on these 2 pages

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Question 4 continued

This is the end of Question 4 answer space. Please turn the page for Question 5 answer space.

(Total for Question 4 is 9 marks)

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Question 5

Write the answer to Question 5 on these 2 pages

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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 8 marks)

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Question 6

Write the answer to Question 6 on these 2 pages

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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 8 marks)

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Question 7

Write the answer to Question 7 on these 2 pages

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Question 7 continued

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(Total for Question 7 is 9 marks)

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Question 8

Write the answer to Question 8 on these 2 pages

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Question 8 continued

This is the end of Question 8 answer space. Please turn the page for Question 9 answer space.

(Total for Question 8 is 7 marks)

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Question 9

Write the answer to Question 9 on these 4 pages

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Question 9 continued

Question 9 continued

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Question 9 continued

This is the end of Question 9 answer space. Please turn the page for Question 10 answer space.

(Total for Question 9 is 9 marks)

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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

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Question 10 continued

(Total for Question 10 is 10 marks)

TOTAL FOR PAPER IS 75 MARKS

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Mark Scheme (Results)

October 2025

International Advanced Level in Pure Mathematics P2

WMA12/01A

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications are awarded by Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk. 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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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
- ⌐ 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 = ...

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

2. Formula

Attempt to use correct formula (with values for a, b and c)

3. Completing the square

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

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)	$(u_2 =)\ k-\frac{8}{1}$ and $(u_3 =)\ k-\frac{8}{k-8}\quad\left(=\frac{k^2-8k-8}{k-8}\right)$ oe	M1A1 **(2)**
(b)	$u_3 = 6 \Rightarrow k-\frac{8}{k-8}=6 \Rightarrow k^2-14k+40=0$ $(k-4)(k-10)=0 \Rightarrow k=...$ or $(k=)\ \frac{14\pm\sqrt{14^2-4\times1\times40}}{2\times1}$ $(k=)\ 4,\ 10$	M1 dM1 A1 **(3)**
		(5 marks)

Mark (a) and (b) together

(a)

M1: Uses the given relation correctly **at least once** so score for sight of $k-\frac{8}{1}$ o.e. or condone a correct follow through expression for u_3 from an incorrect u_2

The expression does not need to be simplified.

A1: Both expressions correct which may be unsimplified or equivalent e.g. $k-\frac{8}{1}$ and $k-\frac{8}{k-\frac{8}{1}}$ scores

M1A1. Isw. Condone slips in the notation used for these terms or may not be seen at all.

(b)

M1: Sets their third term equal to 6 and proceeds to a 3TQ in *k*. You do not need to be concerned by the mechanics of the rearrangement

dM1:Solves their 3TQ in *k* via factorisation, the formula or completing the square (usual rules apply).

They are not allowed to just state the roots (dM0A0) and if solved by factorisation then the factorised version of the quadratic must match the quadratic on the previous line.

Dependent on the previous method mark.

A1: Correct values and no others

Question Number	Scheme	Marks
2.	$\left(2-\frac{x}{2}\right)^6 = 2^6 + \binom{6}{1}2^5.\left(-\frac{x}{2}\right) + \binom{6}{2}2^4.\left(-\frac{x}{2}\right)^2 + \ldots$ $= 64 - 96x + 60x^2 + \ldots$	M1 B1A1A1 **(4)**
		(4 marks)

Note that a correct expression scores 4/4

M1: An attempt at the binomial expansion to get the second and/or third term – needs the **correct** binomial coefficient combined with the correct power of x.

Accept any notation for ${}^6C_1$ and ${}^6C_2$, e.g. $\binom{6}{1}$ and $\binom{6}{2}$ (unsimplified) or 6 and 15 from Pascal's triangle. May be implied by either term correct (which may be unsimplified).

Alternatively $\left(2-\frac{x}{2}\right)^6 = 2^6\left(1-\frac{x}{4}\right)^6 \Rightarrow 2^6 \times 6\left(-\frac{x}{4}\right)$ or $2^6 \times \frac{6\times 5}{2!}\left(-\frac{x}{4}\right)^2$

(You only need to look for the correct binomial coefficient combined with the correct power of x.)

In either approach condone bracket errors/invisible brackets for this mark.

B1: 64 (writing just 2^6 is B0).

A1: One of $-96x$ or $60x^2$ Condone $-96x^1$ Must be simplified.

A1: $-96x$ and $60x^2$ (can follow omission of negative sign in working). Condone $+-96x$ if it was part of an expression (not just an isolated term in a list). Must be simplified.

Note: Terms do not need to be written as a polynomial expression. They may appear as a list or appear on different lines. isw once the correct simplified terms have been found unless they divide all terms by e.g. 4

Question Number	Scheme	Marks
3 (a)	States $h = 3$, or use of $\frac{1}{2}\times 3$	B1
	$\left\{8.485 + 1.100 + 2\left(2.502 + 1.524\right)\right\}$	M1
	$= \frac{1}{2}\times 3 \times \left\{17.637\right\} =$ awrt 26.46	A1
		(3)
(b)	Either adds 9 or halves their answer from part (a)	M1
	Full attempt using a correct method Estimate = 9 + 13.23 = awrt 22.2	dM1A1ft
		(3)
		(6 marks)

(a)Note using the integration button on the calculator gives 22.307… and is unlikely to score any marks.

B1: for using $\frac{1}{2}\times 3$ or 1.5 or equivalent (allow for sight of a correct calculation or expression for h) or just states $h = 3$

M1: requires the correct $\{.....\}$ bracket structure. It typically requires

- the "outside" brackets to contain first y value plus last y value and the "inside" bracket
- the "inside" bracket needs to be multiplied by 2 and to be the summation of the remaining y values in the table with no additional values.

If the only mistake is a copying error this may be regarded as a slip and the M mark can be allowed

Condone a missing trailing bracket and condone invisible brackets if the correct structure is implied by their answer.

M0 if values used in brackets are x values instead of y values

May attempt separate trapezia which is acceptable condoning a copying error only.

A1: awrt 26.46 after attempt at trapezium rule. isw

(b) Note using the integration button on the calculator gives 20.153623… with no working scores M0dM0A0
Attempts at using the trapezium rule instead of the answer to part (a) scores M0dM0A0

M1: Correct attempt at one aspect of the integral.

Either 9 +…. or calculates ½ of their answer to part (a) . Allow $11-2$ for 9.

The expression or calculation is sufficient but may be implied by their answer provided it is not 20.1536…. You may need to check this on your calculator.

dM1: Attempts 9+ ½ their answer to part (a). It is dependent on the previous method mark. The expression or calculation is sufficient but may be implied by their answer provided it is not 20.1536…. You may need to check this on your calculator.

A1ft: awrt 22.2 or ft on their answer to part (a) giving an answer to 3sf or better. isw.

Question Number	Scheme	Marks
4 (a)(i)	e.g. $f(-3) = 13-9-(k-3)^2 = 4-(k-3)^2$ and states when $k=5, f(-3)=0$	B1*
(a)(ii)	Uses $f(-3)=0 \Rightarrow (k-3)^2 = 4 \Rightarrow k = (5), 1$	M1A1 **(3)**
(b)(i)	$13+3x+(x+2)(x+5)^2 = 13+3x+(x+2)(x^2+10x+25) = 13+3x+x^3+....$	M1
	$= x^3+12x^2+48x+63$	A1
	Hence $f(x) = (x+3)(x^2+9x+21)$	dM1A1 **(4)**
(b)(ii)	e.g. Attempts "b^2-4ac" for their $(x^2+9x+21)$	M1
	e.g. $b^2-4ac=-3<0 \Rightarrow (x^2+9x+21)$ has no roots and hence $f(x)=0$ has one solution, -3	A1 **(2)**
		(9 marks)

(a) Mark (a) parts (i) and (ii) together

(i)

B1*: Either sets $f(-3)=0$ and states or shows $k=5$, or finds $f(-3)$ and states or shows that when $k=5, f(-3)=0$ Must be *k* not *x*. **The "=0" must be seen somewhere it cannot be implied.**

May be found at the same time as the other possible value for *k* which is fine as we mark both parts together. Allow the root to be stated once a correct equation in *k* only is formed.

May see e.g. $-k^2+6k-5=0 \Rightarrow k=5$

A conclusion referring to $k=5$ is only required if $k=5$ is used in their solution by setting $f(-3)=0$

e.g. $13-9-(k-3)^2 \Rightarrow 13-9-(2)^2=0$ "so $k=5$" or if they attempt to divide the cubic by $x+3$ with $k=5$ substituted to reach a remainder of 0

Allow a preamble followed by a minimal conclusion e.g. proven, shown, tick QED is condoned.

(ii)

M1: Sets up and attempts to solve a quadratic in *k* using a correct valid method (they cannot just state the roots):

e.g. $4-(-3+k)^2=0 \Rightarrow (-3+k)^2=4 \Rightarrow -3+k=\pm 2 \Rightarrow k=5,1$

e.g. $4-(-3+k)^2=0 \Rightarrow k^2-6k+5=0 \Rightarrow (k-5)(k-1)=0 \Rightarrow k=5,1$

(may use the quadratic formula)

Do not allow this mark to be scored for poor attempts at multiplying out the brackets i.e.

$(k-3)^2=4 \Rightarrow k^2-9=4 \Rightarrow k=...$

The "= 0" may be implied.

A1: $k=1$ following M1. Condone $-k^2+6k-5=0\Rightarrow(k-5)(k-1)=0\Rightarrow k=5,1$ but just stating the roots scores M0A0. Condone use of x instead of k for this mark.

Note: There may be other more long winded methods requiring a lot of algebraic manipulation. e.g. look out for attempts at algebraic division and setting the remainder equal to 0.

If you see an approach which you may think deserves credit then send to review.

(b) Mark (b) parts (i) and (ii) together

(b)(i) Note that work seen in (a) must be used in (b) to score

M1: Attempts to multiply out the expression with $k = 5$ to form a 4-term cubic expression Ax^3+Bx^2+Cx+D where $A,B,C,D\neq 0$. Condone algebraic slips including $(x+5)^2=x^2+25$

A1: $x^3+12x^2+48x+63$ (which must be simplified)

dM1:Attempts to divide their cubic by $(x+3)$ to achieve a quadratic factor. It is dependent on the previous method mark.

Look for two correct terms for their cubic (allow $\pm$).
e.g. first and last terms are correct (allow $\pm$) if done by inspection

A1: Correct factorisation $(\mathrm{f}(x)=)\ (x+3)(x^2+9x+21)$ Must be written as a product. Condone missing trailing bracket. Ignore if = 0 is seen

(b)(ii)

M1: Attempts to show that their three-term quadratic "$(x^2+9x+21)$" does not have any roots:

- **Attempts the discriminant**
  e.g. $b^2-4ac=81-4\times1\times21\ \left(=-3\right)$ (may be embedded in the quadratic formula)
- **Attempts to use the quadratic formula**
  e.g. $\left(x=\right)\dfrac{-9\pm\sqrt{9^2-4\times1\times21}}{2}$ but do not allow directly from a calculator $\dfrac{-9\pm\sqrt{3}i}{2}$
- **Attempts to complete the square**
  e.g. $x^2+9x+21=\left(x+\dfrac{9}{2}\right)^2+\ldots\quad\left(=\left(x+\dfrac{9}{2}\right)^2-\dfrac{81}{4}+21\right)$
- **Uses calculus to find the turning point**
  e.g. $\dfrac{\mathrm{d}(x^2+9x+21)}{\mathrm{d}x}=2x+9=0\Rightarrow x=-\dfrac{9}{2}\Rightarrow y=\ldots$

Note that any attempts using the discriminant or quadratic formula must have the values embedded in the correct places (may be partially evaluated) to score M1

A1: **Dependent on a correct** $x^2+9x+21$

Fully correct argument that requires:

- Fully correct work
- A justification depending on strategy and no incorrect reasoning seen
- A conclusion which refers to $(x=)-3$ is a root or the only solution comes from $x+3=0$ (allow $(x=)-3$ to have been stated in their working somewhere which is not the value of the discriminant)

Note be careful not to award this mark if the only reference to -3 is the value of the discriminant

Examples on the next page – Note we must see working before they proceed to a correct root or minimum value – see M1 for guidance

Strategy	Correct work examples	Justification examples	Conclusion examples
Via discriminant	$b^2-4ac=-3$	$-3<0$ -3 so no (real) roots but NOT $-3\neq 0$ so no roots	so "-3 is the only (real) root" / "only solution comes from $x+3=0$" / "only one solution" (provided $x=-3$ has been stated somewhere in their solution) [**Note be careful not to award this mark if the only reference to -3 is the value of the discriminant**]
Via using the quadratic formula	$x=\frac{-9\pm\sqrt{3}i}{2}$ or $x=\frac{-9\pm\sqrt{-3}}{2}$	$-3<0$ / which is not possible / complex roots o.e. / cannot square root a negative / no (real) roots	
Via completing the square	$\left(x+\frac{9}{2}\right)^2+\frac{3}{4}$ or $\left(x+\frac{9}{2}\right)^2+\frac{3}{4}=0\Rightarrow$ $\left(x+\frac{9}{2}\right)^2=-\frac{3}{4}$	which has a minimum value of $\frac{3}{4}$ / minimum (of the positive quadratic) is above the x-axis $-\frac{3}{4}<0$ / cannot square root a negative / no (real) roots	
Via calculus	$x=-\frac{9}{2}\Rightarrow y=\frac{3}{4}$	which has a minimum value of $\frac{3}{4}$ / minimum (of the positive quadratic) is above the x-axis	

Condone $81-84<0$ as a justification that the quadratic has no real roots

Note condone the conclusion -3 is the only (real) solution (instead of (real) root). If $(x+3)$ is described as a root or -3 is described as a factor this scores A0

Question Number	Scheme	Marks
5. (i)	$\log_a x + \log_a 3 = \log_a 27 - 1 \Rightarrow \log_a \frac{3x}{27} = -1$	M1A1
	$\Rightarrow \frac{3x}{27} = a^{-1}$	dM1
	$\Rightarrow x = 9a^{-1}$ or $x = \frac{9}{a}$	A1 **(4)**
(ii)	$p^2 - 7p + 12 = 0$ and attempt to solve to give $p =$ or $\log_5 y =$	M1
	p (or $\log_5 y$) = 3 or 4	B1
	$y = 5^3$ or 5^4	M1
	y = 125 and 625	A1 **(4)**
		8 marks

(i)

M1: Uses sum or difference of logs correctly to combine at least two of the original terms e.g. $\log_a 3x$
May be implied by e.g. $\log_a 9$ or a correct equation not in terms of logs which is not the correct answer.
Condone no base written.

A1: Uses correct log work to obtain a correct simplified equation where either

- the log terms have been collected on one side of an equation $\log_a \frac{3x}{27} = -1$ e.g.
- the equation is simplified to e.g. $\log 3ax = \log 27$ or e.g. $\log_a 3x = \log_a \frac{27}{a}$

Base a does not need to be written. May be implied by an equation with no logs which is not the final answer.

dM1: Removes logs correctly from an equation of the form $\log ... = \log ...$ or $\log ... = ...$ and proceeds to a in terms of x or x in terms of a. May be implied by an equation with no logs which is not the final answer.

It is dependent on the previous method mark.

A1: Correct simplified answer

(ii) Note on epen this is M1A1M1A1 but we are marking this M1B1M1A1

M1: Attempts to solve the quadratic in $\log_5 y$ (or may use another variable) by either factorising, completing the square or using the quadratic formula (usual rules apply). They cannot just state the roots.

B1: Obtains both 3 and 4

M1: Finds a value for y by either $y = 5^{"3"}$ or $y = 5^{"4"}$. We must see this expression for at least one of their y values otherwise M0A0.

A1: 125 and 625 (and no others) **provided all previous marks have been scored.**

Question Number	Scheme	Marks
6(a)	$(x\pm3)^2+(y\pm7)^2\pm\ldots=\ldots$	M1
	Centre = $(3,7)$	A1
		(2)
(b)	Attempts $(\pm3)^2+(\pm7)^2\pm32$	M1
	Radius = $3\sqrt{10}$	A1
		(2)
(c)	Uses radius $<3\Rightarrow9+49-k<9$ or uses radius $>0\Rightarrow9+49-k>0$	M1
	$k>49$ or $k<58$	A1
	Uses radius $<3\Rightarrow9+49-k<9$ and uses radius >0 $\Rightarrow9+49-k>0$	dM1
	$49<k<58$ oe (see notes)	A1
		(4)
		(8 marks)

(a)

M1: Attempts to complete the square. Accept $(x\pm3)^2+(y\pm7)^2\pm\ldots=\ldots$ as evidence.
Also score for $(\pm3,\pm7)$

A1: $(3,7)$ which may be given separately $x=3,\ y=7$
Condone missing brackets provided the intention is clear.

(b)

M1: Attempts to find r or r^2. Look for $(\pm3)^2+(\pm7)^2\pm32$ or $\sqrt{(\pm3)^2+(\pm7)^2\pm32}$. Ignore labelling.
May be implied by sight of ±90 or e.g. $\pm58\pm32$

A1: Radius = $3\sqrt{10}$ or exact equivalent such as $\sqrt{90}$ Isw. Decimal answers only score A0. Do not accept $\pm$

(c) **Condone use of strict or inclusive inequalities for any of the marks in this part**

M1: Uses the fact that the radius must be less than 3 (or „ 3) **or** uses the fact that the radius is > 0 or …0 to form a correct inequality. Do not allow sign slips.

A1: Either $k>49$ or $k<58$ (ignore the other part of the inequality if written as e.g. $0<k<58$. Allow use of inclusive inequality.

dM1: Uses the fact that the radius must be less than 3 (or „ 3) **and** uses the fact that the radius is > 0 (or …0) to form two correct inequalities (or may be combined). Do not allow sign slips. It is dependent on the previous method mark.

A1: $49 < k < 58$ **but condone** $49 < k$,, 58 or 49,, $k \leqslant 58$ or 49,, k,, 58 oe Must be in terms of k
e.g. may be written in alternative forms such as $(49, 58)$, $(49, 58]$, $[49, 58]$, $[49, 58)$ or
e.g. $k > 49 \cap k < 58$ or $58 > k > 49$ or $k > 49$, k,, 58 but do not allow e.g. "$k > 49$ or $k < 58$"

Question Number	Scheme	Marks
7 (i)	$(2\theta=)\arctan\left(\frac{5}{7}\right)$	M1A1
	$(\theta=)$ awrt $17.8°, 107.8°$	dM1A1 **(4)**
(ii)	$24\tan x = 5\cos x \Rightarrow 24\sin x = 5\cos^2 x$ oe	M1
	$\Rightarrow 24\sin x = 5(1-\sin^2 x)$	dM1
	$\Rightarrow 5\sin^2 x + 24\sin x - 5 = 0$	A1
	$\Rightarrow \sin x = \frac{1}{5}$	ddM1
	$\Rightarrow (x=)$ awrt $0.201, 2.940$	A1 **(5)**
		(9 marks)

In either part condone poor notation, mixed variables or omission of variables in their working provided the intention is clear or implied by further work.

There may be other methods e.g. using double angle formulae. Send to review if you think it may be credit-worthy.

(i) Note that answers only with no working seen scores 0 marks

M1: Attempts to use the relationship $\tan 2\theta = \dfrac{\sin 2\theta}{\cos 2\theta}$ to solve the equation.

Score for e.g. $7\sin 2\theta = 5\cos 2\theta \Rightarrow \tan 2\theta = \dfrac{5}{7}$ oe Condone $\tan 2\theta = \dfrac{7}{5}$ oe

(May use another variable e.g. $x = 2\theta$ provided the intention is clear)

A1: $(2\theta=)\arctan\left(\frac{5}{7}\right)$. May be implied by awrt $35.5°$ or a value for θ of awrt $17.8°$ **provided M1 has been scored.** Condone in radians.

dM1: Proceeds to find at least one value for θ Condone slips but the correct order of operations is required. May be implied by one correct value or truncated $17.7°$ (which may be in radians). You may need to check this on your calculator.

A1: $(\theta=)$ awrt $17.8°, 107.8°$ and no others inside the range **following all previous marks scored** (must be in degrees but condone the omission of the degrees symbol). Isw if they round incorrectly following correct answers seen.

Alt(i) Squaring both sides

M1: Squares both sides and uses $\pm\sin^2 x \pm \cos^2 x = \pm 1$ to produce a quadratic equation in $\sin x$ or $\cos x$. Condone slips on the coefficients when squaring.

A1: $\left(49\sin^2 2\theta = 25(1-\sin^2 2\theta) \Rightarrow\right)\ 74\sin^2 2\theta = 25$ oe or

$\left(49(1-\cos^2 2\theta) = 25\cos^2 2\theta \Rightarrow\right)\ 74\cos^2 2\theta = 49$ oe

dM1:Proceeds to find at least one value for θ Condone slips but the correct order of operations is required.

May be implied by one correct value or truncated $17.7°$ (which may be in radians). You may need to check this on your calculator.

A1: $\left(\theta =\right)$ awrt $17.8°, 107.8°$ and no others inside the range **following all previous marks scored** (must be in degrees but condone the omission of the degrees symbol) Isw if they round incorrectly following correct answers seen.

(ii) Note that answers only with no working seen scores 0 marks

M1: Uses the identity $\tan x = \dfrac{\sin x}{\cos x}$ and moves to an equation of the type $A\sin x = B\cos^2 x$ oe

dM1: Uses $\pm\cos^2 x = \pm 1 \pm \sin^2 x$ to produce a quadratic equation in $\sin x$. Terms do not need to be collected on one side of the equation for this mark but any brackets should be multiplied out.

A1: $5\sin^2 x + 24\sin x - 5 = 0$ oe (terms do not need to be on one side for this mark but if they are then the = 0 may be implied by further work)

ddM1:Attempts to solve their 3TQ in $\sin x$ which may be directly via a calculator. You may need to check this. It cannot be implied by correct angles for their roots to the quadratic.

A1: Both (awrt) $\left(x =\right)$ $0.201, 2.940$ and no others inside the range **following the award of the previous 4 marks.** Must be in radians. Isw if they round incorrectly following correct answers seen. Note 2.941 is A0

Question Number	Scheme	Marks
8(a)	$y=(x+2)^2(4-x)=\left(x^2+4x+4\right)(4-x)=\left(16+12x-x^3\right)$	M1
	Area $=\left[16x+6x^2-\frac{1}{4}x^4\right]_{(-2)}^{(4)}$	dM1A1ft
	$=[64+96-64]-[-32+24-4]=108$	ddM1A1
		(5)
(b)	Attempts $4.5\times(a)=486$	B1ft
	Gives a valid reason why the area is 4.5 times greater	B1
		(2)
		(7 marks)

(a) Note that if no integration is seen then maximum score is M1dM0A0ftddM0A0. Attempts at integration by parts send to review.

M1: Attempts to multiply out **to achieve a cubic**. Look for:

eg $y=(x+2)^2(4-x)=\left(x^2+...+4\right)(4-x)=....$ or

$y=(x+2)(x+2)(4-x)=(x+2)\left(8.....-x^2\right)=....$

FYI: $y=16+12x-x^3$ which may be unsimplified.

dM1: Raises the power by one **in at least two terms**. Indices do not need to be processed for this mark. It is dependent on the first method mark.

A1ft: $16x+6x^2-\frac{1}{4}x^4$ follow through **on their cubic** which may be unsimplified. Indices must be processed – may be implied by further work.

ddM1:Uses the limits -2 and 4 and subtracts either way around. The expression with the limits substituted in (or may be partially evaluated) is sufficient to score (condone slips) or

$\left[16x+6x^2-\frac{1}{4}x^4\right]_{-2}^{4}=108$ can score both final marks.

It is dependent on both previous method marks. May be implied by 108 but if no method is shown and just a value stated that is not 108 then ddM0A0. May split the area into separate regions and add together.

A1: 108 provided all previous marks have been scored.

(b) **Note they must be using their answer to part (a) in part (b).**

Condone any reference to incorrect limits which may be seen on their integral expression in (b) which follow through from part (a)

B1ft: $4.5\times(a)=486$ or follow through on their part (a). If just a value is stated then B0ft.

B1: Gives a valid reason why the area is 4.5 times greater than their part (a).

This can done by

- manipulating the expression by taking out factors
  e.g. $\left(y=(3x+6)^2\left(2-\frac{1}{2}x\right)=\right)3^2(x+2)^2\times\frac{1}{2}(4-x)=\frac{9}{2}\times(x+2)^2(4-x)$ oe we would need to see working leading to $\frac{9}{2}$ e.g. both 9 and $\frac{1}{2}$ oe e.g. $\frac{3^2}{2}$ or taking out one of the factors (but not just directly to $\frac{9}{2}$ in one step), or
- multiplying out all of the brackets and proceeding to
  $\left(y=18x^2-\frac{9}{2}x^3+72x-18x^2+72-18x=\right)-\frac{9}{2}x^3+54x+72=\frac{9}{2}\left(-x^3+12x+16\right)$
  Condone just taking out a factor of $\frac{9}{2}$ oe from the correct cubic leading to a correct expression
- showing where 4.5 comes from e.g. $3^2\times\frac{1}{2}=4.5$ or $9\times\frac{1}{2}=4.5$ or $\frac{3^2}{2}=4.5$ but not just $\frac{9}{2}=4.5$
- explaining that the original curve has been stretched by a scale factor of 4.5

There may be other ways of showing this which are credit worthy – send to review if you are unsure.

Question Number	Scheme	Marks
9 (i)	Method of finding r e.g. $r^4 = \dfrac{130}{22}$	M1
	$(r =)$ awrt 1.6	A1
	Max speed in second gear is $22 \times "1.559" =$ awrt 34.3 (kmh^{-1})	dM1A1 **(4)**
(ii)(a)	e.g. $u_n = 208 + (n-1) \times (-0.8) = 0 \Rightarrow n = ...$	M1
	$(n =)$ 261 (or 260) (allow 260.5 see notes)	A1
	e.g. $S_{"261"} = \dfrac{"261"}{2}\left(2 \times 208 + (n-1) \times (-0.8)\right)$	dM1
	Maximum $S_n = 27144$	A1 **(4)**
(b)	522	B1 **(1)**
		(9 marks)

(i)

M1: Either a correct equation in r only e.g. $22r^4 = 130$ or states $a = 22$ and forms a correct equation in a and r e.g. $a = 22, ar^4 = 130$. May be implied by a correct expression for r, which may be part of their calculation to find the maximum speed in second gear.

A1: awrt 1.6. Accept $\sqrt[4]{\dfrac{130}{22}}$ or $\sqrt[4]{\dfrac{65}{11}}$ May be seen within a calculation or implied by awrt 34.3

dM1: For attempting $22 \times "1.559"$ It is dependent on the previous method mark.

A1: awrt $34.3\left(\text{kmh}^{-1}\right)$ Units are not required

(ii)(a) Note candidates must show all stages of their working. Solutions relying entirely on calculator technology are not acceptable. A correct answer only or a correct answer with only 260 or 261 stated send to review.

M1: For an acceptable method of finding the number of terms required to find the maximum value of S. e.g. finds n by e.g. using $u_n = 208 + (n-1)(-0.8) = 0$ (condone missing brackets around -0.8) or alternatively score for $\dfrac{208}{0.8}$. Allow to show trial calculations of $u_{260} = 0.8$ or $u_{261} = 0$. May be implied by 260 or 261

Alternatively sets $S_n = \dfrac{n}{2}\left[2 \times 208 + (n-1) \times (-0.8)\right]$ and either

- differentiates and sets = 0 : $S_n = 208.4n - 0.4n^2 \Rightarrow 208.4 - 0.8n = 0 \Rightarrow n = ...$ look for $n^k \rightarrow n^{k-1}$ for at least one term, set the result equal to zero and finds n (condone slips in the rearrangement)
- uses roots: $S_n = 208.4n - 0.4n^2 = 0 \Rightarrow n(208.4 - 0.4n) = 0 \Rightarrow n = 0,\ n = ...$ and then finds the midpoint of the two roots
- completes the square: $S_n = 208.4n - 0.4n^2 = 0 \Rightarrow -0.4\left(n^2 - 521n\right) \Rightarrow -0.4\left(n - 260.5\right)^2 \pm ... \Rightarrow n = ...$

to find the position of the turning point

A1: 260 or 261 terms required for maximum S_n (condone 260.5 or $\frac{521}{2}$ if using the sum formula)

dM1: Attempts $S_{"261"} = \frac{"261"}{2}\left(2(208)+(n-1)(-0.8)\right)$ or $S_{"260"} = \frac{"260"}{2}\left(2(208)+(n-1)(-0.8)\right)$

Alternatively attempts $S_{"260"} = \frac{"260"}{2}\left(208+"0.8"\right)$ or $S_{"261"} = \frac{"261"}{2}\left(208+"0"\right)$

They must have the correct combination of values. It is dependent on the previous method mark. Condone missing brackets around -0.8

The value for *n* must be an integer which cannot be implied. It must be stated or seen embedded in the sum formula. If the integer value of *n* is stated and they proceed directly to an answer with no method shown then you may need to check this.

A1: 27144 cao **following sight of 260 or 261**

There are other alternative methods which may be credit worthy.
If they use trial and improvement send to review.

(ii)(b)

B1 522 cao

Question Number	Scheme	Marks
10. (a)	Sets $30 = 2r^2 + 2r^2\theta + 2r^2\theta$	M1
	Obtains $4r\theta = \frac{30-2r^2}{r}$ oe or $\theta = \frac{30-2r^2}{4r^2}$ oe or $r\theta = \frac{30-2r^2}{4r}$ oe	A1
	Uses $P = 6r + 4r\theta$ with their θ or $...r\theta$ substituted	dM1
	$P = 6r + \frac{30-2r^2}{r} = 4r + \frac{30}{r}$ *	A1*
		(4)
(b)	Differentiates with $r^{-1} \to r^{-2}$	M1
	$\left(\frac{dP}{dr} =\right) 4 - \frac{30}{r^2}$	A1
	Solves $\frac{dP}{dr} = 0 \Rightarrow \left(r = \sqrt{\frac{15}{2}}\right)$ and substitutes to find P	dM1
	$\left(P = 4\sqrt{\frac{15}{2}} + \frac{30\sqrt{2}}{\sqrt{15}} = 2\sqrt{30} + 2\sqrt{30}\right) = 4\sqrt{30}$	A1
		(4)
(c)	e.g. finds $\left(\frac{d^2P}{dr^2} =\right) \frac{60}{r^3} = \frac{60}{"2.7"^3} = ...$	M1
	e.g. states that $\left(\frac{d^2P}{dr^2} =\right)$ awrt $3 > 0$ hence minimum	A1
		(2)
		(10 marks)

(a) **Note that using θ as an angle in degrees can only score a maximum of M1A0dM1A0***

M1: Uses the area is 30 m^2 to form an equation of an allowable form.

Condone slips/incorrect formulae but score for a form $30 = Ar^2 + Br^2\theta$ oe which may be unsimplified.

A1: Obtains $4r\theta = \frac{30-2r^2}{r}$ or $\theta = \frac{30-2r^2}{4r^2}$ or $r\theta = \frac{30-2r^2}{4r}$ or other equivalences e.g.

$2r\theta = \frac{30}{2r} - r$

dM1: Uses $P = Cr + Dr\theta$ with their θ or $...r\theta$ substituted to form an expression for the perimeter in terms of *r*. It is dependent on the previous method mark.

A1*: Obtains the given answer with no incorrect work but condone bracket omissions to be recovered provided it is before the final answer. Must see *P* = … oe in the correct place which may come earlier than the final line.

Mark (b) and (c) together

Do not be concerned with notation on left hand side provided the intention is clear.

Condone $\frac{dy}{dx}$ **and** $\frac{d^2y}{dx^2}$

(b)

M1: Differentiates $r^{-1} \to r^{-2}$

A1: $\left(\frac{dP}{dr} =\right) 4 - \frac{30}{r^2}$

dM1: Solves $M - \frac{N}{r^2} = 0 \Rightarrow r = ... \left(= \sqrt{\frac{15}{2}}\right) \Rightarrow P = ...$ (where $M \times N > 0$) and uses the model with *r* to find a value for *P*. (Do not allow this mark to be scored from unsolvable equations such as $4 + \frac{30}{r^2} = 0$)

You do not need to be concerned with the mechanics of the rearrangement. Condone use of Inequalities provided they reach a single value for *P*. It is dependent on the previous method mark. You may need to check this on your calculator but the use of decimals will score M0 (and subsequently A0).

A1: $\left(P =\right)\ 4\sqrt{30}$ only

(c)

M1: **Any of the following possible approaches:**

- finds $\left(\frac{d^2P}{dr^2} =\right) \frac{k}{r^3}$ and either calculates its value at their *r* or considers its sign at their *r* (which must be positive and not made positive from a negative answer)
- finds the value of $\frac{dP}{dr}$ either side of their $r = \sqrt{\frac{15}{2}}$
- finds *P* either side of their $r = \sqrt{\frac{15}{2}}$ provided a value for *P* at their $r = \sqrt{\frac{15}{2}}$ was found

A1: **Requires** a correct second derivative, a correct r (to at least 2sf), a correct calculation (or statement) and a conclusion.

e.g. $\left(\frac{\mathrm{d}^2P}{\mathrm{d}r^2}=\right)\frac{60}{r^3}$ with $\left(\frac{\mathrm{d}^2P}{\mathrm{d}r^2}=\right)$ awrt $3>0$ at $r=$ awrt 2.7 means (P is a) minimum.

e.g. $\left(\frac{\mathrm{d}^2P}{\mathrm{d}r^2}=\right)\frac{60}{r^3}$ with $\left(\frac{\mathrm{d}^2P}{\mathrm{d}r^2}=\right)\frac{60}{r^3}>0$ as $r>0$ so (P is a) minimum

e.g. $\left(\frac{\mathrm{d}^2P}{\mathrm{d}r^2}=\right)\frac{60}{r^3}$ with $\left(\frac{\mathrm{d}^2P}{\mathrm{d}r^2}=\right)\frac{60}{\left(\sqrt{\frac{15}{2}}\right)^3}>0$ so (P is a) minimum

Condone poorly worded conclusions which suggest the value of r is a minimum (instead of P)

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 15 October 2025

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 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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P 8 1 2 6 9 A 0 1 3 2

Pearson

1. An arithmetic series starts

$$78 + 75 + 72 + ...$$

Find

(a) the 18^{th} term in the series,

(2)

(b) the sum of the first 100 terms of the series.

(2)

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Question 1 continued

(Total for Question 1 is 4 marks)

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2. The first 4 terms, in ascending powers of x, in the binomial expansion of

$$(1 + px)^{10}$$

are

$$1 + 15x + qx^2 + rx^3$$

where p, q and r are constants.

Find the value of p, the value of q and the value of r.

(6)

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Question 2 continued

(Total for Question 2 is 6 marks)

3.

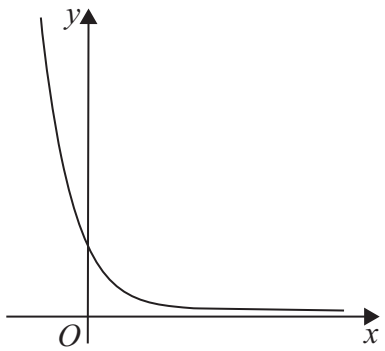

Figure 1

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 with equation $y = 3 \times 2^{-x}$

The point $P(k, 300\,000)$ lies on the curve.

(a) Use logarithms to find the value of k to 2 decimal places.

(2)

x	–0.5	1	2.5	4.0	5.5	7
y	4.243	1.5	0.530	0.188	0.066	0.023

The table shows corresponding values of x and y for $y = 3 \times 2^{-x}$

The values of y are given to 3 decimal places where appropriate.

(b) (i) Use the trapezium rule, with all the values of y from the table, to find an approximate value, to 2 decimal places, for

$$\int_{-0.5}^{7} 3 \times 2^{-x} \, dx$$

(3)

(ii) Use your answer to part (b)(i) to estimate

$$\int_{-0.5}^{7} 2^{-x} \, dx + \int_{-7}^{0.5} 2^{x} \, dx$$

(2)

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Question 3 continued

Question 3 continued

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Question 3 continued

(Total for Question 3 is 7 marks)

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

$$f(x) = 4x^3 + 13x^2 - 10x + 8$$

(a) When $f(x)$ is divided by $(x - 2)$ the remainder is R and the quotient is $Q(x)$.

(i) Find $Q(x)$.

(ii) Find R.

(4)

(b) (i) Use the factor theorem to show that $(x + 4)$ is a factor of $f(x)$.

(ii) Hence prove, using algebra, that the equation $f(x) = 0$ has only one real solution.

(5)

(c) Find the range of values of x for which $f(x)$ is decreasing.

(3)

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

(i) Solve, for $0 < \theta \leqslant 360°$, the equation

$$4 \tan \theta + 5 \sin \theta = 0$$

giving any non-exact answers to one decimal place.

(5)

(ii) Solve, for $0 < x < \pi$, the equation

$$\frac{\sin x}{\cos x} + \frac{\cos x}{\sin x} = \frac{5}{\cos x}$$

giving the answers, in radians, to 3 significant figures.

(4)

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Question 5 continued

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Question 5 continued

(Total for Question 5 is 9 marks)

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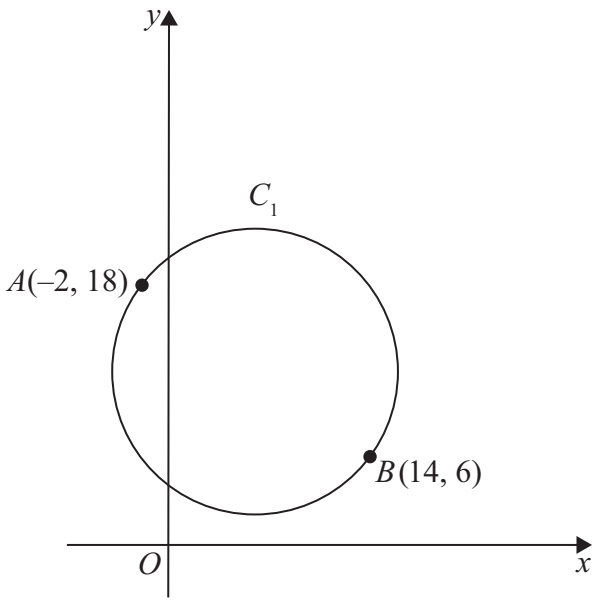

Figure 2

The points $A(-2, 18)$ and $B(14, 6)$ lie on a circle C_1 as shown in Figure 2.

Given that AB is a diameter of the circle C_1

(a) find an equation for C_1 making your method clear.

(5)

A circle C_2 has its centre at the origin.

Given that circles C_1 and C_2 touch,

(b) find possible equations for C_2

(4)

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Question 6 continued

Question 6 continued

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Question 6 continued

(Total for Question 6 is 9 marks)

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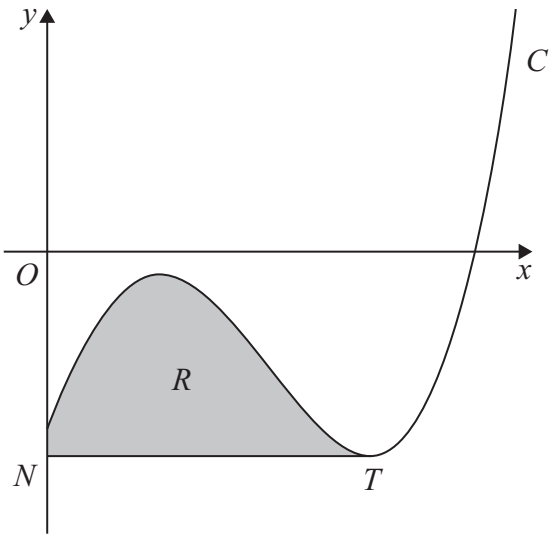

Figure 3

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

Figure 3 shows a sketch of part of the curve C with equation

$$y = x^3 - 4x^{\frac{5}{2}} - kx^{\frac{1}{2}} + 28x - 44 \qquad x \geqslant 0$$

where k is a positive constant.

(a) Find $\dfrac{dy}{dx}$ in simplest form.

(2)

The point T, shown in Figure 3, is a minimum stationary point on C.

Given that the x coordinate of T is 9

(b) show that $k = 6$

(2)

The line through T parallel to the x-axis meets the y-axis at the point N.

The finite region R, shown shaded in Figure 3, is bounded by C, the y-axis and the line segment NT.

(c) Use algebraic integration to find the area of R, giving the answer to 3 significant figures.

(6)

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Question 7 continued

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Question 7 continued

(Total for Question 7 is 10 marks)

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8. (i) A geometric series has first term a and common ratio r.

Prove that the sum of the first n terms of this series S_n is given by

$$S_n = \frac{a(1-r^n)}{1-r}$$

(3)

(ii) A liquid is to be stored in a barrel.

Due to evaporation, the volume of the liquid in the barrel at the end of each year is 8% less than the volume of the liquid in the barrel at the start of the year.

At the start of the first year, the barrel is filled with 150 litres of the liquid.

(a) Show that the amount of the liquid in the barrel at the end of 6 years is approximately 91 litres.

(2)

At the start of each year a new barrel is filled with 150 litres of the liquid so that, at the end of 40 years, there are 40 barrels containing the liquid.

(b) Calculate the total amount of the liquid, to the nearest litre, in the 40 barrels at the end of 40 years.

(3)

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Question 8 continued

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Question 8 continued

(Total for Question 8 is 8 marks)

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9. **In this question you must show detailed reasoning.**
Solutions relying on calculator technology are not acceptable.

(i) Solve

$$2\log_3(4x + 5) - \log_3(x + 3) = 2$$

(5)

(ii) Given that $a > 0$, $b > 0$ and

$$\log_{10} a + \log_{10} b = \log_{10}(a + b)$$

(a) prove that $a = \dfrac{b}{b-1}$

(3)

(b) Hence write down the full restriction on the value of b, giving a reason for your answer.

(2)

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Question 9 continued

Question 9 continued

(Total for Question 9 is 10 marks)

TOTAL FOR PAPER IS 75 MARKS

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Mark Scheme (Results)

October 2025

International Advanced Level in Pure Mathematics P2

WMA12/01

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October 2025
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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

- ⌐ 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 = ...

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

2. Formula

Attempt to use correct formula (with values for a, b and c)

3. Completing the square

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

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)	$78+17\times-3=27$	M1, A1 **(2)**
(b)	$\frac{100}{2}(2\times78+99\times-3)$	M1
	$=-7050$	A1 **(2)** **(4 marks)**

(a)

M1: Attempts to find the value of $a+(n-1)d$ with $a = 78$, $n = 18$ and $d = -3$. E.g.

Award for $78+17\times-3=...$

Condone slips, so for example 78 written as 87…

BUT writing 78 as 18 (which is the value of n) or -3 as 3 are not regarded as slips

Writing down 27 scores both marks

Listing is acceptable only if they write down 27 as the answer

A1: 27

(b)

M1: Attempts the correct sum formula for 100 terms. So $n = 100$ must be used (twice).

Condone with $d=\pm3$ and slips on 78 …. BUT writing 78 as 18 is not regarded as a slip

Award for an attempt at $\frac{100}{2}(2\times78+99\times-3)$ or $\frac{100}{2}(2\times78+99\times3)$ o.e.

Writing down -7050 scores both marks

You may see the alternative formula used, usually seen with an attempt to find u_{100} first.

Look for $\frac{100}{2}(78+u_{100})$ condoning the same slips on 78 and u_{100} found via $78+99\times\pm3$

A1: -7050 but this is not isw. Withhold this mark if they write -7050 and follow this with 7050

Guidance on applications of formulae for this question:

If a candidate writes out a fully correct formula including bracketing, followed by the correct embedded values they can be awarded M1.
E.g. $n^{\text{th}}\ \text{term} = a + (n-1)d \Rightarrow 18^{\text{th}}\ \text{term} = 78 + (18-1) - 3 = 92$ should be awarded M1, A0 as the correct formula and embedded values are seen

However, $18^{\text{th}}\ \text{term} = 78 + (18-1) - 3 = 92$ should be awarded M0 as the correct formula cannot be implied

Similarly writing $18^{\text{th}}\ \text{term} = 78 + 19 \times -3 = \ldots$ should be awarded M0, A0 as it implies the incorrect formula $a + (n+1)d$

Question Number	Scheme	Marks
2	$(1+px)^{10} = 1+10px+\frac{10\times 9}{2}p^2x^2+\frac{10\times 9\times 8}{6}p^3x^3+\ldots$	
	Sets $10p=15 \Rightarrow p=1.5$ o.e.	M1 A1
	Finds the value of $45p^2 \Rightarrow q=101.25$ o.e.	M1 A1
	Finds the value of $120p^3 \Rightarrow r=405$	M1 A1
		(6) **(6 marks)**

M1: Sets $10p=15 \Rightarrow p=\ldots$ or $10px=15x \Rightarrow p=\ldots$

Alternatively score for a correct simplified expansion of $(1+px)^{10} = 1+10px+45p^2x^2+120p^3x^3+\ldots$

A1: $p=1.5$ o.e. Candidates who simply state that $p=1.5$ can be awarded M1, A1

M1: Finds a value for $45p^2$ or $\frac{10\times 9}{2}p^2x^2$ or equivalent using their value of *p* which may or may not have been found via a correct method.

A1: States a correct value for $q=101.25$ o.e following the award of M1

M1: Finds the value for $120p^3$ or $\frac{10\times 9\times 8}{3!}p^3x^3$ or equivalent using their value of *p* which may or may not have been found via a correct method.

A1: States a correct value for $r=405$ following the award of M1

Special Case I: Candidates who leave the x^2 AND x^3 in their answer

Candidates who show a correct method but state $q = 101.25x^2$ **AND** $r = 405x^3$ following M1, A1 can score SC 1,1,1,1,1,0

Special Case II: Candidates who find the value of *p* and then expand $\left(1+\frac{3}{2}x\right)^{10}$

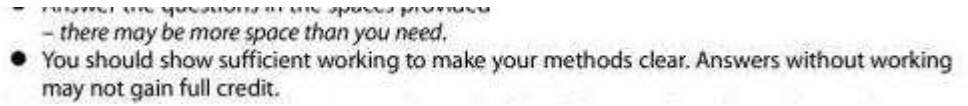
Candidates who show a correct method to find *p* then expand $\left(1+\frac{3}{2}x\right)^{10} = 1+15x+101.25x^2+405x^3$ without explicitly stating *q* and *r* can be awarded all of the marks

Answers with limited or no working;

If the candidate gives a correct expansion of $(1+px)^{10}$, whether simplified or not, then all marks are available.

E.g $(1+px)^{10} = 1+10px+45(px)^2+120(px)^3 \Rightarrow p=\frac{3}{2}, q=\frac{405}{4}, r=405$ scores 6 marks

If the candidate just writes down values without any valid equations/working then we will apply the following.


– 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.

So just stating $p = 1.5$, $q = 101.25$ and $r = 405$ without the necessary equations or expansion is SC: 1,1,1,0,0,0

Question Number	Scheme	Marks
3.(a)	$300\,000 = 3\times 2^{-k} \Rightarrow 2^{-k} = 100000 \Rightarrow -k = \dfrac{\log 100000}{\log 2}$	M1
	$(k) = -16.61$	A1
		(2)
(b) (i)	Strip width = 1.5	B1
	$\dfrac{1.5}{2}\{4.243 + 0.023 + 2(1.5 + 0.530 + 0.188 + 0.066)\}$ = 6.63	M1, A1
		(3)
(ii)	$\displaystyle\int_{-0.5}^{7} 2^{-x}\,\mathrm{d}x + \int_{-7}^{0.5} 2^{x}\,\mathrm{d}x = \frac{1}{3}\times\text{"6.63"} + \frac{1}{3}\times\text{"6.63"} = 4.42$	M1, A1
		(2)
		(7 marks)

(a)

M1: Correct **use of logs** leading to an expression or value for x or $-x$.

Alternatively applies the correct **use of logs** leading to an expression for k or $-k$

There are lots of variations, examples of which include

- $(\pm k) = \dfrac{\log 100000}{\log 2}$, $(\pm x) = \log_2 \dfrac{1}{100000}$ and $(\pm x) = \dfrac{\ln 100000}{\ln 2}$
- $300\,000 = 3\times 2^{-k} \Rightarrow \log 300000 = \log 3 - k\log 2 \Rightarrow k = \ldots$

Condone a slip on the number of zeros (4 or 6 zeros can still score this method mark)

It cannot be scored if they incorrectly combine the 3 and the 2 and work from $6^{-k} = 300\,000$

A1: AWRT –16.61 following M1. ISW after a correct answer

Note that the answer only is M0, A0. The demand is that the candidates use logs

(b)(i)

B1: Correct strip width. E.g. States or uses $h = 1.5$. Condone it being unprocessed.
E.g. $\frac{7-(-0.5)}{5}$ o.e.

Can be implied by a correct h value within an attempted trapezium rule which does not need to be perfect. A correct application would be
$\frac{1.5}{2}\{4.243+0.023+2(1.5+0.530+0.188+0.066)\}$ or
$0.75\{4.243+0.023+2(1.5+0.530+0.188+0.066)\}$

M1: Correct application of the trapezium rule
$\frac{"h"}{2}\{4.243+0.023+2(1.5+0.530+0.188+0.066)\}$

Condone slips on values but there must be the correct number of them and they must be in the correct place within the formula.

Condone a missing trailing bracket, but hard to decipher bracketing can be awarded this mark only if followed by awrt 6.6. Answers only score M0

A1: awrt 6.63 (Answer in full is 6.6255). ISW after a correct answer

Note that the calculator answer for this integral is 6.087

(b)(ii) Attempts to (b)(ii) must use their answer to (b)(i) but could use an additional attempt at the trapezium rule on $\int_{-7}^{0.5} 2^x \, dx$ with $h = 1.5$ or smaller

M1: Attempts to find $\frac{2}{3}\times"6.63"$ or alternatively $\frac{1}{3}\times"6.63"+\frac{1}{3}\times"6.63"$ following through on their 6.63

Note that $\frac{1}{3}\times"6.63"+2.03 = 4.24$ is M0 as 2.03 is the calculator answer for $\int_{-7}^{0.5} 2^x \, dx$

A1: 4.42. Allow 4.417 or awrt 4.42 if the full answer is used.

Note that the calculator answer for the sum of the two integrals is 4.058...

Question Number	Scheme	Marks
4 (a)	$f(x)=4x^3+13x^2-10x+8$ $x-2\overline{)4x^3+13x^2-10x+8}$ $\quad 4x^2+21x+32$ $4x^3-8x^2$ $21x^2-10x$ $21x^2-42x$ $32x+8$ $32x-64$ 72 Synthetic Division $2 \mid 4 \quad 13 \quad -10 \quad 8$ $\quad\quad 8 \quad 42 \quad 64$ $4 \quad 21 \quad 32 \mid 72$	
(i)	$Q(x)=4x^2+21x+32$	M1, A1
(ii)	$R=72$	M1, A1 **(4)**
(b)(i)	Attempts $f(-4)=4\times-64+13\times16-10\times-4+8$ $=-256+208+40+8=0$ Hence $(x+4)$ is a factor *	M1 A1*
(ii)	$f(x)=4x^3+13x^2-10x+8=(x+4)(4x^2-3x+2)$	M1
	For their $4x^2-3x+2$ attempts "b^2-4ac"$=9-32$, $b^2-4ac'<0$ so $4x^2-3x+2$ has no real roots and $f(x)=0$ has one at $x=-4$	M1 A1* **(5)**
(c)	$(f'(x))=12x^2+26x-10=2(3x-1)(2x+5)$ $-\frac{5}{2}<x<\frac{1}{3}$	M1 dM1, A1 **(3)** **(12 marks)**

(a) (i)

M1: Attempts to divide $f(x)$ by $(x-2)$ and achieves a 3TQ quotient of the form $4x^2+bx+c \quad b\neq 0, c\neq 0$ **AND** a remainder that is a constant. See equivalent form using synthetic division

A1: Achieves a Quotient or $Q(x)=4x^2+21x+32$. It is implied if they write (i) $4x^2+21x+32$

It cannot just be awarded from the expression within the division sum

(a) (ii)

M1: Attempts to divide $f(x)$ by $(x-2)$ and achieves a 3TQ quotient **AND** a remainder that is a constant.
Alternatively attempts to find the value of $f(2)$. Allow $f(2)=72$ but if it is incorrect you must see some evidence for the award such as showing an intermediate line of $4\times 2^3+13\times 2^2-10\times 2+8$
or else $32+52-20+8$ (or equivalent) condoning slips. See equivalent form using synthetic division

A1: States that Remainder or *R* = 72. It is implied if they write (ii) 72
It cannot just be awarded from sight of 72 within the division sum BUT if a candidate gets the division sum completely correct and does not state $Q(x)=4x^2+21x+32$ and *R* = 72 (o.e.) they should be awarded SC 1,1,1,0

Alt (a) via an identity BUT other acceptable methods exist such as by inspection which is a less formal version of this.

Sets up a correct identity $f(x)=4x^3+13x^2-10x+8\equiv(x-2)\left(Ax^2+Bx+C\right)+R$ **AND then**

M1: Compares terms and achieves $A=4$ and values for *B* and *C*

A1: States that Quotient, (i) or $Q(x)=4x^2+21x+32$

M1: Finds *R* via f(2) or solving $8=R\pm 2C$ with their value for C.

A1: States that Remainder, (ii) or *R* = 72

(b)(i)

M1: Attempts to find the value of $f(-4)$. For this to be awarded you must see some values. Look for, for example,

- $f(-4)=4\times(-4)^3+13\times(-4)^2-10\times(-4)+8$ with or without the brackets
- $f(-4)=-256+208+40+8$ condoning slips

You must be convinced that they have attempted $f(-4)$ and not $f(+4)$

Note that dividing $f(x)=4x^3+13x^2-10x+8$ by $(x+4)$ is M0 as it doesn't satisfy the demand of the question.

Note that simply stating $f(-4)=0$ without sight of evidence (e.g. intermediate values) is M0

A1*: Requires

- The award of M1
- Sight of correct values or correct expression, e.g. $\mathrm{f}(-4) = -256 + 208 + 40 + 8$ or $\mathrm{f}(-4) = 4\times(-4)^3 + 13\times(-4)^2 - 10\times(-4) + 8$ (must be correct bracketing) followed by = 0
- and a minimal conclusion which may be QED, hence true, ✓

(b)(ii). Mark part (b) as one complete section. Work in part (i) can count in part (ii)

Although the question states hence, these marks can be awarded independently of (b)(i) so 00111 is possible

M1: Divides $\mathrm{f}(x)$ by $(x+4)$ and achieves an acceptable 3 term quadratic factor

If division is used look for first two terms $4x^2 - 3x + ...$

If they are using inspection, look for first and last terms $(x+4)\left(4x^2 + ...x + 2\right)$

M1: Makes a valid attempt at finding the roots or number of roots of their 3-term quadratic factor resulting from factoring out or dividing by (x+4) . Look for an attempt at the value of "$b^2 - 4ac$" or an attempt at the correct quadratic formula o.e. such as completing the square. It is dependent upon them having a quadratic factor of the form $4x^2 + bx + c, b \neq 0, c \neq 0$

A1*: This requires all of the following;

- a correct division (o.e.) leading to the correct quadratic factor
- a correct 'proof' showing that $4x^2 - 3x + 2$ hasn't any real roots e.g. "$b^2 - 4ac$" $= 9 - 32 < 0$ or attempting to solve $4x^2 - 3x + 2 = 0$ via the quadratic formula followed by 'not possible' o.e.
- a minimal reason/statement showing that $\mathrm{f}(x) = 0$ has only one real solution. This could be a statement that the one (real) solution is $x = -4$ or reasons that the one real solution is as a result of $(x+4) = 0$

There can be no incorrect statements in the body of their proof. Eg. The real solution is $(x+4)$

(c) **This is a non-calculator question/part question**

M1: Attempts to differentiate and find the roots. This requires all of

- Differentiation to a 3TQ expression with at least one correct term. FYI $\left(\mathrm{f}'(x)\right)=12x^2+26x-10$
- A valid non calculator attempt at finding the two critical values of $\mathrm{f}'(x)=0$. Look for a valid attempt to factorise or use the quadratic formula in an attempt to solve $\mathrm{f}'(x)=0$. Condone attempts in which the factor of 2 disappears. E.g. $12x^2+26x-10=0\Rightarrow(2x+5)(3x-1)=0$

dM1: Finds the inside region for their quadratic. It is dependent upon the previous M mark

A1: $-\frac{5}{2}<x<\frac{1}{3}$ or $-\frac{5}{2}$,, x,, $\frac{1}{3}$ o.e. such as $\left(-\frac{5}{2},\frac{1}{3}\right)$

SC: Candidates who use a calculator can be awarded SC 1,1,0 for an otherwise completely correct solution.

E.g. $\mathrm{f}'(x)=12x^2+26x-10<0\Rightarrow -2.5<x<\frac{1}{3}$

Question Number	Scheme	Marks
5(i)	$4\tan\theta+5\sin\theta=0$	
	States or uses $\tan\theta=\dfrac{\sin\theta}{\cos\theta}\rightarrow 4\dfrac{\sin\theta}{\cos\theta}+5\sin\theta=0$	M1
	$\sin\theta\left(4+5\cos\theta\right)=0$	
	$\cos\theta=-\dfrac{4}{5}$	dM1
	$\cos\theta=-\dfrac{4}{5}\Rightarrow\theta=$ awrt $143°$ or awrt $217°$	A1
	$\cos\theta=-\dfrac{4}{5}\Rightarrow\theta=$ awrt $143.1°$ and awrt $216.9°$	A1
	$\sin\theta=0\Rightarrow\theta=180°,360°$	B1
		(5)
(ii)	$\dfrac{\sin x}{\cos x}+\dfrac{\cos x}{\sin x}=\dfrac{5}{\cos x}\overset{\times\sin x\cos x}{\Rightarrow}\sin^2 x+\cos^2 x=5\sin x$	
	$5\sin x=1$	M1, A1
	$x=$ awrt $0.201, 2.94$	dM1, A1
		(4)
		(9 marks)

(i) Condone a lack of a degrees symbol throughout. Condone solutions that drop θ's in their working

M1: States $\tan\theta=\dfrac{\sin\theta}{\cos\theta}$ or attempts to use $\tan\theta=\dfrac{\sin\theta}{\cos\theta}$ in the given equation.

Condone slips in coefficients but writing $4\tan\theta$ as $\dfrac{4\sin\theta}{4\cos\theta}$ is M0.

dM1: Attempts all of the following

- uses $\tan\theta=\dfrac{\sin\theta}{\cos\theta}$ condoning slips in the coefficients
- multiplies by $\cos\theta$ and proceeds to a linear equation in $\cos\theta$ via factorising or cancelling out the term in $\sin\theta$
- achieves $\cos\theta=k$ where $|k|<1$

A1: Achieves $\cos\theta=-\dfrac{4}{5}$ and finds one correct value for θ to the nearest degree or in radians to one dp. So, allow for example, awrt 2.5(0) following $\cos\theta=-\dfrac{4}{5}$

A1: Achieves $\cos\theta=-\dfrac{4}{5}$ and finds both θ values in degrees correct to one dp.

awrt $143.1°$ and awrt $216.9°$

Any extra values in the range (for $\cos\theta = -\frac{4}{5}$) is A0

B1: Correctly achieves $\sin\theta = 0$ for their equation followed by $\theta = 180°, 360°$

Condone 0 appearing as a solution

……

Alternative approaches exist and can be marked in a similar way:

If you see an approach that deserves credit and you don't know how to score it, please send to review.

Alt I, II and III are examples of alternative approaches.

Alt I Using $\sin\theta = \tan\theta\cos\theta$

$4\tan\theta + 5\sin\theta = 0 \Rightarrow 4\tan\theta + 5\tan\theta\cos\theta = 0 \Rightarrow \tan\theta\left(4 + 5\cos\theta\right) = 0$

then solve $\cos\theta = -\frac{4}{5}$ and $\tan\theta = 0$

M1: Writing $\sin\theta$ as $\cos\theta\tan\theta$

dM1: Factorises out $\tan\theta$ and proceeds to $\cos\theta = k$ where $|k| < 1$

Alt II Squaring approach

$4\sin\theta + 5\sin\theta\cos\theta = 0 \Rightarrow 4\sin\theta = -5\sin\theta\cos\theta \Rightarrow 16\sin^2\theta = 25\sin^2\theta\cos^2\theta$

This will produce $\sin\theta = \pm\frac{3}{5}$ and $\sin\theta = 0$

M1: As main method

dM1: Squaring each term including the coefficients, factorising and cancelling leading to $\sin\theta = k$ where $|k| < 1$ Note that an approach $a + b = 0 \Rightarrow a^2 + b^2 = 0$ would score

dM0. It must be $a + b = 0 \Rightarrow a^2 - b^2 = 0$

B1: Allow this to be scored even from an approach where dM1has not been awarded

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Alt III using Pythagoras' theorem

$$4\frac{\sin\theta}{\cos\theta} + 5\sin\theta = 0 \Rightarrow 4\frac{\sin^2\theta}{\cos\theta} + 5\sin^2\theta = 0 \Rightarrow 4\frac{\left(1-\cos^2\theta\right)}{\cos\theta} + 5\left(1-\cos^2\theta\right) = 0 \Rightarrow 5\cos^3\theta + 4\cos^2\theta - 5\cos\theta - 4 = 0$$

Then solve by any means to find values for $\cos\theta$

$\Rightarrow \cos\theta = \pm 1, -\frac{4}{5} \Rightarrow \theta = 180°, 360°,$ awrt $143.1°$ and awrt $216.9°$

M1: As main method. dM1: Correct method of producing a 4 term cubic in $\cos\theta$ followed by a valid attempt to solve to produce value(s) for $\cos\theta$

(ii) Condone solutions that drop *x*'s in parts of the working and notational errors e.g. $\sin x^2 \leftrightarrow \sin^2 x$ as long as the candidate proceeds in a manner equivalent to the scheme

M1: Attempts to multiply by $\sin x \cos x$, seen on the two terms on the lhs of the equation and then uses $\sin^2 x + \cos^2 x = 1$. Condone slips when rearranging this identity as long as the equation leads to $\sin x = k, |k| < 1$ o.e

Alternatively uses a common denominator approach and simplifies $\frac{\sin x}{\cos x} + \frac{\cos x}{\sin x}$ to $\frac{1}{\sin x \cos x}$

A1: Proceeds to $5\sin x = 1$ or exact equivalent

dM1: Correct attempt to solve $5\sin x = 1$, implied by one correct solution to 2 sf in radians or 1 dp in degrees within the given range. 0 to So

$5\sin x = 1 \Rightarrow \sin x = \frac{1}{5} \Rightarrow x = 0.2$ only is dM0 but *x* = 0.20 or 2.9 is dM1.

Note that the degree answer is 11.5.

Also, solutions such as 0.064π (radians) are acceptable

Allow a miscopy on the 5. So, for example, if they had written $\frac{\sin x}{\cos x} + \frac{\cos x}{\sin x} = \frac{3}{\cos x}$ it would be for a solution of $3\sin x = 1$.

A1: $x =$ awrt $0.201, 2.94$ and no extras within the given domain (condoning the appearance of $\frac{\pi}{2}$ which occurs from a solution of $\cos x = 0$). Award as soon as you see the two correct solutions, so long as there are no additional solutions inside the range.

Also allow multiples of π so accept $x = 0.064\pi, 0.936\pi$ with the decimal aspect being accurate to at least 3dp

Question Number	Scheme	Marks
6 (a)	Centre of circle is midpoint of $(-2,18)$ and $(14,6) = (6,12)$	B1
	Attempts radius^2 or diameter^2. E.g. $D^2 = (14--2)^2 + (6-18)^2 = 400$	M1
	Radius^2 = 100	A1
	$(x-6)^2 + (y-12)^2 = 100$	M1, A1
		(5)
(b)	Recognises equation of C_2 is $x^2 + y^2 = k^2$	B1
	Attempts to find one value of k or k^2 Look for $\sqrt{"6"^2 + "12"^2} \pm \sqrt{"100"}$	M1
	$x^2 + y^2 = \left(6\sqrt{5}+10\right)^2$ or $x^2 + y^2 = \left(6\sqrt{5}-10\right)^2$ o.e.	A1
	$x^2 + y^2 = \left(6\sqrt{5}+10\right)^2$ and $x^2 + y^2 = \left(6\sqrt{5}-10\right)^2$ o.e.	A1
		(4)
		(9 marks)

(a) **The demand here is that the method must be made clear**

B1: Correctly finds the midpoint of the two given points to find the centre of the circle.
It can be implied within the circle formula $(x-6)^2 + (y-12)^2 = r^2$

M1: Attempts to find the radius, radius^2 , diameter or diameter^2.
It does not need to be correctly assigned to either the radius or the diameter
So $(14--2)^2 + (6-18)^2$, $16^2 + 12^2$, $\sqrt{8^2 + 6^2}$ or radius = 10 are acceptable attempts that score M1

A1: Correctly calculates the radius^2 = 100 o.e. or the radius = 10
Alternatively states that the diameter = 20 or diameter^2 = 400
It must be simplified and correctly assigned (radius or diameter) but may be implied from within a circle formula $(x \pm "6")^2 + (y \pm "12")^2 = 100$

M1: Attempts correct form for circle using $(x-a)^2 + (y-b)^2 = r^2$
where (a, b) is their m.p. of *AB* and r is the value of what they think is the radius of the circle.
If there is no statement i.e, radius(*r*) = … or diameter (*d*) = … , the value used must be the equivalent of the distance between the mid-point of *AB* and either point *A* or point *B*.
Look for $(x-"6")^2 + (y-"12")^2 = "100"$ or $(x-"6")^2 + (y-"12")^2 = \frac{"400"}{4}$
So if they clearly state something that is incorrect, e.g. $r^2 = 10$, thus losing the previous A mark, they can score this method mark for $(x-6)^2 + (y-12)^2 = 10$

A1: $(x-6)^2+(y-12)^2=100$, $(x-6)^2+(y-12)^2=10^2$ but not $(x-6)^2+(y-12)^2=\left(\sqrt{100}\right)^2$

ISW after a correct answer.

The method used must have been made clear for A1 to be scored. So, look for all of the following

- a correct calculation of the mid-point of *AB* or alternatively words such as 'centre of circle is $(6,12)$'
- a correct calculation for radius (radius^2) or diameter (diameter^2) or alternatively words such as 'radius of circle is 10'
- a correct equation

(b)

B1: Recognises equation of C_2 is $x^2+y^2=k^2$. Allow for any $x^2+y^2=p, \quad p>0$

Accept $(x\pm 0)^2+(y\pm 0)^2=p, \quad p>0$ Allow 'letters' here so long as the rhs is positive, so k^2 is fine but *p* isn't unless *p* is defined to be positive.

M1: Attempts to find at least one value for the radius of C_2.

For example, score for a radius of $\sqrt{a^2+b^2}\pm r$ for their $(x-a)^2+(y-b)^2=r^2$

A1: $x^2+y^2=\left(6\sqrt{5}+10\right)^2$ or $x^2+y^2=\left(6\sqrt{5}-10\right)^2$ or exact equivalents including versions such as $(x\pm 0)^2+(y\pm 0)^2=\left(6\sqrt{5}+10\right)^2$. ISW after sight of a correct answer.

Expanded equivalents are $x^2+y^2=280+120\sqrt{5}$ or $x^2+y^2=280-120\sqrt{5}$ but isw after a correct answer

A1: $x^2+y^2=\left(6\sqrt{5}+10\right)^2$ and $x^2+y^2=\left(6\sqrt{5}-10\right)^2$ o.e. including versions such as $(x\pm 0)^2+(y\pm 0)^2=\left(6\sqrt{5}+10\right)^2$. ISW after sight of correct answers.

Expanded equivalents are $x^2+y^2=280+120\sqrt{5}$ and $x^2+y^2=280-120\sqrt{5}$ but isw after a correct answer

(b) Longer alternative

Substitutes $y=2x$ into $(x-6)^2+(y-12)^2=100$ and solves

E.g. $(x-6)^2+(2x-12)^2=100\Rightarrow 5(x-6)^2=100\Rightarrow (x-6)^2=20\Rightarrow x=6\pm 2\sqrt{5}$

Hence points of intersection are $\left(6-2\sqrt{5},12-4\sqrt{5}\right)$ and $\left(6+2\sqrt{5},12+4\sqrt{5}\right)$

Radius for smaller circle is found via $r^2 = \left(6-2\sqrt{5}\right)^2 + \left(12-4\sqrt{5}\right)^2 = 280-120\sqrt{5}$

Radius for larger circle is found via $r^2 = \left(6+2\sqrt{5}\right)^2 + \left(12+4\sqrt{5}\right)^2 = 280+120\sqrt{5}$

The same scoring traits can be applied

B1: Recognises equation of C_2 is $x^2+y^2=k^2$. Allow for any $(x\pm 0)^2+(y\pm 0)^2 = p, \quad p>0$

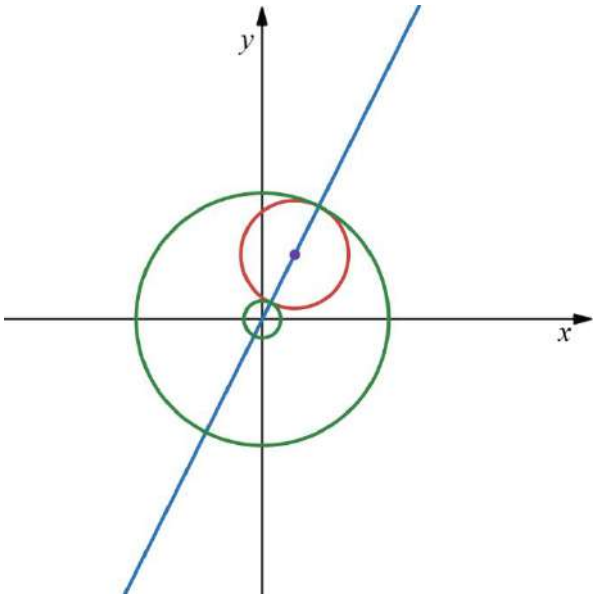
M1: Attempts to find at least a value of r or a value of r^2 for C_2.

For example,

- find at least one intersection point of the line through (0, 0) and their (6, 12) and the circle
- find the distance from the origin to one of the points of intersection

A1: $x^2+y^2 = 280-120\sqrt{5}$ or $x^2+y^2 = 280+120\sqrt{5}$ or exact equivalents

A1: $x^2+y^2 = 280-120\sqrt{5}$ and $x^2+y^2 = 280+120\sqrt{5}$ or exact equivalents



Question Number	Scheme	Marks
7.(a)	$y = x^3 - 4x^{\frac{5}{2}} - kx^{\frac{1}{2}} + 28x - 44$ $y = x^3 - 4x^{\frac{5}{2}} - kx^{\frac{1}{2}} + 28x - 44 \Rightarrow \left(\frac{dy}{dx}\right) = 3x^2 - 10x^{\frac{3}{2}} - \frac{k}{2}x^{-\frac{1}{2}} + 28$	M1, A1 **(2)**
(b)	Subs $x = 9$ into $\frac{dy}{dx}$ and sets = 0 $\Rightarrow 3\times 81 - 10\times 27 - \frac{k}{6} + 28 = 0$ $243 - 270 - \frac{k}{6} + 28 = 0 \Rightarrow \frac{k}{6} = 1 \Rightarrow k = 6$ *	M1 A1* **(2)**
(c)	$\int x^3 - 4x^{\frac{5}{2}} - 6x^{\frac{1}{2}} + 28x - 44\,dx = \frac{1}{4}x^4 - \frac{8}{7}x^{\frac{7}{2}} - 4x^{\frac{3}{2}} + 14x^2 - 44x$ Correct value of $y = -53$ at T Shaded area = $"53"\times 9 + \left[\frac{1}{4}x^4 - \frac{8}{7}x^{\frac{7}{2}} - 4x^{\frac{3}{2}} + 14x^2 - 44x\right]_0^9$ = 248	M1, A1, A1 B1 dM1 A1 **(6)** **(10 marks)**

(a)

M1: Attempts to differentiate. Look for **two** correct terms, one of which could be $-44 \to 0$.
Allow the coefficients to be un-simplified but the indices must be processed

A1: $\left(\frac{dy}{dx}\right) = 3x^2 - 10x^{\frac{3}{2}} - \frac{k}{2}x^{-\frac{1}{2}} + 28$ or other simplified equivalent. ISW after a correct answer

(b)

M1: Substitutes $x = 9$ into their $\frac{dy}{dx}$ and sets = 0. Look for embedded values, or 4 simplified terms set = 0

For the M1 only, allow a substitution of $x = 9$ into their $\frac{dy}{dx}$ which develops into an equation that implies $\frac{dy}{dx}$ = 0. E.g. $\frac{dy}{dx} = 3\times 9^2 - 10\times 9^{\frac{3}{2}} - \frac{k}{2}\times 9^{-\frac{1}{2}} + 28 = \frac{k}{6} - 1$ So $\frac{k}{6} = 1$

Alternatively substitutes $x = 9$ and $k = 6$ into their $\frac{dy}{dx}$ and finds the value of $\frac{dy}{dx}$ with conditions as above.

A1*: Shows that $k = 6$

Via the main method you must see

- an un-simplified equation such as $3\times 81 - 270 - \frac{1}{6}k + 28 = 0$
- a simplified equation such as $\frac{k}{6} = 1$ o.e.
- and the given answer $k = 6$

Via the alternative method you must see

- an un-simplified expression for $\frac{\mathrm{d}y}{\mathrm{d}x} = 3\times 81 - 270 - \frac{1}{6}\times 6 + 28$
- before proceeding to $\frac{\mathrm{d}y}{\mathrm{d}x} = 0$
- followed by a conclusion stating that there is a stationary point when $k = 6$

(c) Main method: Finds both areas and subtracts

M1: Attempts to integrate. Look for two correct indices which must be processed

A1: Two correct terms but allow the coefficients to be left un-simplified

A1: $\frac{1}{4}x^4 - \frac{8}{7}x^{\frac{7}{2}} - 4x^{\frac{3}{2}} + 14x^2 - 44x$ allowing coefficients to be left un-simplified.

Condone an additional +c

B1: $y = -53$ at *T* May be awarded at any point in the question, even from the diagram

dM1: Look for a FULL method that involves (area of rectangle –area under curve) either way around to find a value for the area of *R*. Condone slips but it is dependent upon the previous M.

The area of the rectangle must be found using $9\times$ (an attempt at the *y* value of the curve at *x* = 9), and not for instance using 9×44 as 44 is the intersection of the curve with the *y* -axis.

You don't need to see working for the evaluation of $\left[\frac{1}{4}x^4 - \frac{8}{7}x^{\frac{7}{2}} - 4x^{\frac{3}{2}} + 14x^2 - 44x\right]_0^9$

A1: AWRT 248. Allow the exact answer $\frac{6939}{28}$ Note that -248 is A0

(c) Alt method via integration of line – curve (or curve –line)

This could also be attempted by translating the curve upwards by 53 units

The following example shows a correct line – curve approach

$$\int '-53' - \left(x^3 - 4x^{\frac{5}{2}} - 6x^{\frac{1}{2}} + 28x - 44\right)\mathrm{d}x = \int -9 - x^3 + 4x^{\frac{5}{2}} + 6x^{\frac{1}{2}} - 28x\,\mathrm{d}x$$

$$-9x - \frac{1}{4}x^4 + \frac{8}{7}x^{\frac{7}{2}} + 4x^{\frac{3}{2}} - 14x^2$$

Shaded area = $-9\times 9 - \frac{1}{4}\times 9^4 + \frac{8}{7}\times 9^{\frac{7}{2}} + 4\times 9^{\frac{3}{2}} - 14\times 9^2 = \frac{6939}{28}$

Area to 3sf = 248 which must be +ve

M1: Attempts to integrate an expression of the form $\pm\left(-x^3+4x^{\frac{5}{2}}+6x^{\frac{1}{2}}-28x\pm p\right)$.

Look for two correct indices which must be processed. Condone bracketing errors

Allow even with p = 97 or 0

A1: Two correct terms of $\pm\left(-\frac{1}{4}x^4+\frac{8}{7}x^{\frac{7}{2}}+4x^{\frac{3}{2}}-14x^2\pm px\right)$ but allow the coefficients to be left un-simplified. Follow through on their value of p which may be 97 or 0

A1: Correct integration. So look for $\pm\left(-\frac{1}{4}x^4+\frac{8}{7}x^{\frac{7}{2}}+4x^{\frac{3}{2}}-14x^2\pm px\right)$, allowing the coefficients to be left un-simplified. Follow through on their value of p which may be 97 or 0. Condone an additional + c

B1: For $y=-53$ at T. May be awarded at any point in the question, even from the diagram

dM1: Attempts the value of $\pm\left[-\frac{1}{4}x^4+\frac{8}{7}x^{\frac{7}{2}}+4x^{\frac{3}{2}}-14x^2-9x\right]_0^9$. No intermediate working is required.

This is dependent upon the first M and also obtaining '9x'

A1: AWRT 248. Allow the exact answer $\frac{6939}{28}$

Note that final answers of -248 and $|-248|$ are A0

Question Number	Scheme	Marks
8 (i)	$S_n = a + ar + ar^2 + ...ar^{n-1}$	B1
	$S_n = a + ar + ar^2 + ...ar^{n-1}$ **and** $rS = ar + ar^2 + ar^3 + ...ar^n$	
	Finds S_n and rS_n and subtracts. E.g. $S - rS = ...$	M1
	Completes proof $\Rightarrow S_n(1-r) = a(1-r^n) \Rightarrow S_n = \dfrac{a(1-r^n)}{(1-r)}$ *	A1*
		(3)
(ii) (a)	Attempts $U = 150 \times 0.92^n$ with $n = 5 \text{ or } 6$	M1
	$\Rightarrow (U_6) = 150 \times (0.92)^6 = 90.95$ (≈ 91 litres) *	A1*
		(2)
(b)	Attempts $S_n = \dfrac{a(1-r^n)}{(1-r)}$ with $n = 39/40/41$ $a = 150/138$ and $r = 0.92$	M1
	$S = \dfrac{138(1-0.92^{40})}{(1-0.92)}$, $S = 150 \times \dfrac{0.92(1-0.92^{40})}{(1-0.92)}$ OR $S = \dfrac{150(1-0.92^{41})}{(1-0.92)} - 150$	A1
	1664 litres	A1
		(3)
		(8 marks)

Do not be too concerned with labelling here. It should be obvious which part of the question candidates are attempting to answer

(i) Condone $S \leftrightarrow S_n$ throughout.

A proof via the infinite sum formula gains no credit unless you see a correct expression for S_n.

B1: Scored for a correct expression for S_n. For example, $S_n = a + ar + ar^2 + ...ar^{n-1}$

including the "S_n" with a minimum of 3 terms and must include the first and the nth term.

$S_n = a + ar + ...ar^{n-1}$ would be acceptable but $S_n = a + ...ar^{n-1}$ is not.

It cannot be scored if some terms are incorrect $S_n = a + ... + \underline{\underline{ar^n}} + ar^{n-1}$

Or they are not in the correct order $S_n = a + ...ar^{n-1} + ar^{n-2}$

M1: States $S_n = a + ar + ar^2 + ...ar^{n-1}$ (minimum of 3 **correct** terms including **first** and **last** terms)

and $rS_n = ar + ar^2 + ...ar^n$ (minimum of 3 correct terms including first and last terms)

followed by an attempt to subtract either way around

A1*: Fully correct proof. Look for the following 3 lines (or their equivalents) following B1, M1

- $S_n - rS_n = a - ar^n$
- $S_n(1-r) = a(1-r^n)$
- $S_n = \dfrac{a(1-r^n)}{(1-r)}$ (Note that this is a given answer)

Special case: Candidates who do not have the '+' signs in their work

Example

$S_n : a \quad ar \quad ar^2 \quad ..... \quad ar^{n-1}$

$rS_n : ar \quad ar^2 \quad ar^3 \quad ..... \quad ar^n$

$rS_n - S_n = ar^n - a$

$(r-1)S_n = a(r^n - 1) \Rightarrow S_n = \dfrac{a(r^n-1)}{(r-1)} \Rightarrow S_n = \dfrac{a(1-r^n)}{(1-r)}$

Scores SC B0, M1, A1

(Note that this candidate subtracts the other way around, but the given answer must be produced and follow correct working)

(ii) (a)

M1: Attempts $U_n = 150 \times 0.92^n$ with $n = 5 \text{ or } 6$.

You may see variations on this such as $150 \times (92\%)^5$

Allow step by step solutions such as

$150 \overset{\times 0.92}{\rightarrow} 138 \overset{\times 0.92}{\rightarrow} 126.96 \overset{\times 0.92}{\rightarrow} 116.8032 \overset{\times 0.92}{\rightarrow} 107.458944 \overset{\times 0.92}{\rightarrow} 98.86222848 \overset{\times 0.92}{\rightarrow} 90.9532502$

(with accuracy at least 1dp for the M1)

A1*: Awrt 90.95 but accept the truncated value 90.9. You should expect to see an answer that isn't exactly 91

ISW after sight of a correct answer

Note that candidates who just write $150 \times 0.92^6 = 91$ then award M1, A0 as this is incorrect

If attempted via step by step solutions (listing) then intermediate answers must be correct to 2dp rounded or truncated.

(b)

M1: Attempts $S_n = \dfrac{a(1-r^n)}{(1-r)}$ with $n = 39/40/41$, $a = 150/138$ and $r = 0.92$ o.e. such as 92%

A1: A correct expression. You may see variations of the following

$S = \dfrac{138(1-0.92^{40})}{(1-0.92)}$, $S = 150 \times \dfrac{92\%(1-92\%^{40})}{(1-92\%)}$ OR $S = \dfrac{150(1-0.92^{41})}{(1-0.92)} - 150$

A1: cao 1664 litres

Question Number	Scheme	Marks
9 (i)	$2\log_3(4x+5)-\log_3(x+3)=2 \Rightarrow \log_3\dfrac{(4x+5)^2}{(x+3)}=2$	M1, M1
	$\Rightarrow \dfrac{(4x+5)^2}{(x+3)}=9$	A1
	$\Rightarrow 16x^2+31x-2=0$	
	$(16x-1)(x+2)=0 \Rightarrow x=\dfrac{1}{16}$ only	dM1, A1
		(5)
(ii) (a)	States that $\log a+\log b=\log(ab)$ or else uses rule and proceeds from given equation $\log a+\log b=\log(a+b)$ to $\log ab=\log(a+b)$	B1
	Deduces $ab=a+b \Rightarrow ab-a=b \Rightarrow a(b-1)=b \Rightarrow a=\dfrac{b}{b-1}$ *	M1, A1*
(b)	States either $b>1$ or $b\neq 1$ as *a* would not be defined	B1
	$b>1$ as logs only exist for positive numbers	B1
		(5)
		(10 marks)

(i) **We are now scoring this question M1, M1, A1, dM1, A1**

M1: Usually scored for the power law of logs $2\log_3(4x+5) \rightarrow \log_3(4x+5)^2$ (allow without the base 3)

But may be awarded for writing 2 as $\log_3 9$

M1: For combining two terms of the original equation.

E.g $\log_3\dfrac{(4x+5)^2}{(x+3)}=2$ (allow without the base 3) or $2\log_3(4x+5)=\log_3 9(x+3)$

A1: A correct equation not involving logs. E.g. $\dfrac{(4x+5)^2}{(x+3)}=9$ or $(4x+5)^2=9(x+3)$

dM1: Requires all of the following

- A starting equation of the form (or equivalent to the form) $\dfrac{(4x+5)^2}{(x+3)}=k, \quad k>0$
- An intermediate equation that is a 3TQ
- A correct attempt to solve the 3TQ by any means condoning the use of a calculator here.

It is dependent upon scoring at least one of the previous M marks

A1: CSO $\dfrac{1}{16}$ oe only. The decimal equivalent is 0.0625

'Correct' solutions with missing or incorrect lines

Example I: Incorrect statement

$2\log_3(4x+5)-\log_3(x+3)=2 \Rightarrow \dfrac{\log_3(4x+5)^2}{\log_3(x+3)}=2 \Rightarrow \dfrac{(4x+5)^2}{(x+3)}=9$ leading to full and correct solution

Score Special Case M1, M0, A1, dM1, A0 for 3 out of 5

Example II: Missing lines

$2\log_3(4x+5)-\log_3(x+3)=2 \Rightarrow \log_3\dfrac{(4x+5)^2}{(x+3)}=2 \Rightarrow \dfrac{(4x+5)^2}{(x+3)}=9$

Or even $2\log_3(4x+5)-\log_3(x+3)=2 \Rightarrow \dfrac{(4x+5)^2}{(x+3)}=9$ leading to full and correct solution

can be awarded all the marks.

(ii) You can condone the omission of the base

(a) Main method

B1: States or uses $\log a+\log b=\log(ab)$ o.e. It is implied when $\log(ab)=\log(a+b)$ is written down or $ab=a+b$ but it cannot be awarded following incorrect work. Condone $\log a+b$ for $\log(a+b)$ if the intention is clear (but the use of this would mean that the A1* mark is not scored)

Alternatives exist such as $\log(a+b)-\log b=\log(\dfrac{a+b}{b})$

M1: Following correct log work, candidate removes the logs, correctly deduces $ab=a+b$, and then attempts to collect terms in *a*. To award this mark the two terms in *a* must be moved to the same side of the equation and the *a* factorised out. It can be awarded when the term in '*a*' is isolated. E.g $ab\pm a=b \Rightarrow a(b\pm 1)=b$

Alternatively removes the logs, deduces $a=\dfrac{a+b}{b}$ and then attempts to collect terms in *a*

Acceptable alternatives exist. E.g. $ab=a+b \overset{\div a}{\Rightarrow} \underline{\underline{b=1+\dfrac{b}{a}}} \Rightarrow \dfrac{b}{a}=b-1 \Rightarrow a=\dfrac{b}{b-1}$

The method mark can be awarded here when there is a single term in *a*. See double underlined expression

A1*: Correctly proves that $a=\dfrac{b}{b-1}$ via $a(b-1)=b$ or $ab-a=b$.

This is a given answer and **ALL** appropriate lines must be seen and be correct.

Condone a missing trailing bracket.

The appropriate lines that must be seen (as a minimum) via the standard approach are;

$$\log ab=\log(a+b) \Rightarrow ab=a+b \Rightarrow a(b-1)=b \Rightarrow a=\frac{b}{b-1}$$

(a) Alt method

B1: Substitutes $a = \frac{b}{b-1}$ in $\log a + \log b$ and proceeds to $\log(\frac{b^2}{b-1})$

M1: Substitutes $a = \frac{b}{b-1}$ in $\log(a+b)$ and proceeds to $\log\left(\frac{b}{b-1}+b\right)$ and attempts to write as a single fraction

A1*: Shows that $\log a + \log b = \log(ab)$ when $a = \frac{b}{b-1}$ and makes a minimal statement.

This is a given answer and all appropriate lines must be seen and be correct (including any bracketing).

(ii)(b)

B1: For either (i) giving the full restriction on *b*. E.g. $b > 1$, '*b* is more than one' or 'it must be bigger than one'. No (correct) explanation required.

or (ii) stating that $b \neq 1$ with a reason such as $\frac{b}{b-1} \to \infty$ or $b-1=0$.

Allow reasons such as 'the denominator cannot be 0' 'when *b* = 1 you get a maths error'

Do not accept ambiguous statements such as $b \neq 1$ because it cannot be 0

or (iii) stating that $b \ldots 1$ with a reason such as $b-1$ cannot be negative

B1: $b > 1$ or '*b* must be more than one' as logs only exist for positive numbers.

Allow '$b > 1$ as *a* must be greater than 0'

Allow variations that imply this so accept $b > 1$ as $\frac{b}{b-1}$ needs to be positive or $b-1$ needs to be positive

There really needs to be some words here and the statement and explanation must be given together and in a logical order. A minimum acceptable response could be 'as *a* > 0, *b* >1'

Do not accept incorrect reasons such as '$b > 1$ as *a* must be greater than or equal to 0'

Do not award this mark if there are incorrect statements along with correct ones. If unsure use review.

Pearson Edexcel International Advanced Level

Tuesday 21 October 2025

Afternoon (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. Find

(i) (a) $\int (2x + 3)^{12} \mathrm{d}x$

(2)

(b) $\int \frac{5x}{4x^2 + 1} \mathrm{d}x$

(2)

(ii) Given that

$$\int_a^{2a} \frac{t+1}{t} \mathrm{d}t = \ln 7 \qquad a > 0$$

find the exact value of constant a.

(*Solutions relying on calculator technology are not acceptable.*)

(4)

(Total for Question 1 is 8 marks)

---

2. $$y = (2x^2 - 3)\tan\left(\frac{1}{2}x\right) \qquad 0 < x < \pi$$

Given that $\frac{\mathrm{d}y}{\mathrm{d}x} = 0$ when $x = \alpha$

(a) show that

$$2\alpha^2 - 3 + 4\alpha \sin \alpha = 0$$

(6)

The iterative formula

$$x_{n+1} = \frac{3}{(2x_n + 4\sin x_n)}$$

can be used to find an approximation for α.

(b) Taking $x_1 = 0.7$, find the values of x_2 and x_3, giving each answer to 4 decimal places.

(2)

(c) By choosing a suitable interval and a suitable function that should be stated, show that $\alpha = 0.7283$ to 4 decimal places.

(2)

(Total for Question 2 is 10 marks)

3. $$g(x) = \frac{x^4 + x^3 - 7x^2 + 8x - 48}{x^2 + x - 12} \qquad x > 3 \qquad x \in \mathbb{R}$$

(a) Given that

$$\frac{x^4 + x^3 - 7x^2 + 8x - 48}{x^2 + x - 12} \equiv x^2 + A + \frac{B}{x - 3}$$

find the values of the constants A and B.

(4)

(b) Hence, or otherwise, find the equation of the tangent to the curve with equation $y = g(x)$ at the point where $x = 4$. Give your answer in the form $y = mx + c$, where m and c are constants to be determined.

(*Solutions relying on calculator technology are not acceptable.*)

(5)

(Total for Question 3 is 9 marks)

---

4. A curve has equation

$$y = \ln(1 - \cos 2x) \qquad x \in \mathbb{R} \qquad 0 < x < \pi$$

Show that

(a) $\frac{dy}{dx} = k \cot x$, where k is a constant to be found.

(4)

Hence find the exact coordinates of the point on the curve where

(b) $\frac{dy}{dx} = 2\sqrt{3}$

(4)

(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.

(a) Prove that

$$2\operatorname{cosec} 2A - \cot A \equiv \tan A \qquad A \neq \frac{n\pi}{2} \qquad n \in \mathbb{Z}$$

(4)

(b) Hence solve, for $0 \leqslant \theta \leqslant \frac{\pi}{2}$

(i) $2\operatorname{cosec} 4\theta - \cot 2\theta = \sqrt{3}$

(ii) $\tan\theta + \cot\theta = 5$

Give your answers to 3 significant figures.

(5)

(Total for Question 5 is 9 marks)

6.

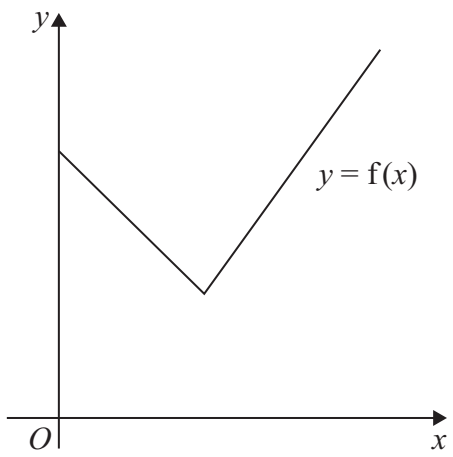


Figure 1

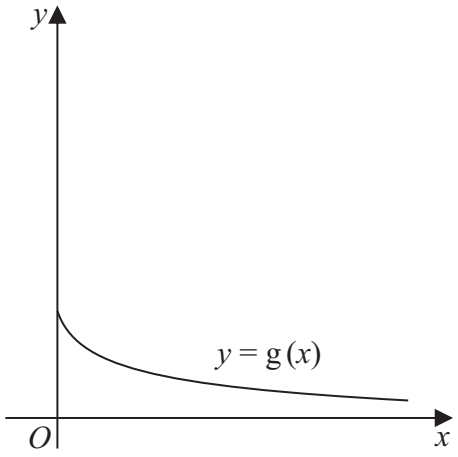


Figure 2

Figure 1 shows a sketch of part of the graph $y = \mathrm{f}(x)$, where

$$\mathrm{f}(x) = 2|3 - x| + 5 \qquad x \geqslant 0$$

Figure 2 shows a sketch of part of the graph $y = \mathrm{g}(x)$, where

$$\mathrm{g}(x) = \frac{x+9}{2x+3} \qquad x \geqslant 0$$

(a) Find the value of $\mathrm{fg}(1)$

(2)

(b) State the range of g

(2)

(c) Find g^{-1}

(3)

Given that the equation $\mathrm{f}(x) = k$, where k is a constant, has exactly two roots,

(d) state the range of possible values of k.

(3)

(Total for Question 6 is 10 marks)

7.

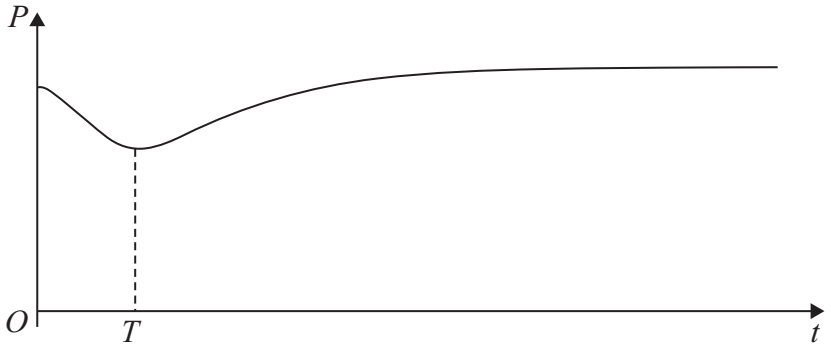


Figure 3

A colony of bees is being studied. The number of bees in the colony is modelled by the equation

$$P = 200 - \frac{160e^{0.6t}}{15 + e^{0.8t}} \qquad t \in \mathbb{R} \qquad t \geqslant 0$$

where P is the number of bees, measured in thousands, t years after the study started.
A sketch of the graph of P against t is shown in Figure 3

(a) Calculate the number of bees in the colony at the start of the study.

(2)

(b) Find $\frac{dP}{dt}$

(3)

The population of bees initially decreases, reaching a minimum value after T years, as shown in Figure 3

(c) Using your answer to part (b), calculate the value of T to 2 decimal places.

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

(4)

(Total for Question 7 is 9 marks)

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

(a) Express $10\cos\theta - 3\sin\theta$ in the form $R\cos(\theta + \alpha)$, where $R > 0$ and $0 < \alpha < 90°$

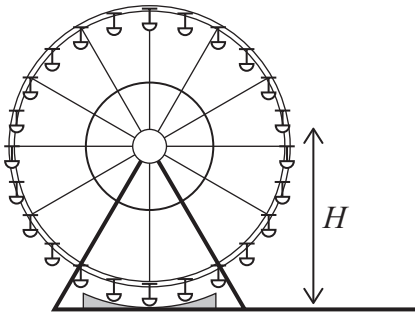
Give the exact value of R and the value of α to 2 decimal places.

(3)

Alana models the height above the ground of a passenger on a Ferris wheel by the equation

$$H = 12 - 10\cos(30t)° + 3\sin(30t)°$$

where the height of the passenger above the ground is H metres at time t minutes after the wheel starts turning.



Use part (a) and the equation of the model to answer parts (b), (c) and (d).

(b) Calculate

(i) the maximum value of H

(ii) the value of t when this maximum first occurs.

Give each answer to 2 decimal places.

(3)

(c) Calculate the value of t when the passenger is 18 m above the ground for the first time.

Give your answer to 2 decimal places.

(4)

(d) Determine the time taken for the Ferris wheel to complete two revolutions.

(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

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Tuesday 21 October 2025

Afternoon (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 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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Question 1 continued

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(Total for Question 1 is 8 marks)

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Question 2

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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 2 pages

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Question 3 continued

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(Total for Question 3 is 9 marks)

Question 4

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Question 4 continued

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(Total for Question 4 is 8 marks)

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Question 5

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Question 5 continued

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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)

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Question 6

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Question 6 continued

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Question 6 continued

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Question 6 continued

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(Total for Question 6 is 10 marks)

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Question 7

Write the answer to Question 7 on these 4 pages

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Question 7 continued

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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

Write the answer to Question 8 on these 3 pages

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Question 8 continued

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Question 8 continued

(Total for Question 8 is 12 marks)

TOTAL FOR PAPER IS 75 MARKS

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Pearson

Mark Scheme (Results)

October 2025

International Advanced Level in Pure Mathematics P3

WMA13/01A

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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: 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
   - $\sqsubset$ 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 $x = \ldots$

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

2. Formula

Attempt to use correct formula (with values for a, b and c)

3. Completing the square

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

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(i)(a)	$\int (2x+3)^{12}\mathrm{d}x = \dfrac{(2x+3)^{13}}{26}(+c)$	M1 A1
		(2)
(i)(b)	$\int \dfrac{5x}{4x^2+1}\mathrm{d}x = \dfrac{5}{8}\ln\left(4x^2+1\right)(+c)$	M1 A1
		(2)

(i) Notes

(a)

M1: Correct form for the integration. Look for $\lambda(2x+3)^{13}$ or e.g. $\mu\left(x+\dfrac{3}{2}\right)^{13}$

Allow the index unprocessed e.g. $\lambda(2x+3)^{12+1}$

May see substitution e.g. $u = 2x + 3$ leading to λu^{13} and this would imply this mark.

A1: Correct integration with or without the + c.

Allow any equivalent correct expression simplified or unsimplified and apply isw once a correct answer is seen.

Award for e.g. $\dfrac{(2x+3)^{13}}{26}$ or $\dfrac{(2x+3)^{13}}{2\times 13}$ or $\dfrac{2^{12}\left(x+\dfrac{3}{2}\right)^{13}}{13}$ or $\dfrac{4096\left(x+\dfrac{3}{2}\right)^{13}}{13}$

The index must be processed and any constants evaluated e.g. 13 not 12 + 1 but e.g. 2×13 is acceptable.

Ignore any spurious integral signs and/or dx's and just look for a correct expression.

(b)

M1: Correct form of integration. Look for $\ldots\ln\left(4x^2+1\right)$ or $\ldots\ln\left|4x^2+1\right|$ but condone missing brackets e.g. $\ldots\ln 4x^2+1$

Can also be awarded for $\ldots\ln k\left(4x^2+1\right)$ or $\ldots\ln k\left|4x^2+1\right|$

May see substitution e.g. $u = 4x^2+1$ leading to $\ldots\ln u$ and this would imply this mark.

A1: Correct integration with or without the + c.

Allow any equivalent correct expression simplified or unsimplified and apply isw once a correct answer is seen.

Brackets must be present and allow $\dfrac{5}{8}\ln\left(4x^2+1\right)(+c)$ or $\dfrac{5}{8}\ln\left|4x^2+1\right|(+c)$

Note that e.g. $\dfrac{5}{8}\ln\left(x^2+\dfrac{1}{4}\right)(+c)$ or $\dfrac{5}{8}\ln\left|x^2+\dfrac{1}{4}\right|(+c)$ are also correct.

Allow equivalents for $\dfrac{5}{8}$ e.g. 0.625 or e.g. $\dfrac{1}{1.6}$

Ignore any spurious integral signs and/or dx's and just look for a correct expression.

(ii)	$\int \frac{t+1}{t}\,\mathrm{d}t = \int\left(1+\frac{1}{t}\right)\mathrm{d}t = t+\ln t\,(+c)$	M1 A1
	$\left[t+\ln t\right]_a^{2a} = 2a+\ln 2a-(a+\ln a) = \ln 7$	**d**M1
	$a+\ln 2 = \ln 7 \Rightarrow a = \ln\frac{7}{2}$ or $\ln 7-\ln 2$	A1
		(4)
		(8 marks)

(ii) Notes

M1: Writes $\frac{t+1}{t}$ as $...+\frac{1}{t}$ where … $\neq 0$ and integrates $\frac{1}{t} \to \ln t$

A1: Correct integration with or without an arbitrary constant.

dM1: Applies the limits a and $2a$ the right way round, subtracts and sets equal to $\ln 7$

Condone poor bracketing e.g. $2a+\ln 2a-a+\ln a = \ln 7$

Depends on the first method mark.

A1: $a = \ln\frac{7}{2}$ or e.g. $\ln 3.5$

Condone $a = \ln 7-\ln 2$ but if this becomes $\ln 5$ score A0

Condone clear confusion with the variable if the intention is clear e.g.

$$\int_a^{2a}\frac{t+1}{t}\,\mathrm{d}t = \int_a^{2a}\left(1+\frac{1}{t}\right)\mathrm{d}t = \left[x+\ln t\right]_a^{2a} \to 2a+\ln 2a-(a+\ln a) = \ln 7 \text{ etc.}$$

Alternative attempts by parts for the first 2 marks:

I	$\int \frac{t+1}{t}\,\mathrm{d}t = \frac{1}{t}\left(\frac{t^2}{2}+t\right)-\int -\frac{1}{t^2}\left(\frac{t^2}{2}+t\right)\mathrm{d}t$	M1
	$= \frac{1}{t}\left(\frac{t^2}{2}+t\right)+\int\frac{1}{2}+\frac{1}{t}\,\mathrm{d}t = \frac{1}{t}\left(\frac{t^2}{2}+t\right)+\frac{t}{2}+\ln t\,(+c)$	A1

Notes

M1: Award for $\int \frac{t+1}{t}\,\mathrm{d}t = \frac{1}{t}\left(\frac{t^2}{2}+t\right)-\int -\frac{1}{t^2}\left(\frac{t^2}{2}+t\right)\mathrm{d}t$

Must be correct as shown.

A1: Fully correct integration. $\frac{1}{t}\left(\frac{t^2}{2}+t\right)+\frac{t}{2}+\ln t\,(+c)$ or equivalent.

II	$\int \frac{t+1}{t}\,\mathrm{d}t = (t+1)\ln t-\int \ln t\,\mathrm{d}t$	M1
	$\int \frac{t+1}{t}\,\mathrm{d}t = (t+1)\ln t-t\ln t+t\,(+c)$	A1

Notes

M1: Award for $\int \frac{t+1}{t}\,\mathrm{d}t = (t+1)\ln t-\int \ln t\,\mathrm{d}t$

Must be correct as shown.

A1: Fully correct integration. $(t+1)\ln t-t\ln t+t\,(+c)$ or equivalent.

Question Number	Scheme	Marks
2(a)	$y=(2x^2-3)\tan\left(\frac{1}{2}x\right)\Rightarrow\left(\frac{\mathrm{d}y}{\mathrm{d}x}=\right)4x\tan\left(\frac{1}{2}x\right)+(2x^2-3)\times\frac{1}{2}\sec^2\left(\frac{1}{2}x\right)$	M1A1A1
	$x=\alpha\Rightarrow 4\alpha\tan\left(\frac{1}{2}\alpha\right)+(2\alpha^2-3)\times\frac{1}{2}\sec^2\left(\frac{1}{2}\alpha\right)=0$ $\Rightarrow 8\alpha\frac{\sin\left(\frac{1}{2}\alpha\right)}{\cos\left(\frac{1}{2}\alpha\right)}+(2\alpha^2-3)\times\frac{1}{\cos^2\left(\frac{1}{2}\alpha\right)}=0$	M1
	$8\alpha\sin\left(\frac{1}{2}\alpha\right)\cos\left(\frac{1}{2}\alpha\right)+(2\alpha^2-3)=0$ $4\alpha\sin\alpha+(2\alpha^2-3)=0$	**d**M1
	$2\alpha^2-3+4\alpha\sin\alpha=0*$	A1*
		(6)

Notes

Brackets around the $\frac{1}{2}x$ are not required.

M1: Attempts the product rule on $y=(2x^2-3)\tan\left(\frac{1}{2}x\right)$ or on $y=2x^2\tan\left(\frac{1}{2}x\right)$ if they multiply out.
It is for **either** $(2x^2-3)\tan\left(\frac{1}{2}x\right)\to Ax\tan\left(\frac{1}{2}x\right)+B(2x^2-3)\sec^2\left(\frac{1}{2}x\right),\ A,B>0$
or for $2x^2\tan\left(\frac{1}{2}x\right)\to Ax\tan\left(\frac{1}{2}x\right)+Bx^2\sec^2\left(\frac{1}{2}x\right),\ A,B>0$

A1: One term correct: of $4x\tan\left(\frac{1}{2}x\right)$ or $(2x^2-3)\times\frac{1}{2}\sec^2\left(\frac{1}{2}x\right)$ or $(2x^2)\times\frac{1}{2}\sec^2\left(\frac{1}{2}x\right)$

A1: e.g. $\left(\frac{\mathrm{d}y}{\mathrm{d}x}=\right)4x\tan\left(\frac{1}{2}x\right)+(2x^2-3)\times\frac{1}{2}\sec^2\left(\frac{1}{2}x\right)$.

A fully correct unsimplified or simplified derivative. $\frac{\mathrm{d}y}{\mathrm{d}x}=$ is not required.

M1: They need to have a derivative with both $\tan\left(\frac{1}{2}x\right)$ and $\sec^2\left(\frac{1}{2}x\right)$. It is for using

$\tan\left(\frac{1}{2}x\right)=\frac{\sin\left(\frac{1}{2}x\right)}{\cos\left(\frac{1}{2}x\right)}$ and $\sec^2\left(\frac{1}{2}x\right)=\frac{1}{\cos^2\left(\frac{1}{2}x\right)}$ or $\sec^2\left(\frac{1}{2}x\right)=1+\tan^2\left(\frac{1}{2}x\right)=1+\frac{\sin^2\left(\frac{1}{2}x\right)}{\cos^2\left(\frac{1}{2}x\right)}$

and setting $\frac{\mathrm{d}y}{\mathrm{d}x}=0$ which may be implied. This mark is for converting to an equation in $\sin\left(\frac{1}{2}x\right)$ and $\cos\left(\frac{1}{2}x\right)$ only using the correct identities which may be implied by their work.

dM1: Uses the correct identity $2\sin\left(\frac{1}{2}x\right)\cos\left(\frac{1}{2}x\right)=\sin x$.
This may be implied by their work but if the identity $\sin\left(\frac{1}{2}x\right)\cos\left(\frac{1}{2}x\right)=\sin x$ is suggested, score dM0.
Depends on the previous method mark.

A1*: $2\alpha^2-3+4\alpha\sin\alpha=0$ (Allow $4\alpha\sin\alpha+2\alpha^2-3=0$).
This is a printed answer so must follow all previous marks.
There must have been no errors, including bracketing errors.
May work in x or α (or a) or a mixture of both but must be α or a for final A1

(b)	$x_2 = \dfrac{3}{\left(2\times 0.7 + 4\sin 0.7\right)}$	M1
	$x_2 = 0.7544, x_3 = 0.7062$	A1
		(2)

Notes

(b)

M1: For substituting $x_1 = 0.7$, into the given iterative formula to find a value for x_2.

It may be implied by the sight of $x_2 = \dfrac{3}{\left(2\times 0.7 + 4\sin 0.7\right)} = ...$ or $x_2 =$ awrt 0.75 and also (if degrees were used) $x_2 =$ awrt 2.1

Do not condone misreads of the given iteration formula.

A1: $x_2 = 0.7544, x_3 = 0.7062$ (both awrt 4 dp)

Remember to isw so allow e.g. $x_2 = 0.75436 = 0.7543, x_3 = 0.7062$

(c)	Chooses interval e.g. $[0.72825, 0.72835]$ AND function, e.g. $f(x) = 2x^2 - 3 + 4x\sin x$ and attempts the value of $f(0.72825)$ and $f(0.72835)$	M1
	$2\times0.72825^2 - 3 + 4\times0.72825\sin 0.72825 = -0.0005$ $2\times0.72835^2 - 3 + 4\times0.72835\sin 0.72835 = 0.00026$ + reason + conclusion	A1
		(2)
		(10 marks)

Notes

(c)

M1: Chooses

- A suitable interval e.g. $[0.72825, 0.72835]$
- A suitable function and attempts to find the value of the function at both ends.

The function may be implied by embedded values e.g.

$2(0.72825)^2 - 3 + 4(0.72825)\sin(0.72825)$ and $2(0.72835)^2 - 3 + 4(0.72835)\sin(0.72835)$

or by their working/values e.g. $0.72825 \rightarrow \frac{dy}{dx} = \ldots$, $0.72835 \rightarrow \frac{dy}{dx} = \ldots$,

Accept as suitable functions, $\pm(2\alpha^2 - 3 + 4\alpha\sin\alpha)$, $\pm\left(x - \frac{3}{(2x + 4\sin x)}\right)$, their $\frac{dy}{dx}$

Allow a smaller interval containing the root.

The interval does not have to be stated so the values may be seen at the point of substitution.

Condone the use of degree mode – see table below for values.

A1: Achieves

- Correct values to 1 sf rounded or truncated
- Gives a valid reason e.g. change of sign (or equivalent e.g. > 0, < 0)
- Minimal conclusion such as "hence root", "turning point", "proven"

There is no requirement to reference continuity and any mention of it can be ignored.

For reference:

Function f	f (0.72825)	f (0.72835)
$2x^2 - 3 + 4x\sin x$	–0.00051431… (Degrees = –1.90227…)	0.00026066… (Degrees = –1.90197…)
$x - \frac{3}{(2x + 4\sin x)}$	–0.00012487… (Degrees = –1.26201…)	0.000063278… (Degrees = –1.26163…)
$\frac{dy}{dx}$	–0.0002945… (Degrees = –0.95117…)	0.000149267 (Degrees = –0.95102…)

Attempts at repeated iteration score no marks in (c).

Question Number	Scheme	Marks
3(a)	$$\begin{array}{r} x^2+5 \\ x^2+x-12\overline{)\,x^4+x^3-7x^2+8x-48} \\ \underline{x^4+x^3-12x^2} \\ 5x^2+8x-48 \\ \underline{5x^2+5x-60} \\ 3x+12 \end{array}$$	M1A1
	$\dfrac{x^4+x^3-7x^2+8x-48}{x^2+x-12} \equiv x^2+5+\dfrac{3(x+4)}{(x+4)(x-3)}$	M1
	$\equiv x^2+5+\dfrac{3}{(x-3)}$	A1
		(4)

Notes

M1: Divides $x^4+x^3-7x^2+8x-48$ by x^2+x-12 to obtain a quadratic quotient and a linear remainder $\alpha x+\beta$ with α and β non-zero.

A1: Correct quotient x^2+5 and correct remainder $3x+12$.

M1: Writes their answer as $\dfrac{x^4+x^3-7x^2+8x-48}{x^2+x-12} = \text{Their Quotient} + \dfrac{\text{Their Remainder}}{(x+4)(x-3)}$

This may be implied by a correct expression following a correct quotient and remainder or by correct values for A and B as long as there is no incorrect work.

A1: Correct expression $x^2+5+\dfrac{3}{(x-3)}$ or states $A=5$, $B=3$

If they obtain $x^2+5+\dfrac{3}{(x+4)}$ this scores A0, even if they subsequently state $A=5$, $B=3$

	(a) Alternative 1 comparing coefficients/substitution	
	$x^4+x^3-7x^2+8x-48 \equiv (x^2+A)(x^2+x-12)+B(x+4)$ or $x^4+x^3-7x^2+8x-48 \equiv x^2(x^2+x-12)+A(x^2+x-12)+B(x+4)$	M1
	2 correct equations from comparing coefficients or substituting values: e.g. $x^2: A-12=-7$, $x: A+B=8$, const: $-12A+4B=-48$ or e.g. $x=3 \Rightarrow 21=7B$, $x=0 \Rightarrow -48=-12A+4B$	A1
	$\Rightarrow A=\ldots$ or $B=\ldots$	M1
	$A=5, B=3$	A1

Notes

M1: Multiplies up by x^2+x-12 or e.g. $(x-3)(x+4)$ to obtain a correct lhs and one of $(x^2+A)(x^2+x-12)$ or $B(x+4)$ on the rhs.

If $(x^2+A)(x^2+x-12)$ is expanded must see both $x^2(x^2+x-12)$ and $A(x^2+x-12)$

A1: Compares 2 coefficients (or may substitute 2 values) and obtains 2 correct equations.

M1: Solves to obtain one of A or B.

A1: Both values correct.

	(a) Alternative 2 repeated division I	
	$\left(x^4+x^3-7x^2+8x-48\right)\div(x-3)\rightarrow Q_1=x^3+4x^2+5x+23,\ R_1=21$ then $\left(x^3+4x^2+5x+23\right)\div(x+4)\rightarrow Q_2=x^2+5,\ R_2=3$	M1A1
	$\left(x^4+x^3-7x^2+8x-48\right)\div(x+4)(x-3)=x^2+5+\dfrac{21}{(x+4)(x-3)}+\dfrac{3}{x+4}$	M1
	$=x^2+5+\dfrac{21+3x-9}{(x+4)(x-3)}=x^2+5+\dfrac{3(x+4)}{(x+4)(x-3)}=x^2+5+\dfrac{3}{(x-3)}$	A1

Notes

M1: Divides by $(x-3)$ first to give a cubic quotient Q_1 and constant remainder R_1.
Then divides Q_1 by $(x+4)$ to give a quadratic quotient Q_2 and constant remainder R_2.

A1: For $Q_1=x^3+4x^2+5x+23,\ R_1=21,\ Q_2=x^2+5,\ R_2=3$

M1: Writes g(x) as $\mathrm{Q}_2+\dfrac{R_1}{(x+4)(x-3)}+\dfrac{R_2}{x+4}$

A1: Correct expression or correct values for A and B.

	(a) Alternative 3 repeated division II	
	$\left(x^4+x^3-7x^2+8x-48\right)\div(x+4)\rightarrow Q_1=x^3-3x^2+5x-12,\ R_1=0$ then $\left(x^3-3x^2+5x-12\right)\div(x-3)\rightarrow Q_2=x^2+5,\ R_2=3$	M1A1
	$\left(x^4+x^3-7x^2+8x-48\right)\div(x+4)(x-3)=x^2+5+\dfrac{3}{x-3}$	M1A1

Notes

M1: Divides by $(x+4)$ first to give a cubic quotient Q_1 and constant remainder R_1.
Then divides Q_1 by $(x-3)$ to give a quadratic quotient Q_2 and constant remainder R_2.

A1: For $Q_1=x^3-3x^2+5x-12,\ R_1=0,\ Q_2=x^2+5,\ R_2=3$

M1: Writes g(x) as $\mathrm{Q}_2+\dfrac{R_1}{(x+4)(x-3)}+\dfrac{R_2}{x-3}$

A1: Correct expression or correct values for A and B.

	(a) Alternative 4 substituting values	
	$\dfrac{x^4+x^3-7x^2+8x-48}{x^2+x-12}\equiv x^2+A+\dfrac{B}{(x-3)}$ e.g. $x=0\Rightarrow 4=A-\dfrac{B}{3}:\ x=1\Rightarrow\dfrac{45}{10}=1+A-\dfrac{B}{2}$	M1A1
	$4=A-\dfrac{B}{3}:\dfrac{45}{10}=1+A-\dfrac{B}{2}\Rightarrow A=\ldots$ or $B=\ldots$	M1
	$A=5,\ B=3$	A1

Notes

M1: Substitutes 2 values for x
A1: Any 2 correct equations.
M1: Solves to obtain one of A or B.
A1: Correct values for A and B.

(b)	$g'(x) = 2x - \dfrac{3}{(x-3)^2}$ **or** $g'(x) = \dfrac{\left(x^2+x-12\right)\left(4x^3+3x^2-14x+8\right)-\left(x^4+x^3-7x^2+8x-48\right)(2x+1)}{\left(x^2+x-12\right)^2}$	M1A1ft
	$x=4 \Rightarrow g'(4) = 2\times 4 - \dfrac{3}{(4-3)^2} = 5$	M1
	$x=4 \Rightarrow g(4) = 4^2+5+\dfrac{3}{4-3}(=24)$ $\Rightarrow y-24=5(x-4)$ **or e.g.** $y=5x+c \Rightarrow 24=5\times 4+c \Rightarrow c=...$	**d**M1
	$y=5x+4$	A1
		(5)
		(9 marks)

Notes

Note that candidates should not be using a calculator in this part so if there is no algebraic differentiation, they will generally score no marks.

M1: Differentiates their $x^2 + A + \dfrac{B}{x-3}$ to obtain $2x \pm \dfrac{B}{(x-3)^2}$ oe e.g. $2x \pm B(x-3)^{-2}$

or differentiates $\dfrac{x^4+x^3-7x^2+8x-48}{x^2+x-12}$ to obtain an expression of the form

$$g'(x) = \frac{\left(x^2+x-12\right)\times \text{a cubic polynomial} - \left(x^4+x^3-7x^2+8x-48\right)\times \text{a 2 term linear expression}}{\left(x^2+x-12\right)^2}$$

A1ft: $x^2 + A + \dfrac{B}{x-3} \rightarrow 2x - \dfrac{B}{(x-3)^2}$. Follow through on their B or allow the letter B or a made up B.

or $g'(x) = \dfrac{\left(x^2+x-12\right)\left(4x^3+3x^2-14x+8\right)-\left(x^4+x^3-7x^2+8x-48\right)(2x+1)}{\left(x^2+x-12\right)^2}$

which must be correct (nothing to follow through).

M1: Subtitutes $x=4$ into their $g'(x)$ in an attempt to find a numerical gradient.
May be implied by their $g'(4)$ following an attempt to differentiate.

dM1: For the correct method of finding an equation of the tangent with

- $x = 4$
- y an attempt at g(4) which may be implied by their value or by 24
- the gradient an attempt at $g'(4)$ following an attempt to differentiate
- the values correctly placed

If $y = mx + c$ is used they must proceed to a value for c.
Depends on the previous method mark.

A1: $y = 5x + 4$ cao and **cso**
Note that an incorrect value for A in part (a) will give the correct answer in (b) but this mark is cso and should be withheld in such cases.

Question Number	Scheme	Marks
4(a)	$y=\ln(1-\cos 2x)\Rightarrow\left(\frac{dy}{dx}=\right)\frac{2\sin 2x}{1-\cos 2x}$	M1A1
	$\Rightarrow\left(\frac{dy}{dx}=\right)\frac{4\sin x\cos x}{1-\left(1-2\sin^2 x\right)}$	M1
	$=\frac{4\sin x\cos x}{2\sin^2 x}=2\cot x$	A1
		(4)

Notes

Note that "$\frac{dy}{dx}=$" is not required apart from in alternative 3 below.

M1: For differentiating $\ln(1-\cos 2x)$ to obtain $\frac{\pm A\sin 2x}{1-\cos 2x}$

A1: $\left(\frac{dy}{dx}=\right)\frac{2\sin 2x}{1-\cos 2x}$ oe

M1: Uses the correct double angle identities $\sin 2x=2\sin x\cos x$ and $\cos 2x=1-2\sin^2 x$
The identity for $\cos 2x$ may be implied by poor bracketing in the denominator e.g.
$1-1-2\sin^2 x$

A1: Simplifies to obtain $\left(\frac{dy}{dx}=\right)2\cot x$ following M1A1M1 previously.

There must be at least one intermediate correct line between $\frac{4\sin x\cos x}{1-\left(1-2\sin^2 x\right)}$ and $2\cot x$

which will usually be $\frac{4\sin x\cos x}{2\sin^2 x}$ or e.g. $\frac{2\cos x}{\sin x}$

	(a) Alternative 1	
	$y=\ln(1-\cos 2x)=\ln\left(2\sin^2 x\right)\Rightarrow\left(\frac{dy}{dx}=\right)\frac{4\sin x\cos x}{2\sin^2 x}$	M1A1
	$\frac{4\sin x\cos x}{2\sin^2 x}=2\cot x$	M1A1

Notes

M1: Writes $\ln(1-\cos 2x)$ as $\ln(2\sin^2 x)$ and differentiates to obtain $\frac{\pm A\sin x\cos x}{\sin^2 x}$

A1: $\left(\frac{dy}{dx}=\right)\frac{4\sin x\cos x}{2\sin^2 x}$ oe

M1: Obtains $\left(\frac{dy}{dx}=\right)\frac{\pm A\sin x\cos x}{\sin^2 x}$ and simplifies to obtain $k\cot x$

A1: Obtains $\left(\frac{dy}{dx}=\right)2\cot x$ following M1A1M1 previously.

	(a) Alternative 2	
	$y=\ln(1-\cos 2x)=\ln\left(2\sin^2 x\right)=\ln 2+2\ln\sin x \Rightarrow \left(\frac{\mathrm{d}y}{\mathrm{d}x}=\right)0+\frac{2\cos x}{\sin x}$	M1A1
	$\frac{2\cos x}{\sin x}=2\cot x$	M1A1

Notes

M1: Writes $\ln(1-\cos 2x)$ as $\ln(2\sin^2 x)$ then $\ln 2+2\ln\sin x$ and differentiates to obtain $\frac{\pm A\cos x}{\sin x}$

A1: $\left(\frac{\mathrm{d}y}{\mathrm{d}x}=\right)\frac{2\cos x}{\sin x}$ oe

M1: Obtains $\left(\frac{\mathrm{d}y}{\mathrm{d}x}=\right)\frac{\pm A\cos x}{\sin x}$ and simplifies to obtain $k\cot x$

A1: Obtains $\left(\frac{\mathrm{d}y}{\mathrm{d}x}=\right)2\cot x$ following M1A1M1 previously.

	(a) Alternative 3	
	$y=\ln(1-\cos 2x)\Rightarrow \mathrm{e}^y=1-\cos 2x \Rightarrow \mathrm{e}^y\frac{\mathrm{d}y}{\mathrm{d}x}=2\sin 2x$	M1A1
	$\Rightarrow \frac{\mathrm{d}y}{\mathrm{d}x}=\frac{2\sin 2x}{\mathrm{e}^y}=\frac{2\sin 2x}{1-\cos 2x}=\frac{4\sin x\cos x}{1-\left(1-2\sin^2 x\right)}$	M1
	$\frac{4\sin x\cos x}{2\sin^2 x}=2\cot x$	A1

Notes

M1: Writes $y=\ln(1-\cos 2x)$ as $\mathrm{e}^y=1-\cos 2x$ and differentiates to obtain $\mathrm{e}^y\frac{\mathrm{d}y}{\mathrm{d}x}=A\sin 2x$

A1: $\mathrm{e}^y\frac{\mathrm{d}y}{\mathrm{d}x}=2\sin 2x$ oe

M1: Divides by $\mathrm{e}^y=1-\cos 2x$ to obtain $\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{\pm A\sin 2x}{1-\cos 2x}$ and uses the correct double angle identities $\sin 2x=2\sin x\cos x$ and $\cos 2x=1-2\sin^2 x$

The identity for $\cos 2x$ may be implied by poor bracketing in the denominator e.g. $1-1-2\sin^2 x$

A1: Simplifies to obtain $\frac{\mathrm{d}y}{\mathrm{d}x}=2\cot x$ following M1A1M1 previously.

There must be at least one intermediate correct line between $\frac{4\sin x\cos x}{1-\left(1-2\sin^2 x\right)}$ and $2\cot x$

which will usually be $\frac{4\sin x\cos x}{2\sin^2 x}$ or e.g. $\frac{2\cos x}{\sin x}$

(b)	$2\cot x = 2\sqrt{3} \Rightarrow \tan x = \dfrac{1}{\sqrt{3}}$ $x = \arctan\left(\dfrac{1}{\sqrt{3}}\right) \Rightarrow x = \dfrac{\pi}{6}$	M1A1
	$y = \ln\left(1-\cos\left(\dfrac{2\pi}{6}\right)\right) = \ln\dfrac{1}{2}$ or $-\ln 2$	M1A1
		(8 marks)

Notes

If $k = 2$ is obtained fortuitously or guessed in part (a) do not allow the A marks in part (b).

M1: Uses $\cot x = \dfrac{1}{\tan x}$ to find $\tan x$ and then arctan to find x which may be implied by their value of x. Note that some candidates may not be able to find a value of x depending on their value of k from part (a) so allow this mark for e.g. $k\cot x = 2\sqrt{3} \Rightarrow \tan x = \dfrac{k}{2\sqrt{3}} \Rightarrow x = \tan^{-1}\left(\dfrac{k}{2\sqrt{3}}\right)$ with their numerical k.

A1: $x = \dfrac{\pi}{6}$ following $k = 2$ obtained correctly in part (a). (Do not accept $30°$ for this mark)

Must be evaluated e.g. not $x = \tan^{-1}\left(\dfrac{1}{\sqrt{3}}\right)$.

Ignore additional (incorrect) values such as $x = \dfrac{5\pi}{6}$

M1: Substitutes their value of x in $y = \ln(1-\cos 2x)$ to find the y coordinate.

May be implied by their value and allow e.g. $y = \ln\left(1-\cos 2\left(\tan^{-1}\left(\dfrac{k}{2\sqrt{3}}\right)\right)\right)$ with their numerical k.

A1: $y = \ln\dfrac{1}{2}$ or $-\ln 2$ following $x = \dfrac{\pi}{6}$ or $30°$ from fully correct work including $k = 2$ obtained correctly in part (a).

Must be evaluated e.g. not $y = \ln\left(1-\cos 2\left(\tan^{-1}\left(\dfrac{1}{\sqrt{3}}\right)\right)\right)$.

Withhold this mark if other values of x and y are given within the range.

(4)

Question Number	Scheme	Marks
5(a)	$2\text{cosec}2A = \dfrac{2}{\sin 2A}$	B1
	$\dfrac{2}{\sin 2A} - \cot A = \dfrac{2}{2\sin A\cos A} - \dfrac{\cos A}{\sin A}$	M1
	$= \dfrac{2-2\cos^2 A}{2\sin A\cos A}$	M1
	$= \dfrac{2\sin^2 A}{2\sin A\cos A} = \dfrac{\sin A}{\cos A} = \tan A$ *	A1*
		(4)

Notes

Condone use of a different variable e.g. θ or x for A.

Condone the use of mixed variables for the B and M marks as long as the intention is clear.

B1: Writes $\text{cosec}2A$ as $\dfrac{1}{\sin 2A}$

M1: Uses $\sin 2A = 2\sin A\cos A$ or e.g. $\sin 2A = \sin A\cos A + \cos A\sin A$ and $\cot A = \dfrac{\cos A}{\sin A}$ to write the lhs in terms of sin A and cos A only.

M1: For writing the lhs as a single fraction in terms of sin A and cos A only.

It is for writing $\dfrac{a}{b\sin A\cos A} - \dfrac{\cos A}{\sin A}$ as a single fraction with a correct common denominator (which may not be the lowest) and 2 terms in the numerator, one of which must have been "modified".

e.g. $\dfrac{2}{2\sin A\cos A} - \dfrac{\cos A}{\sin A} = \dfrac{2\sin A - 2\sin A\cos^2 A}{2\sin^2 A\cos A}$

is acceptable without a lowest common denominator

e.g. $\dfrac{2}{2\sin A\cos A} - \dfrac{\cos A}{\sin A} = \dfrac{\sin A - 2\cos^2 A}{2\sin A\cos A}$

is acceptable with a correct denominator and 2 terms in the numerator of which at least 1 has been modified

A1*: Completes the proof with no errors.

The 2's must be cancelled at some point but it is ok for them to just "disappear".

The $1-\cos^2 A$ in the numerator must be replaced with $\sin^2 A$ and the expression $\dfrac{\sin A}{\cos A}$ must be seen before being replaced with tan A but allow this appear in the form of cancelling e.g. $\dfrac{\cancel{2}\sin^{\cancel{2}} A}{\cancel{2}\cancel{\sin A}\cos A}$. For this mark condone minor notational errors (e.g. a missing A) but not consistent poor notation throughout such as mixed variables or writing $\cos^2 A$ as $\cos A^2$.

For the final 2 marks, allow a "meet in the middle" approach

e.g. sets $\dfrac{2}{2\sin A\cos A} - \dfrac{\cos A}{\sin A} = \dfrac{\sin A}{\cos A}$

$\times 2\sin A\cos A \rightarrow 2 - 2\cos^2 A = 2\sin^2 A \Rightarrow 2\sin^2 A = 2\sin^2 A$ Hence proven.

Score the first B1M1 as in the main scheme and then M1 for e.g. multiplying through by $2\sin A\cos A$ and A1* for a fully correct proof with a (minimal) conclusion.

(b)(i)	$2\text{cosec}4\theta - \cot 2\theta = \sqrt{3} \Rightarrow \tan 2\theta = \sqrt{3} \Rightarrow \theta = ...$	M1
	$\Rightarrow \theta = \dfrac{\arctan\sqrt{3}}{2} = \dfrac{\pi}{6}$ or awrt 0.524	A1

M1: Uses part (a) to write the given equation in form $\tan 2\theta = \sqrt{3}$ and proceeds to a value for θ by finding arctan of $\sqrt{3}$ and dividing by 2.

It may be implied by e.g. $A = 2\theta \rightarrow \tan A = \sqrt{3} \Rightarrow A = ...$ as long as they then find a value for θ by finding arctan of $\sqrt{3}$ and dividing by 2.

If a candidate restarts then they must reach $\tan 2\theta = \sqrt{3}$

A1: Achieves $\theta = \dfrac{\pi}{6}$ or accept awrt 0.524 but not 30°

Ignore extra solutions outside the range but withhold this mark if there are extra solutions in range. Must follow the award of M1 so correct answer only scores no marks.

(ii)	$\tan\theta + \cot\theta = 5 \Rightarrow \sin 2\theta = \dfrac{2}{5}$	M1
	$\Rightarrow \theta = \dfrac{1}{2}\arcsin\left(\dfrac{2}{5}\right) =$ awrt 0.206,1.37	M1 A1
		(5)
		(9 marks)

M1: Uses part (a) to deduce that $\sin 2\theta = \dfrac{2}{5}$

M1: Uses the correct order of operations to find at least one angle for θ

It is for $\sin 2\theta = k$ where $|k| < 1$ followed by $\theta = \dfrac{1}{2}\arcsin(k) = ...$

If working is not shown you may need to check.

A1: For awrt 0.206 and awrt 1.37 and no other values in the range.

Accept awrt 0.0656π and awrt 0.436π.

Apply isw if values are subsequently rounded further.

Answers in degrees score A0 and correct answers with no working scores no marks.

Special cases:

$$\tan\theta + \cot\theta = 5 \Rightarrow \frac{\sin\theta}{\cos\theta} + \frac{\cos\theta}{\sin\theta} = 5 \Rightarrow \frac{1}{\frac{1}{2}\sin 2\theta} = 5 \Rightarrow \sin 2\theta = \frac{2}{5}$$

Scores M1 for reaching $\sin 2\theta = \dfrac{2}{5}$ as in the main scheme and then **d**M1A1 as above.

BUT

$$\tan\theta + \cot\theta = 5 \Rightarrow \tan\theta + \frac{1}{\tan\theta} = 5 \Rightarrow \tan^2\theta - 5\tan\theta + 1 = 0$$

$$\Rightarrow \tan\theta = \frac{5 \pm \sqrt{21}}{2} \Rightarrow \theta = \text{awrt } 0.206, 1.37$$

Scores M1 for reaching $\tan\theta = \dfrac{5 \pm \sqrt{21}}{2}$ and obtains awrt 0.206 **or** awrt 1.37

and then M1 for reaching $\tan\theta = \dfrac{5 \pm \sqrt{21}}{2}$ and obtains awrt 0.206 **and** awrt 1.37

The A1 is **not** available as they have not used part (a).

Question Number	Scheme	Marks
6(a)	$\text{fg}(1) = \text{f}(2) = 7$	M1A1
		(2)
(b)	Either $\text{g}(0) = 3$ or $\text{g}(x \to \infty) \to 0.5$	M1
	$0.5 < \text{g}(x)$,, 3	A1
		(2)
(c)	$y = \dfrac{x+9}{2x+3} \Rightarrow y(2x+3) = x+9$ $\Rightarrow x(2y-1) = 9-3y \Rightarrow x = \dfrac{9-3y}{2y-1}$	M1
	$\text{g}^{-1}(x) = \dfrac{9-3x}{2x-1}, \quad 0.5 < x \leq 3$	A1, B1ft
		(3)
(d)	Attempts to find $\text{f}(0) = 2\times3+5=11$ OR $\text{f}(3) = 5$	M1
	$5 < k \leq 11$	A1 A1
		(3)
		(10 marks)

Notes

(a)

M1: Full method for substituting their g(1) into f.

Can also be scored for seeing $x = 1$ substituted into $2\left|3-\dfrac{x+9}{2x+3}\right|+5$

A1: 7. Sight of 7 can achieve both marks if no incorrect work is seen.
Do not accept multiple answers.

(b)

M1: Achieves the correct value for either end of the range. Sight of 0.5 or 3 or e.g. $\dfrac{9}{3}$ is sufficient.

A1: Correct range and correct notation. Accept $0.5 < y \leq 3$ or e.g. $0.5 < \text{g} \leq 3$ or e.g. $(0.5, 3]$

(c)

M1: Full attempt to change the subject for $y = \dfrac{x+9}{2x+3}$ or $x = \dfrac{y+9}{2y+3}$

They must cross multiply and collect terms to get $x = \dfrac{ay+b}{cy+d}$ or $y = \dfrac{ax+b}{cx+d}$ oe where

a, b, c and d are non-zero.

A1: $\text{g}^{-1}(x) = \dfrac{9-3x}{2x-1}$. Accept y or g^{-1} for $\text{g}^{-1}(x)$

B1ft: Correct domain or follow through on their answer for (b) but it must be appropriate notation in terms of x.

E.g. $0.5 < x$,, 3 or $(0.5, 3]$

Do not follow through on $y \in \mathbb{R} \to x \in \mathbb{R}$

(d)

M1: Attempts f(0) or f(3).

Evidence could be seeing $2|3-0|+5$ or $2|3-3|+5$ or the sight of 5 or 11

It may be seen as one of the limits on k.

A1: Achieves correct limits of 5 and 11 which may be seen embedded e.g. $5 < k \leqslant 11$

A1: Fully correct $5 < k \leq 11$ oe e.g. $(5, 11]$

Question Number	Scheme	Marks
7(a)	$t=0 \Rightarrow (P=) 200-\dfrac{160}{15+1}=190 \Rightarrow 190\ 000$	M1A1
		(2)
(b)	$e^{kt} \rightarrow ae^{kt}$	M1
	$\left(\dfrac{dP}{dt}=\right)-\dfrac{(15+e^{0.8t})\times 96e^{0.6t}-160e^{0.6t}\times 0.8e^{0.8t}}{(15+e^{0.8t})^2}$	M1A1
		(3)

Notes

(a)

M1: Sets $t = 0$ and uses $e^0 = 1$. It is for attempting $200-\dfrac{160}{15+1}$ but not $\dfrac{200-160}{15+1}$

This can be awarded for a correct answer.

A1: Correct answer only. Accept 190 000 or 190 thousand or (P =) 190 (bees).
The answer is an integer so do not allow awrt 190 or 190 000 i.e. no decimals.

(b)

M1: For evidence of $e^{kt} \rightarrow ae^{kt}$ where a is a constant.
This may be embedded within the quotient (or product) rule or their attempt to differentiate.

M1: For applying the quotient rule to obtain $\left(\dfrac{dP}{dt}=\right)\pm\dfrac{(15+e^{0.8t})\times pe^{0.6t}-qe^{0.8t}\times e^{0.6t}}{(15+e^{0.8t})^2}$ or the product rule to obtain $\left(\dfrac{dP}{dt}=\right)\pm\left[Ae^{0.6t}(15+e^{0.8t})^{-1}+Be^{0.6t}(15+e^{0.8t})^{-2}\times Ce^{0.8t}\right]$

Condone invisible brackets for this mark but not for the A mark below.

A1: A correct unsimplified or simplified derivative.

e.g. $\left(\dfrac{dP}{dt}=\right)-\dfrac{(15+e^{0.8t})\times 96e^{0.6t}-160e^{0.6t}\times 0.8e^{0.8t}}{(15+e^{0.8t})^2}$ oe

or e.g.

$\left(\dfrac{dP}{dt}=\right)-160\times 0.6e^{0.6t}(15+e^{0.8t})^{-1}+160\times 0.8e^{1.4t}(15+e^{0.8t})^{-2}$ oe

"$\dfrac{dP}{dt}=$" is **not** required so just look for a correct expression.

Apply isw once a correct derivative is seen.

(c)	Sets $\dfrac{(15+\mathrm{e}^{0.8t})\times 96\mathrm{e}^{0.6t}-160\mathrm{e}^{0.6t}\times 0.8\mathrm{e}^{0.8t}}{(15+\mathrm{e}^{0.8t})^2}=0$ $\Rightarrow (15+\mathrm{e}^{0.8t})\times 96\mathrm{e}^{0.6t}-160\mathrm{e}^{0.6t}\times 0.8\mathrm{e}^{0.8t}=0$ $\Rightarrow 1440\mathrm{e}^{0.6t}=32\mathrm{e}^{1.4t}$ or e.g. $\mathrm{e}^{0.8t}=45$ oe **or** $-160\mathrm{e}^{0.6t}(15+\mathrm{e}^{0.8t})^{-2}\times 0.8\mathrm{e}^{0.8t}+(15+\mathrm{e}^{0.8t})^{-1}\times 128\mathrm{e}^{0.6t}=0$ $\Rightarrow 1440\mathrm{e}^{0.6t}=32\mathrm{e}^{1.4t}$ or e.g. $\mathrm{e}^{0.8t}=45$ oe	M1A1
	$\Rightarrow T=\dfrac{\ln 45}{0.8}=4.76$	**d**M1A1
		(4)
		(9 marks)

Notes

Allow recovery here if signs are reversed in their derivative.

May work in *T* and/or *t*.

M1: Sets the numerator of their quotient rule attempt = 0 or sets their product rule attempt = 0 and obtains $p\mathrm{e}^{0.8t}=q$ or $A\mathrm{e}^{0.6t}=B\mathrm{e}^{1.4t}$ or equivalent.
The denominator of their quotient rule (correct or incorrect) can be ignored in part (c).

A1: $1440\mathrm{e}^{0.6t}=32\mathrm{e}^{1.4t}$ or $\mathrm{e}^{0.8t}=45$ or an equivalent correct equation.
Must follow correct work but allow this mark if the only error is reversed signs in their derivative.

dM1: Having set $\dfrac{\mathrm{d}P}{\mathrm{d}t}=0$ and obtained either $A\mathrm{e}^{\pm kt}=B$ (k may be incorrect) or $C\mathrm{e}^{\pm\alpha t}=D\mathrm{e}^{\pm\beta t}$ where $k,\alpha,\beta\neq 0$ it is for the correct order of operations including taking ln's leading to $t=\ldots$
May be implied by their value of t.
It cannot be awarded for impossible equations e.g. $\mathrm{e}^{0.8t}=-45$
Depends on the first method mark.

A1: $T=\dfrac{\ln 45}{0.8}$ or equivalent or awrt 4.76
Must follow correct work but allow this mark if the only error is reversed signs in their derivative.

Question Number	Scheme	Marks
8(a)	$R = \sqrt{109}$	B1
	$\tan\alpha = \frac{3}{10} \Rightarrow \alpha = \text{awrt}\, 16.70°$	M1A1
		(3)
(b)(i)	Max height = 12+ ' $\sqrt{109}$ '= awrt 22.44 (m)	B1ft
(ii)	Occurs when $30t + '16.70' = 180 \Rightarrow t = 5.44$	M1A1
		(3)

Notes

(a)

B1: $R = \sqrt{109}$. Apply isw after this is seen e.g. if they convert to a decimal.
Do not allow $R = \pm\sqrt{109}$.

M1: Attempts to find α. Look for $\tan\alpha = \pm\frac{3}{10} \Rightarrow \alpha = ...$ but condone $\tan\alpha = \pm\frac{10}{3} \Rightarrow \alpha = ...$

or if R is used allow $\sin\alpha = \pm\frac{3}{R} \Rightarrow \alpha = ...$ or $\cos\alpha = \pm\frac{10}{R} \Rightarrow \alpha = ...$

A1: $\alpha = \text{awrt}\, 16.70°$ but condone $\alpha = 16.7°$
It is **not** for awrt 16.7 e.g. 16.67 scores A0
An answer of $\alpha = \text{awrt}\, 0.29$ radians scores A0

(b)(i)

B1ft: For awrt 22.44 (m) or $12 + \sqrt{109}$ following a correct value for R but ft on their R value so allow for 12 + their R in exact form or for 12 + their R as awrt 2dp (you may need to check).
Units are **not** required but if any are present they should be correct.

(b)(ii)

M1: Attempts to solve $30t + '16.70' = 180$ to obtain a value for t.
If radians were used in part (a) then allow an attempt to solve $30t + '0.29' = \pi$
(which leads to $t = 0.095\ldots$) but do **not** allow mixing of degrees and radians e.g.
$30t + '0.29' = 180 \Rightarrow t = ...$
Allow methods that use e.g. $x = 30t \Rightarrow x + '16.70' = 180$ etc. provided they subsequently replace x with $30t$ and find t.
May be implied by their value for t.

A1: awrt 5.44 only.
If multiple solutions are found then awrt 5.44 must clearly be identified as their chosen solution.

(c)	$18 = 12 - \sqrt{109}\cos(30t + 16.70) \Rightarrow \cos(30t + 16.70) = -\dfrac{6}{\sqrt{109}}$ $(-0.57..)$	M1A1
	$\Rightarrow 30t + 16.70 = \arccos\left(-\dfrac{6}{\sqrt{109}}\right)(= 125.078...^\circ) \Rightarrow t = ..$	**d**M1
	$t =$ awrt 3.61(2dp)	A1
		(4)

Notes

M1: Uses $H = 18$ in their answer to part (a) and proceeds to $\cos(30t + '16.70') = k$ where $|k| < 1$

Allow this mark for $18 = 12 - "\sqrt{109}"\cos(30t + "16.70")$ leading to $\cos(30t + '16.70') = k$ where $|k| < 1$

A1: $\cos(30t + '16.70') = -\dfrac{6}{\sqrt{109}}$ or awrt $-0.57...$ following through on their α

May be implied by $30t + '16.70' =$ awrt 125° or awrt 2.2 radians.

dM1: Correct order of operations to find a **positive** value for t from their **negative** value for k.

The order of operations must be correct from their $\cos(30t + '16.70') = k$ $(-1 < k < 0)$ and the value chosen must be in the second quadrant.

Condone use of radians if consistent with their value of α e.g.

$18 = 12 - \sqrt{109}\cos(30t + "0.29") \Rightarrow \cos(30t + "0.29") = -\dfrac{6}{\sqrt{109}}$ $(-0.57..)$

$\Rightarrow 30t + "0.29" = \arccos\left(-\dfrac{6}{\sqrt{109}}\right) = 0.2183... \Rightarrow t = ..(0.0631\ldots)$

but do not allow mixing of degrees and radians.

Depends on the first method mark.

A1: awrt 3.61 and no other values following the award of M1, A1 dM1

Allow methods that use e.g. $x = 30t$ etc. provided they subsequently replace x with $30t$ and find t.

For reference:

Work and marks for a candidate working entirely in radians in (a), (b) and (c):

(a) $R = \sqrt{109}$, $\alpha = 0.29$ B1M1A0

(b)(i) 12+ '$\sqrt{109}$'= awrt 22.44 m B1

(b)(ii) $30t + 0.29 = \pi \Rightarrow t = 0.095...$ M1A0

(c) $18 = 12 - \sqrt{109}\cos(30t + 0.29) \Rightarrow \cos(30t + 0.29) = -\dfrac{6}{\sqrt{109}}$ $(-0.57..)$ M1A1

$\Rightarrow 30t + 0.29 = \arccos\left(-\dfrac{6}{\sqrt{109}}\right)(= 2.183...) \Rightarrow t = ..$ M1

$\Rightarrow t = 0.063...$ A0

(d)	$30t = 360 \Rightarrow t = ..$ or $30t = 720 \Rightarrow t = ..$	M1
	24 minutes	A1
		(2)
Notes		
M1: Attempts to solve either $30t = 360$ or $30t = 720$ to find t or else states 12 or 24		
A1: 24 minutes. Requires minutes or e.g. "mins", "min", "m".		
		(12 marks)

Please check the examination details below before entering your candidate information

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Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Tuesday 21 October 2025

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

The functions f and g are defined by

$$f(x) = \ln(x^2 + 3) \qquad x \in \mathbb{R}$$

$$g(x) = \frac{3 + 5x}{x + 2} \qquad x \in \mathbb{R} \quad x > -2$$

(a) State the range of f

(1)

(b) Find g^{-1}

(3)

(c) Find $fg(0)$

(2)

(d) Find the exact value of a for which

$$g\left(e^{2a}\right) = f\left(\sqrt{e^4 - 3}\right)$$

(3)

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Question 1 continued

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Question 1 continued

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2.

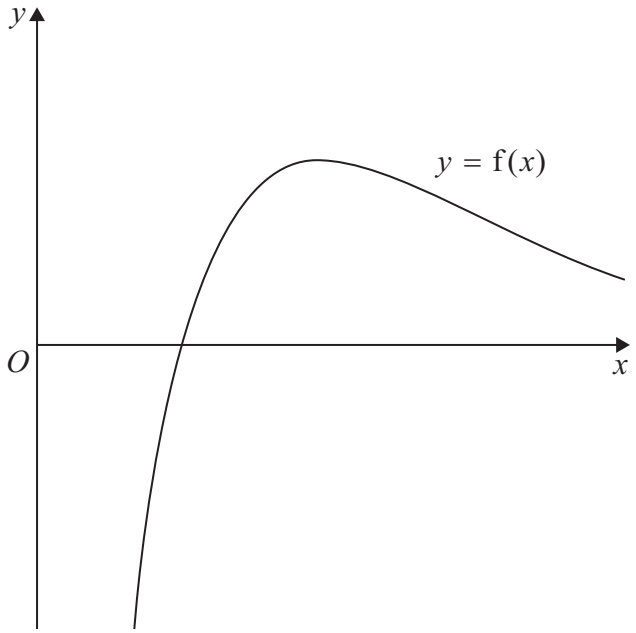

Figure 1

Figure 1 shows a sketch of part of the curve with equation $y = f(x)$ where

$$f(x) = \frac{2x^2 + 3x - 4}{e^x} - \frac{1}{x^2} \qquad x \in \mathbb{R} \quad x \neq 0$$

(a) Show that $f(x) = 0$ has a root α in the interval $[1, 2]$

(2)

(b) Show that the equation $f(x) = 0$ can be written in the form

$$x = \sqrt[3]{\frac{e^x + 4x^2}{2x + 3}}$$

(2)

Using the iteration formula

$$x_{n+1} = \sqrt[3]{\frac{e^{x_n} + 4x_n^{\,2}}{2x_n + 3}} \qquad \text{with } x_1 = 1$$

find, to 4 decimal places,

(c) (i) the value of x_3

(ii) the value of α

(3)

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Question 2 continued

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Question 2 continued

(Total for Question 2 is 7 marks)

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3. The share price, £V, of a company is being monitored.

A graph is drawn of $\log_{10} V$ against t, where t is the number of years after monitoring began.

The graph is a straight line passing through the points $(0, 2)$ and $(5, 2.25)$

Using this information,

(a) find an equation for the line in the form

$$\log_{10} V = mt + c$$

where m and c are constants.

(2)

(b) Write the answer to part (a) in the form

$$V = ab^t$$

where a and b are constants to be found.

Give the exact value of a and the value of b to 3 significant figures.

(3)

When $t = T$, the rate of increase in the share price of the company was £50 per year.

(c) Find the value of T, giving your answer to the nearest integer.

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

(4)

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Question 3 continued

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Question 3 continued

(Total for Question 3 is 9 marks)

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

(a) $f(x) = \sqrt{3}\sin 2x - 3\cos 2x$

Express $f(x)$ in the form $R\sin(2x - \alpha)$, where R and α are constants,

$$R > 0 \text{ and } 0 < \alpha < \frac{\pi}{2}$$

Give the exact value of R and the exact value of α.

(3)

(b) $$g(x) = \frac{18}{f(3x) + 4\sqrt{3}} \qquad x > 0$$

Using the answer to part (a),

(i) write down the exact minimum value of $g(x)$,

(ii) find the smallest value of x for which this minimum value occurs.

You must make your method clear.

(3)

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Question 4 continued

(Total for Question 4 is 6 marks)

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

The number of squirrels in a forest is being studied.

The number of squirrels, N, in the forest, t years after the start of the study, is modelled by the equation

$$N = \frac{4000e^{0.1t}}{19 + e^{0.2t}} \qquad t \geqslant 0$$

Use the equation of the model to answer parts (a), (b), (c) and (d).

(a) Find the number of squirrels in the forest at the start of the study.

(1)

(b) Find $\frac{dN}{dt}$

(2)

The number of squirrels in the forest is at a maximum when $t = T$

Using the answer to part (b),

(c) show that $e^{0.2T} = A$, where A is a constant to be found.

(2)

(d) Hence find the maximum number of squirrels in the forest.

Show your working and give your answer to the nearest whole number.

(3)

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Question 5 continued

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Question 5 continued

(Total for Question 5 is 8 marks)

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

(i) Given $y = \ln\left(2x^2 + 5\right)$ find $\dfrac{\mathrm{d}y}{\mathrm{d}x}$

(2)

(ii) A curve C has equation $y = \mathrm{f}(x)$ where

$$\mathrm{f}(x) = \frac{21x}{3x^2 + k} \qquad x \in \mathbb{R}$$

where k is a positive integer, $k > 1$

Given that

$$\int_1^k \mathrm{f}(x)\,\mathrm{d}x < 7\ln 8$$

find the greatest possible value of k

(5)

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Question 6 continued

(Total for Question 6 is 7 marks)

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

A curve C has equation

$$y = 2xe^{x^2+(3k-2)x}$$

where k is a constant.

Given that C has two distinct turning points, find the range of possible values of k.

(7)

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Question 7 continued

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Question 7 continued

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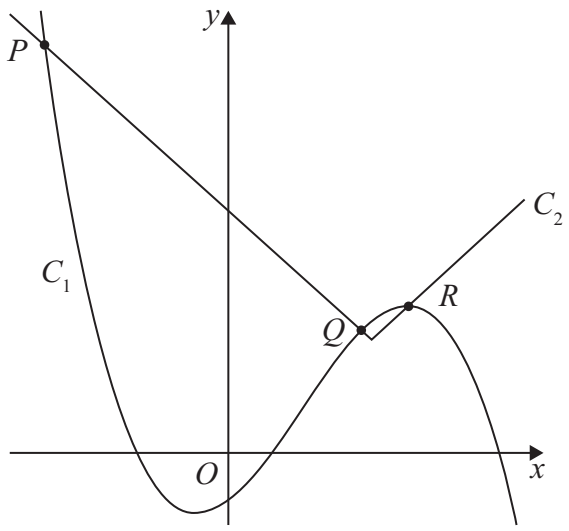

Figure 2

Figure 2 shows a sketch of the graph C_1 with equation

$$y = -2x^3 + 5x^2 + 4x - 3$$

and a sketch of the graph C_2 with equation

$$y = a + |5x + b|$$

where a and b are constants.

Graphs C_1 and C_2 intersect at point P, point Q and point R, as shown in Figure 2.

Given that P has coordinates $(-2, 25)$

(a) show that

$$a = 15 + b$$

(2)

Given also that R has coordinates $(2, 9)$

(b) find the value of a and the value of b

(3)

Using the answer to part (b),

(c) state the coordinates of the vertex of C_2

(2)

(d) Find, using algebra, the coordinates of Q. Show each stage of your working.

(*Solutions relying on calculator technology are not acceptable.*)

(6)

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Question 8 continued

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Question 8 continued

(Total for Question 8 is 13 marks)

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

(a) Express

$$6\sin^2\theta\cot 2\theta + 4\sin\theta\cos\theta$$

in terms of $\sin 2\theta$ and $\cos 2\theta$ only.

(3)

(b) Hence show that the equation

$$3\cot 2\theta - 14 = 6\sin^2\theta\cot 2\theta + 4\sin\theta\cos\theta$$

can be written in the form

$$5\sin^2 2\theta + 14\sin 2\theta - 3 = 0$$

(3)

(c) Hence solve, for $0 < x < 90°$, the equation

$$3\cot 2x - 14 = 6\sin^2 x\cot 2x + 4\sin x\cos x$$

giving your answers to one decimal place.

(3)

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Question 9 continued

Question 9 continued

(Total for Question 9 is 9 marks)

TOTAL FOR PAPER IS 75 MARKS

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Mark Scheme (Results)

October 2025

International Advanced Level in Pure Mathematics P3

WMA13/01

Edexcel and BTEC Qualifications

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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 √ 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 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 $x = \ldots$

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

2. Formula

Attempt to use correct formula (with values for a, b and c)

3. Completing the square

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

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)	$\mathrm{f}(x) \geqslant \ln 3$	B1
		(1)
(b)	$\mathrm{g}^{-1}(x) = \dfrac{3-2x}{x-5}$ or $-2-\dfrac{7}{x-5}$ oe $x<5$	M1A1 B1
		(3)
(c)	$\mathrm{g}(0) = \dfrac{3}{2} \Rightarrow \mathrm{f}\left(\dfrac{3}{2}\right) = \ln\left(\dfrac{21}{4}\right)$	M1A1
		(2)
(d)	$\dfrac{3+5\mathrm{e}^{2a}}{\mathrm{e}^{2a}+2} = 4 \Rightarrow 5\mathrm{e}^{2a}+3 = 4\mathrm{e}^{2a}+8 \Rightarrow \mathrm{e}^{2a} = \ldots$ $\mathrm{e}^{2a} = 5 \Rightarrow 2a = \ln 5 \Rightarrow a = \ldots$ $a = \dfrac{1}{2}\ln 5$	M1 dM1 A1
		(3)
		(9 marks)

(a)

B1: $\mathrm{f}(x) \geqslant \ln 3$ o.e. Accept with *y* in place of f(*x*).

(b)

M1: Attempts to rearrange to find the inverse. Score for achieving the form $y = \dfrac{\pm 3 \pm 2x}{\pm x \pm 5}$ or $x = \dfrac{\pm 3 \pm 2y}{\pm y \pm 5}$. If they use $y = 5 - \dfrac{7}{\mathrm{x}+2}$ score for reaching $x = \dfrac{\pm 7}{\pm 5 \pm y} \pm 2$ oe for *y* =….

A1: $\mathrm{g}^{-1}(x) = \dfrac{3-2x}{x-5}$ o.e. (e.g. see scheme). Allow with just g^{-1} or *y* or even f^{-1}

B1: $x<5$

(c)

M1: Attempts to find $\mathrm{fg}(0)$. May find the function $\mathrm{fg}(x)$ and substitute 0 into this. Condone slips. May be implied by awrt 1.7 if no substitution is shown.

A1: $\ln\left(\dfrac{21}{4}\right)$ or exact simplified equivalent and isw.

(d)

M1: Sets $\dfrac{3+5\mathrm{e}^{2a}}{\mathrm{e}^{2a}+2} = 4$ and proceeds to make e^{2a} (or condone $A\mathrm{e}^{2a}$) the subject. They must achieve the 4 although this may appear later in working.

Alternatively, sets $\mathrm{g}^{-1}\mathrm{g}(\mathrm{e}^{2a}) = \mathrm{g}^{-1}\mathrm{f}\left(\sqrt{\mathrm{e}^4-3}\right) \Rightarrow \mathrm{e}^{2a} = \mathrm{g}^{-1}(4) = \dfrac{-5}{-1} = 5$

dM1: Takes valid lns of both sides (must be lns of positive numbers) and proceeds to find a value for *a*. It is dependent on the previous method mark.

A1: $(a=)\ \frac{1}{2}\ln 5$ or exact equivalent and isw

Question Number	Scheme	Marks
2(a)	$f(1)=\frac{2(1)^2+3(1)-4}{e^1}-\frac{1}{1^2}=\ldots$ **and** $f(2)=\frac{2(2)^2+3(2)-4}{e^2}-\frac{1}{(2)^2}=\ldots$	M1
	$f(1)=-0.6(321\ldots)[<0]$ **and** $f(2)=1.(103\ldots)[>0]$ $\Rightarrow$ There is a sign change and f(x) is continuous over the interval hence root (in the interval $[1,2]$)	A1
		(2)
(b)	$\frac{2x^2+3x-4}{e^x}-\frac{1}{x^2}=0\Rightarrow 2x^4+3x^3=e^x+4x^2$	M1
	$x^3(2x+3)=e^x+4x^2\Rightarrow x=\sqrt[3]{\frac{e^x+4x^2}{2x+3}}$ *	A1*
		(2)
(c) **(i)**	$x_2=\sqrt[3]{\frac{e^1+4(1)^2}{2(1)+3}}=\text{awrt}\,1.1035\Rightarrow x_3=\text{awrt}\,1.1484$	M1A1
(ii)	1.1813	A1
		(3)
		(7 marks)

(a)

M1: Attempts $f(1)$ and $f(2)$. Values embedded in the expression is sufficient (accept slips if the intention is clear), or if no substitution is seen accept one correct value (truncated or rounded to 1sf) with an attempt at both made.

A1: Both $f(1)$ and $f(2)$ correct (truncated or rounded to 1sf), reason (e.g. "sign change" or < 0, > 0 shown) and conclusion. Must refer to the function being continuous (over the interval) in some way, though be tolerant with language used.

Note: a narrower interval may be used but if so must contain the root 1.183… to score the M.

(b)

M1: Sets f(x) = 0 (may be implied), attempts to multiply both sides by x^2 and e^x and isolates the quartic and cubic terms on one side.

A1*: Factorises the left-hand side and proceeds to the given answer via an intermediate step with no errors seen.

Note: Working backwards is possible. For the M look for cubing and cross multiplying to reach a similar intermediate stage, and all correct for the A mark.

(c)

(i)

M1: Substitutes $x = 1$ into the iterative formula. May be implied by awrt 1.10 or awrt 1.15 if substitution not seen. Condone miscopies if the substitution is shown. NB Correct value for x_3 stated implies this mark.

A1: (x_3 =) awrt 1.1484. Must be x_3 and not another term (if labelled).

(ii)

A1: cao 1.1813 as the final answer (cannot be scored without M1 being scored in (c)(i))

Question Number	Scheme	Marks
3(a)	$m = \dfrac{2.25-2}{5}$ $\log_{10} V = 0.05t + 2$	M1 A1
		(2)
(b)	$\log_{10} V = 0.05t + 2 \Rightarrow V = 10^{0.05t+2}$ $a = 100$ or $b = 1.12$ $V = 100\times(1.12)^t$	M1 A1 A1
		(3)
(c)	$\dfrac{\mathrm{d}V}{\mathrm{d}t} = 100\times\ln 1.12\times(1.12)^t \quad \left(=11.33(1.12)^t\right)$ $100\times\ln 1.12\times(1.12)^T = 50 \Rightarrow (1.12)^T = \dfrac{50}{100\ln 1.12}$ $(T=)\ \log_{1.12}\left(\dfrac{50}{100\ln 1.12}\right) = \ldots$ $(T=)13$	B1ft M1 dM1 A1
		(4)
		(9 marks)

(a)

M1: Attempts to find the gradient of the line, must be change in "*y*"/change in "*x*". May be found via simultaneous equations – look for an attempt to solve the correct equations.

A1: $\log_{10} V = 0.05t + 2$ Accept log in place of $\log_{10}$ here and throughout but must be correct variables.

(b)

M1: Correct attempt to make *V* the subject, or alternatively takes log of $V = ab^t$ and finds an equation in just *a* or *b* ie either $2 = \log_{10} a$ or $\dfrac{1}{20} = \log_{10} b$. If there is no incorrect working allow for obtaining an expression for *a* or *b*, e.g. $a = 10^2$ or $b = 10^{0.05}$.

A1: $a = 100$ or $b = \text{awrt}\,1.12$ (may be stated or embedded in an equation of the correct form).

A1: $V = 100\times(\text{awrt } 1.12)^t$. The equation must be given not just values.
SC Award M1A1A0 for candidates who start with an incorrect step of $V = 10^{0.05t} + 10^2$ but recover to $V = 10^2\times 10^{0.05t} = 100(1.12)^t$ in subsequent work (and similar for variants).

(c)

B1ft: Differentiates to the form $"100"\ln"1.12"\times("1.12")^t$ follow through their values for *a* and *b* from part (b). Accept any unsimplified equivalents and values correct to 3sf.

M1: Sets their $\frac{\mathrm{d}V}{\mathrm{d}t}$ - which must be a changed function of the form $K("1.12")^t$ (*K* may be 1) equal to 50 and rearranges to the form $("1.12")^T = ...$

dM1: Correctly proceeds from and equation of form $("1.12")^T = ...$ to $T = ...$ (any valid means, you may need to check their value if no method is shown).

Question Number	Scheme	Marks
4(a)	$R = \sqrt{12}$ or $2\sqrt{3}$	B1
	$\alpha = \tan^{-1}\left(\frac{3}{\sqrt{3}}\right) = ...$	M1
	$\left(f(x) =\right)\sqrt{12}\sin\left(2x - \frac{\pi}{3}\right)$	A1
		(3)
(b)(i)	Minimum value $= \frac{18}{\sqrt{12}+4\sqrt{3}}\left(=\sqrt{3}\right)$	B1
(ii)	$\sin\left(6x - \frac{\pi}{3}\right) = 1 \Rightarrow x = \frac{5}{36}\pi$	M1A1
		(3)
		(6 marks)

A1: $\left(T =\right)13$

(a)

B1: $\sqrt{12}$ oee

M1: Attempts to find $\alpha = \tan^{-1}\left(\pm\frac{3}{\sqrt{3}}\right) = ...$ or $\alpha = \tan^{-1}\left(\pm\frac{\sqrt{3}}{3}\right) = ...$ or $\alpha = \cos^{-1}\left(\pm\frac{\sqrt{3}}{2\sqrt{3}}\right) = ...$ or $\alpha = \sin^{-1}\left(\pm\frac{3}{2\sqrt{3}}\right) = ...$

A1: $\left(f(x) =\right)\sqrt{12}\sin\left(2x - \frac{\pi}{3}\right)$ (or exact equivalent). Must give the expression but accept if given in (b), not just the values for R and α, but full marks can be scored in subsequent parts from the correct values if the expression is not explicitly stated.

(b)
(i)

B1: $\sqrt{3}$ or exact equivalent. No need to simplify. If multiple answers are given they must clearly identify this as the minimum value to score the mark.

(ii)

M1: Sets their $\sin\left(6x-\frac{\pi}{3}\right)=1$ and attempts to find a value for *x*. Follow through on f(3*x*) for their f(*x*).

A1: $\frac{5}{36}\pi$ only

Note: Answers only with no working shown is M0 (calculator method).

Question Number	Scheme	Marks
5(a)	$\left(\frac{4000\mathrm{e}^{0}}{19+\mathrm{e}^{0}}\right)=200$	B1
		(1)
(b)	$\frac{\mathrm{d}N}{\mathrm{d}t}=\frac{\left(19+\mathrm{e}^{0.2t}\right)\times 400\mathrm{e}^{0.1t}-4000\mathrm{e}^{0.1t}\times 0.2\mathrm{e}^{0.2t}}{\left(19+\mathrm{e}^{0.2t}\right)^{2}}$	M1A1
		(2)
(c)	$\left(19+\mathrm{e}^{0.2t}\right)\times 400\mathrm{e}^{0.1t}-4000\mathrm{e}^{0.1t}\times 0.2\mathrm{e}^{0.2t}=0\Rightarrow \mathrm{e}^{0.2T}=19$	M1A1
		(2)
(d)	$\mathrm{e}^{0.2T}=19\Rightarrow T=\frac{\ln 19}{0.2}\ (=14.7...)$ $N=\frac{4000\mathrm{e}^{0.1"14.7"}}{19+\mathrm{e}^{0.2"14.7"}}=458.8...\Rightarrow 459$ squirrels	M1 dM1A1
		(3)
		(8 marks)

(a)

B1: 200

(b)

M1: Attempts to differentiate via the quotient rule (or the product rule). Look for reaching $\frac{\left(19+\mathrm{e}^{0.2\mathrm{t}}\right)\times A\mathrm{e}^{0.1t}-B\mathrm{e}^{0.1t}\times\mathrm{e}^{0.2t}}{\left(19+\mathrm{e}^{0.2\mathrm{t}}\right)^{2}}$ or $A\mathrm{e}^{0.1t}\times\left(19+\mathrm{e}^{0.2\mathrm{t}}\right)^{-1}+B\mathrm{e}^{0.1t}\times-\left(19+\mathrm{e}^{0.2\mathrm{t}}\right)^{-2}\times\mathrm{e}^{0.2t}$ where $A, B > 0$

Condone missing brackets for the M mark.

A1: Correct unsimplified derivative and isw. Any missing brackets must have been recovered.

(c)

M1: Sets their numerator of the form $\pm P\mathrm{e}^{0.1T}\pm Q\mathrm{e}^{0.3T}$ (or unsimplified equivalent) equal to zero and rearranges to $\mathrm{e}^{0.2T}=A$

A1: $\mathrm{e}^{0.2T}=19$ and isw. Accept with t instead of T. Allow from answers to (b) with an incorrect denominator but correct numerator or negative of the numerator.

(d)

M1: Takes lns of both sides and proceeds to find a value for T (accept awrt 14.7 if method is not shown). There must be evidence of using logarithms. Alternatively score for stating or implying $\mathrm{e}^{0.1t}=\sqrt{19}$

dM1: Substitutes their positive value for T or $e^{0.1t}$ into the original equation to find a value for N. It is dependent on the previous method mark.

A1: 459 (accept 458) provided the Ms have been scored. The $e^{0.2T} = 19$ must have been genuinely found, not fluked from an incorrect numerator. However, as long as the numerator was correct in (b), this mark may be

Question Number	Scheme	Marks
6(i)	$\left(\frac{\mathrm{d}y}{\mathrm{d}x}=\right)\ \frac{4x}{2x^2+5}$	M1A1
		(2)
(ii)	$\int \frac{21x}{3x^2+k}\mathrm{d}x=\frac{7}{2}\ln(3x^2+k)\ \ (+c)$	M1A1
	$\left[\frac{7}{2}\ln(3x^2+k)\right]_1^k<7\ln 8\Rightarrow\frac{7}{2}\ln\left(\frac{3k^2+k}{3+k}\right)<7\ln 8\Rightarrow\frac{3k^2+k}{3+k}<64$	M1
	$\frac{3k^2+k}{3+k}(<)64\Rightarrow 3k^2-63k-192\ \ (<0)\Rightarrow k=\ldots$	dM1
	$k=23$	A1
		(5)
		(7 marks)

awarded if subsequent working was correct.

(i)

M1: $\frac{\ldots}{2x^2+5}$. Allow with anything for the …

A1: $\left(\frac{\mathrm{d}y}{\mathrm{d}x}=\right)\ \frac{4x}{2x^2+5}$ o.e. and isw

(ii)

M1: Attempts to integrate to an expression of the form $A\ln(3x^2+k)$ or $B\ln\left(x^2+\frac{k}{3}\right)$. Allow for cancelling x's e.g $\frac{Ax\ln(3x^2+k)}{x}$ (Allow A or B to be 1)

A1: $\frac{7}{2}\ln(3x^2+k)$ o.e. with or without the constant of integration. Condone missing brackets for this mark and condone if extra integral symbols are left in.

M1: Attempts to substitute in the limits into their changed expression (which must involve ln), sets the expression less than $7\ln 8$ (condone an equation)

and uses correct log laws to remove lns – including correct bracketing used. You may allow ln 8 to be written as a decimal but any ln or exponential work must be correct. Note the form for their integral must be such that they are able to use log laws to remove lns.

dM1: Rearranges their inequality (may be an equation), proceeds to a three-term quadratic in k and attempts to find a value for k (usual rules apply for solving a quadratic – if using a calculator the value(s) must be correct for their equation). It is dependent on the previous method mark.

A1: 23 cao

Question Number	Scheme	Marks
7	$\left(\dfrac{\mathrm{d}y}{\mathrm{d}x}=\right) 2\mathrm{e}^{x^2+(3k-2)x}+2x\mathrm{e}^{x^2+(3k-2)x}\times\left(2x+(3k-2)\right)$ $\Rightarrow 2x^2+(3k-2)x+1=0 \Rightarrow (3k-2)^2-4\times2\times1$ $9k^2-12k-4\left(>0\right)$ $9k^2-12k-4=0 \Rightarrow k=\dfrac{12\pm\sqrt{(-12)^2-4\times9\times(-4)}}{2\times9} \Rightarrow k=\ldots$ $k<\dfrac{2-2\sqrt{2}}{3}$ or $k>\dfrac{2+2\sqrt{2}}{3}$	M1A1A1 dM1A1 M1A1
		(7 marks)

M1: Attempts the product rule achieving $\left(\dfrac{\mathrm{d}y}{\mathrm{d}x}=\right) A\mathrm{e}^{\left(x^2+(3k-2)x\right)}+\mathrm{e}^{\left(x^2+(3k-2)x\right)}\times\mathrm{f}(x)$ where f(x) is a quadratic function of x, condone missing/misplaced brackets for the M.

A1: One of $2\mathrm{e}^{x^2+(3k-2)x}$ or $2x\mathrm{e}^{x^2+(3k-2)x}\times\left(2x+(3k-2)\right)$ (unsimplified)

A1: Correct unsimplified derivative

dM1: Sets their derivative equal to zero (may be implied), collects terms and attempts b^2-4ac on a 3 term quadratic – must be extracted not just part of the quadratic formula. It is dependent on the previous method mark.

A1: $(3k-2)^2-8(>0)$ or equivalent quadratic expression or multiple thereof. Need not be simplified.

M1: Must have attempted $\dfrac{\mathrm{d}y}{\mathrm{d}x}=0$ and reached a quadratic in k. Attempts to solve their quadratic in k (including via a calculator) and attempts the outside region for their critical values (accept with endpoints included.). Accept with decimals answer correct to 3 s.f. for this mark.

A1: $k<\dfrac{2-2\sqrt{2}}{3}$ or $k>\dfrac{2+2\sqrt{2}}{3}$ or exact equivalent. Allow with "and" instead of "or" when given as two ranges, but use of set notation must use union, not intersection. E.g. $k\in\left(-\infty,\dfrac{2-2\sqrt{2}}{3}\right)\cup\left(\dfrac{2+2\sqrt{2}}{3},\infty\right)$

Alternative method via implicit differentiation scores the same way with M1A1A1 for correct differentiation. M1 for a correct form of derivative statement up to constant/sign errors.

NB: method must be seen for the dM mark, if critical values appear from a derivative statement with no method shown (by calculator) then it is dM0. The discriminant must be considered. But the last mark is not dependent, so may be scored for selecting the correct "outside" region for their cvs.

Question Number	Scheme	Marks
8(a)	$25 = a + -(5\times -2+b)\ (\Rightarrow 25 = a+10-b) \Rightarrow a = 15+b$ *	M1A1*
		(2)
(b)	$9 = a+10+b \Rightarrow a = \ldots$ or $b = \ldots.$ $a = 7,\ b = -8$	M1 A1A1
		(3)
(c)	$\left(\frac{8}{5}, 7\right)$	B1ftB1
		(2)
(d)	$15-5x = -2x^3+5x^2+4x-3 \Rightarrow 2x^3-5x^2-9x+18=0$ $2x^3-5x^2-9x+18 = (x+2)(2x^2-9x+9)$ $2x^2-9x+9=0 \Rightarrow x = \frac{3}{2}$ (ignore $x=3$) $\left(\frac{3}{2}, \frac{15}{2}\right)$	M1 dM1A1 ddM1 M1A1
		(6)
		(13 marks)

(a)

M1: Substitutes $(-2,\ 25)$ into $y = a-(5x+b)$. You must **either** see a correct unsimplified equation without the modulus before the answer **or** indication of correct branch with attempt to substitute.
Note they may use the cubic and substitute $x = -2$ to achieve the 25.
For methods via squaring send to review if you are unsure if the marks are deserved.

A1*: Achieves the given answer with no errors seen following a correct unsimplified equation.
If they attempt both equations, they must clearly indicate the choice of solution.

(b)

M1: Substitutes $(2,\ 9)$ into $y = a+(5x+b)$ and solves simultaneously with the equation from (a) to find a value for *a* or a value for *b*. May be implied by a correct value for *a* or *b*.

A1: One of $a = 7,\ b = -8$

A1: Both $a = 7,\ b = -8$ only

Note if there are attempts at squaring they must reach only the correct values. If unsure, use review.

(c)

B1ft: One of the coordinates of $\left(\frac{8}{5}, 7\right)$. Follow through their *a* and *b* for this mark ie one of $\left(-\frac{b}{5}, a\right)$

B1: $\left(\frac{8}{5}, 7\right)$ Aceept as *x* = …, *y* = …

(d)

M1: Sets their $y = 15 - 5x$ equal to $-2x^3 + 5x^2 + 4x - 3$ and collects terms to achieve a cubic. Condone a miscopy of the cubic if the intention is clear.

dM1: Attempts to find a quadratic factor (by division or equating coefficients). It is dependent on the previous method mark. For factorisation expect to see $(x \pm 2)(2x^2 + ...\pm 9)$ or via division $(x \pm 2)(2x^2 + ...x + ...)$ Valid non-calculator method must be seen, solutions which go direct to a "factorised" form with no intermediate quadratic factor seen score dM0. Note they may use another linear factor to divide through by, the scheme applies the same way, but must be one of the correct factors.

A1: $2x^2 - 9x + 9$ (or correct factor for their linear term).

ddM1: Attempts to solve their quadratic via a non-calculator method, leading to a value for *x*. It is dependent on the previous two method marks. Valid non-calculator method must be seen to award this mark.

M1: Proceeds to find both coordinates of Q, accepting answers where the *x* value was found via a calculator. It is not dependent on the previous Ms but must attempted an initial equation using the cubic and either branch, set up to show what has been solved on the calculator. Correct answer with no working at all seen will score no marks.

A1: $\left(\frac{3}{2}, \frac{15}{2}\right)$ (oee) only. A0 if a second set of coordinates is given. Allow for solutions where the cubic or quadratic was solved via calculator.
Allow listed as *x* =…, *y* = … and isw but must clear clearly seen as the correct coordinates.

Attempts at squaring, use review if you are unsure how to score unsuccessful attempts.

NB If no quadratic factor or suitable method is seen to solve the cubic then maximum of three mark is available, M1dM0A0ddM0M1A1.
If the quadratic factor is reached but the quadratic is solved via calculator a maximum of 5 marks may be scored, M1dM1A1ddM0M1A1.
M0dM0A0ddM0M1A1 is also possible if they give the initial equation and proceed to give the solutions without first gathering terms.
A non-calculator approach must be shown for full marks.

Question Number	Scheme	Marks
9(a)	$4\sin\theta\cos\theta = 2\sin 2\theta$	B1
	e.g. $\Rightarrow 6\sin^2\theta\cot 2\theta + 2\sin 2\theta = (3-3\cos 2\theta)\dfrac{\cos 2\theta}{\sin 2\theta} + 2\sin 2\theta$	M1A1
		(3)
(b)	$3\cot 2\theta - 14 = 6\sin^2\theta\cot 2\theta + 4\sin\theta\cos\theta$	
	e.g. $\Rightarrow 3\cot 2\theta\sin 2\theta - 14\sin 2\theta = (3-3\cos 2\theta)\cos 2\theta + 2\sin^2 2\theta$	M1
	$\Rightarrow -14\sin 2\theta = -3(1-\sin^2 2\theta) + 2\sin^2 2\theta$	M1
	$5\sin^2 2\theta + 14\sin 2\theta - 3 = 0$ *	A1*
		(3)
(c)	$(\sin 2x =)\dfrac{1}{5} \Rightarrow x = \ldots$	M1
	$x = \text{awrt } 5.8°,\ \text{awrt } 84.2°$	A1A1
		(3)
		(9 marks)

(a)

B1: $4\sin\theta\cos\theta = 2\sin 2\theta$ (seen or implied)

M1: Attempts to use $\cos 2\theta = \pm 1 \pm 2\sin^2\theta$ and $\cot 2\theta = \dfrac{\cos 2\theta}{\sin 2\theta}$ or alternative versions of these formulae to get to an expression in just $\sin 2\theta$ and $\cos 2\theta$. Other routes are possible, but any trig identities must be correct up to sign error to reach an expression in just $\sin 2\theta$ and $\cos 2\theta$.

A1: $(3-3\cos 2\theta)\dfrac{\cos 2\theta}{\sin 2\theta} + 2\sin 2\theta$ or equivalent. isw once a correct expression is seen. Alternatives are possible here.

(b)

M1: Uses their expression from part (a) in the given equation and attempts to multiply both sides by $\sin 2\theta$. Alternatively they may rework part (a) again in this part but must reach an expression in terms of $\sin 2\theta$ and $\cos 2\theta$ only on one line.

M1: Cancels $3\cos 2\theta$ from both sides, attempts to use $\pm\sin^2 2\theta \pm \cos^2 2\theta = \pm 1$ and proceeds to a 3TQ in $\sin 2\theta$ only (terms do not need to be collected on the same side)

A1*: Achieves the given answer with no errors seen (including invisible brackets).

(c)

M1: Solves the quadratic (usual rules, accept calculator usage) and attempts to use arcsin find a value for x. Accept if radians used or they neglect to divide by 2 as long as a value for x is reached. Condone use of θ throughout this part.

A1: One of awrt 5.8 or awrt 84.2 (provided $\sin 2x = \frac{1}{5}$ or $2x = \sin^{-1}\left(\frac{1}{5}\right)$ is seen)

A1: $\text{awrt } 5.8, \text{ awrt } 84.2$ (provided $\sin 2x = \frac{1}{5}$ or $2x = \sin^{-1}\left(\frac{1}{5}\right)$ is seen) and no others in the given range.

Pearson Edexcel International Advanced Level

Tuesday 28 October 2025

Afternoon (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

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P 8 7 4 3 6 A

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1. Prove by contradiction that, if a and b are real numbers, $a > 0$ and $b > 0$, then

$$\frac{9a}{b} + \frac{4b}{a} \geqslant 12$$

(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.

Use integration by parts to find the exact value of $\int_1^{\mathrm{e}} \frac{\ln x}{x^2}\,\mathrm{d}x$

Write your answer in the form $a + \frac{b}{\mathrm{e}}$, where a and b are integers.

(6)

(Total for Question 2 is 6 marks)

---

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

A curve C has equation

$$3^x + 6y = \frac{3}{2}xy^2$$

Find the exact value of $\frac{\mathrm{d}y}{\mathrm{d}x}$ at the point on C with coordinates (2, 3). Give your answer in the form $\frac{a + \ln b}{8}$, where a and b are integers.

(7)

(Total for Question 3 is 7 marks)

---

4. (a) Use the binomial expansion, in ascending powers of x, of $\frac{1}{\sqrt{(1-2x)}}$ to show that

$$\frac{2+3x}{\sqrt{(1-2x)}} \approx 2 + 5x + 6x^2 \qquad |x| < 0.5$$

(4)

(b) Substitute $x = \frac{1}{20}$ into

$$\frac{2+3x}{\sqrt{(1-2x)}} = 2 + 5x + 6x^2$$

to obtain an approximation to $\sqrt{10}$

Give your answer as a fraction in its simplest form.

(3)

(Total for Question 4 is 7 marks)

5.

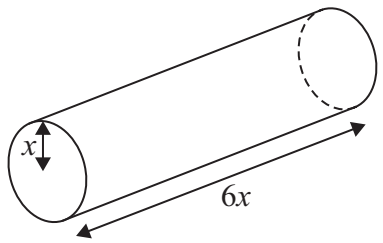

Figure 1

Figure 1 shows a right circular cylindrical rod which is expanding as it is heated.

At time t seconds the radius of the rod is x cm and the length of the rod is $6x$ cm.

Given that the **cross-sectional area** of the rod is increasing at a constant rate of $\frac{\pi}{20}$ cm^2 s^{-1}, find the rate of increase of the volume of the rod when $x = 2$

Write your answer in the form $k\pi$ cm^3 s^{-1} where k is a rational number.

(6)

(Total for Question 5 is 6 marks)

6.

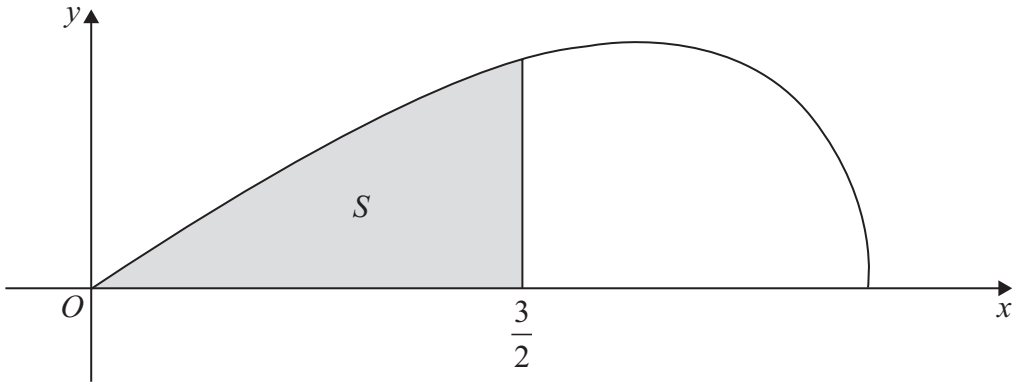

Figure 2

Figure 2 shows a sketch of the curve with parametric equations

$$x = 3\sin t \qquad y = 2\sin 2t \qquad 0 \leqslant t \leqslant \frac{\pi}{2}$$

The finite region S, shown shaded in Figure 2, is bounded by the curve, the x-axis and the line with the equation $x = \frac{3}{2}$

The shaded region S is rotated through 2π radians about the x-axis to form a solid of revolution.

(a) Show that the volume of the solid of revolution is given by

$$k\int_0^a \sin^2 t \cos^3 t \, \mathrm{d}t$$

where k and a are constants to be given in terms of π.

(4)

(b) Use the substitution $u = \sin t$, or otherwise, to find the exact value of this volume, giving your answer in the form $\frac{p\pi}{q}$ where p and q are integers.

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

(5)

(Total for Question 6 is 9 marks)

7. (a) Express $\dfrac{1}{(4-x)(2-x)}$ in partial fractions.

(2)

The mass, x grams, of a substance at time t seconds after a chemical reaction starts is modelled by the differential equation

$$\frac{dx}{dt} = k(4-x)(2-x) \qquad t \geqslant 0 \qquad 0 \leqslant x < 2$$

where k is a constant.

Given that when $t = 0$, $x = 0$

(b) solve the differential equation and show that the solution can be written as

$$x = \frac{4 - 4e^{2kt}}{1 - 2e^{2kt}}$$

(*Solutions relying on calculator technology are not acceptable.*)

(6)

Given that $k = 0.1$

(c) find the value of t when $x = 1$, giving your answer, in seconds, to 3 significant figures.

(2)

(Total for Question 7 is 10 marks)

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

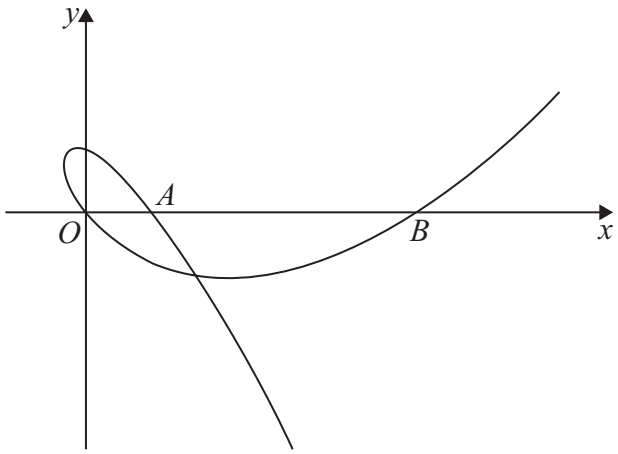

Figure 3

Figure 3 shows a sketch of part of the curve with parametric equations

$$x = t^2 + 2t \qquad y = t^3 - 9t \qquad t \in \mathbb{R}$$

The curve cuts the x-axis at the origin and at the points A and B as shown in Figure 3.

(a) Find the coordinates of point A and show that point B has coordinates (15, 0).

(3)

(b) Find the equation of the tangent to the curve at B, giving your answer in the form $ax + by + c = 0$, where a, b and c are integers.

(4)

The tangent to the curve at B cuts the curve again at point X.

(c) Use algebra to find the coordinates of X, showing each stage of your working.

(5)

(Total for Question 8 is 12 marks)

9. Relative to a fixed origin O, the line l has vector equation

$$\mathbf{r} = \begin{pmatrix} -1 \\ -4 \\ 6 \end{pmatrix} + \lambda \begin{pmatrix} 2 \\ 1 \\ -1 \end{pmatrix}$$

where λ is a scalar parameter.

Points A and B lie on the line l, where A has coordinates $(1, a, 5)$ and B has coordinates $(b, -1, 3)$.

(a) Find the value of the constant a and the value of the constant b.

(3)

(b) Find the vector $\overrightarrow{AB}$

(2)

The point C has coordinates $(4, -3, 2)$

(c) Find the size of angle CAB.

(3)

(d) Find the exact area of the triangle CAB.

(2)

The point D lies on the line l so that the area of the triangle CAD is twice the area of the triangle CAB.

(e) Find the coordinates of the two possible positions of D.

(4)

(Total for Question 9 is 14 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

Tuesday 28 October 2025

Afternoon (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

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Question 1 continued

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(Total for Question 1 is 4 marks)

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Question 2

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Question 2 continued

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(Total for Question 2 is 6 marks)

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Question 3

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Question 3 continued

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(Total for Question 3 is 7 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)

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Question 5

Write the answer to Question 5 on these 2 pages

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Question 5 continued

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(Total for Question 5 is 6 marks)

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Question 6

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Question 6 continued

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(Total for Question 6 is 9 marks)

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Question 7

Write the answer to Question 7 on these 4 pages

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Question 7 continued

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Question 7 continued

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(Total for Question 7 is 10 marks)

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Question 8

Write the answer to Question 8 on these 4 pages

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Question 8 continued

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Question 8 continued

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Question 8 continued

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(Total for Question 8 is 12 marks)

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Question 9

Write the answer to Question 9 on these 3 pages

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Question 9 continued

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Question 9 continued

(Total for Question 9 is 14 marks)

TOTAL FOR PAPER IS 75 MARKS

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Pearson

Mark Scheme (Results)

October 2025

International Advanced Level in Pure Mathematics P4

WMA14/01A

Edexcel and BTEC Qualifications

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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
   - $\sqsubset$ 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 $x = \ldots$

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

2. Formula

Attempt to use correct formula (with values for a, b and c)

3. Completing the square

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

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	Assume there are positive numbers *a* and *b* such that $\frac{9a}{b}+\frac{4b}{a}<12$	B1
	Multiplies by $ab \Rightarrow 9a^2+4b^2<12ab$	M1
	$\Rightarrow 9a^2-12ab+4b^2<0 \Rightarrow (3a-2b)^2<0$	A1
	Square numbers cannot be negative, so we have a contradiction and hence, if *a* and *b* are positive real numbers, then $\frac{9a}{b}+\frac{4b}{a}\geq 12$	A1*
		(4 marks)

Condone $\leq$ for < for the first 3 marks in this question

B1: Sets up the argument. It requires the following three aspects

- Words such as 'assume' or 'let'
- 'positive (real) numbers *a* and *b*' or equivalent such as $a>0$ and $b>0$
- $\frac{9a}{b}+\frac{4b}{a}<12$ but condone $\frac{9a}{b}+\frac{4b}{a}\leq 12$

M1: Multiplies $\frac{9a}{b}+\frac{4b}{a}\ldots 12$ by *ab* to reach $9a^2+4b^2\ldots 12ab$ or $9a^2-12ab+4b^2\ldots 0$ where … can be = or any inequality.

Alternatives exist so $\frac{9a^2-12ab+4b^2}{ab}\ldots 0$, $\frac{9a^2+4b^2}{ab}\ldots 12$ and $9\left(\frac{a}{b}\right)^2-12\left(\frac{a}{b}\right)+4\ldots 0$ are all valid methods

A1: Reaches a point at which the contradiction can be proven. Examples of suitable alternatives include

$9a^2-12ab+4b^2<0 \Rightarrow (3a-2b)^2<0$, $\frac{9a^2-12ab+4b^2}{ab}<0 \Rightarrow \frac{(3a-2b)^2}{ab}<0$ or $9\left(\frac{a}{b}\right)^2-12\left(\frac{a}{b}\right)+4<0 \Rightarrow \left(\frac{3a}{b}-2\right)^2<0$ but condone attempts with ≤ instead of <

A1*: CSO. Fully correct proof with reason and conclusion.

Look for all of the following

- A correct set up
- correct algebra leading to $(3a-2b)^2<0$ o.e. NOT $(3a-2b)^2\leq 0$

- a correct statement or reason in the correct place that indicates a contradiction has been reached. For example, 'numbers are ≥ 0 when squared' or 'but $(3a-2b)^2 \geq 0$' o.e.

  If the intermediate form $\frac{(3a-2b)^2}{ab}$ is reached there must be some statement about

  ab being >0 and $(3a-2b)^2 \geq 0$ (Note that stating > 0 would be incorrect)
- a correct conclusion such as 'hence $\frac{9a}{b}+\frac{4b}{a} \geq 12$' 'hence contradiction, so proven' if the inequality is restated you can condone the omission of *a* and *b* being positive

Simply stating $(3a-2b)^2 \geq 0$ without any words like 'but' is insufficient. Stating 'proven' without stating a reason such as there is a 'contradiction' is also insufficient
A minimal acceptable proof would be;

Assume there are positive numbers *a* and *b* such that $\frac{9a}{b}+\frac{4b}{a} < 12$

$9a^2+4b^2 < 12ab \Rightarrow 9a^2-12ab+4b^2 < 0 \Rightarrow (3a-2b)^2 < 0$

As $(3a-2b)^2 \geq 0$, we have a contradiction. Hence proven

Question Number	Scheme	Marks
2	$\int \frac{\ln x}{x^2}\mathrm{d}x = \int x^{-2}\ln x\,\mathrm{d}x = \frac{x^{-1}}{-1}\ln x - \int \frac{x^{-1}}{-1}\times\frac{1}{x}\,\mathrm{d}x$ $= \frac{x^{-1}}{-1}\ln x + \int x^{-2}\,\mathrm{d}x$ $= \frac{x^{-1}}{-1}\ln x + \frac{x^{-1}}{-1}(+c)$ $\int_1^{\mathrm{e}} \frac{\ln x}{x^2}\mathrm{d}x = \left[\frac{-1}{x}\ln x - \frac{1}{x}\right]_1^{\mathrm{e}} = \left(\frac{-1}{\mathrm{e}}\ln \mathrm{e} - \frac{1}{\mathrm{e}}\right) - \left(\frac{-1}{1}\ln 1 - \frac{1}{1}\right)$ $= 1 - \frac{2}{\mathrm{e}}$	M1A1 dM1A1 ddM1 A1 **(6)**

M1: An application of integration by parts the right way around.
If the rule is quoted it must be correct. (A version appears in the formula booklet)

Accept as evidence $\int x^{-2}\ln x\,\mathrm{d}x = \pm Ax^{-1}\ln x \pm B\int x^{-1}\times\frac{1}{x}\,\mathrm{d}x$ o.e.

A1: Accept a correct un-simplified application $= \frac{x^{-1}}{-1}\ln x - \int \frac{x^{-1}}{-1}\times\frac{1}{x}\,\mathrm{d}x$ o.e

dM1: Dependent upon having scored the previous M mark.
It is for reaching a form $\pm Ax^{-1}\ln x \pm Bx^{-1}$ o.e

A1: A completely correct integral.

For students who substitute in limits look for $= \left(\frac{\mathrm{e}^{-1}}{-1}\ln \mathrm{e}\right) - \left(\frac{1^{-1}}{-1}\ln 1\right) + \left[\frac{x^{-1}}{-1}\right]_1^{\mathrm{e}}$

ddM1: Dependent upon both previous M's.
It is awarded for

- achieving an integral of the form $\pm Ax^{-1}\ln x \pm Bx^{-1}$
- substituting in limits and subtracting either way around
- using both $\ln \mathrm{e} = 1$ & ln1 = 0 and achieving an expression of the form $a + \frac{b}{\mathrm{e}}$ which may be un-simplified. Note that an intermediate expression of $-\frac{1}{\mathrm{e}} + 1 + \frac{1}{\mathrm{e}}$ (which may be implied) leading to 1 is fine for this mark

A1 : cso and cao $= 1 - \frac{2}{\mathrm{e}}$ or $-\frac{2}{\mathrm{e}} + 1$ Condone $1 + -\frac{2}{\mathrm{e}}$ but $1 - \frac{2}{\mathrm{e}} + c$ is A0

Note that you may see attempts at the integration via D & I methods. These are essentially the same as via the main method. So still expect to see variations on $-\frac{1}{x}\ln x+\int\frac{1}{x^2}\,\mathrm{d}x$ for the M1, A1.

All stages of working must be seen (bold sentences), so there is an expectation that the intermediate step is seen.

If $\int\frac{\ln x}{x^2}\mathrm{d}x==\frac{-1}{x}\ln x-\frac{1}{x}(+c)$ appears without any justification score this 1,0,1, 0 followed by potentially 1,0

Question Number	Scheme	Marks
3	Differentiates wrt x $\quad 3^x \ln 3 + 6\underline{\underline{\frac{dy}{dx}}} = \frac{3}{2}y^2 + 3xy\underline{\frac{dy}{dx}}$ Substitutes (2, 3) **AND** rearranges to get $\frac{dy}{dx}$ or vice versa $\Rightarrow 9\ln 3 + 6\frac{dy}{dx} = \frac{27}{2} + 18\frac{dy}{dx} \Rightarrow \frac{dy}{dx} = \frac{9\ln 3 - \frac{27}{2}}{12} = \frac{6\ln 3 - 9}{8} = \frac{-9 + \ln 729}{8}$	B1 $\underline{\underline{\text{B1}}}, \underline{\text{M1}}, \text{A1}$ M1 A1, A1 **(7)** **(7 marks)**

B1: Differentiates $3^x \rightarrow 3^x \ln 3$ or equivalent such as $e^{x\ln 3} \rightarrow e^{x\ln 3}\ln 3$

B1: Differentiates $6y \rightarrow 6\frac{dy}{dx}$

M1: Uses the product rule to differentiate $\frac{3}{2}xy^2$.

Look for sight of $\underline{py^2 + qxy\frac{dy}{dx}} \quad p, q > 0$

A1: A completely correct differential. It need not be simplified.

Variations on this include $3^x \ln 3 dx + \underline{\underline{6dy}} = \underline{\frac{3}{2}y^2 dx + 3xydy}$

Note that $\frac{dy}{dx} = 3^x \ln 3 + 6\underline{\underline{\frac{dy}{dx}}} = \underline{\frac{3}{2}y^2 + 3xy\frac{dy}{dx}}$ is A0 unless there is later recovery to the correct answer

M1: Substitutes $x = 2,\ y = 3$ into their expression to find a 'numerical' value for $\frac{dy}{dx}$

The expression must contain only two $\frac{dy}{dx}$ terms, one from differentiating $6y$, the other from differentiating $\frac{3}{2}xy^2$

Alternatively rearranges to find $\frac{dy}{dx}$ and substitutes in $x = 2,\ y = 3$ FYI a correct $\frac{dy}{dx}$ is $\frac{3^x \ln 3 - 1.5y^2}{3xy - 6}$

Condone slips (e.g. sign and coefficient slips) when rearranging or simplifying under this method.

A1: Any correct numerical answer e.g. $\frac{dy}{dx} = \frac{9\ln 3 - \frac{27}{2}}{12}$ which must be partially simplified.

So, the denominator for instance must not be left as (18 – 6)

A1: Exact answer only and in the required form.

The order of the terms on the numerator is not important so accept $\frac{\ln 729 - 9}{8}$

ISW after a correct answer

Question Number	Scheme	Marks
4 (a)	$\frac{1}{\sqrt{1-2x}} = (1-2x)^{-\frac{1}{2}} = 1+\left(-\frac{1}{2}\right)(-2x)+\frac{\left(-\frac{1}{2}\right)\left(-\frac{3}{2}\right)}{2!}(-2x)^2$	M1A1
	$\frac{2+3x}{\sqrt{1-2x}} = (2+3x)(1+x+\frac{3}{2}x^2+...$	dM1
	$= 2+5x+6x^2$ *	A1* **(4)**
(b)	Sub $x=\frac{1}{20}$ into both sides of $\frac{2+3x}{\sqrt{1-2x}} = 2+5x+6x^2$	M1
	$\frac{\frac{43}{20}}{\sqrt{\frac{9}{10}}} = \frac{453}{200} \Rightarrow \sqrt{10} = ..$	dM1
	$\sqrt{10} = \frac{1359}{430}$	A1 **(3)** **(7 marks)**

(a)

M1: Uses the binomial expansion with $n=-\frac{1}{2}$ to achieve correct binomial coefficients for terms 2 and 3 combined with the correct powers of *x*

Look for $1+\left(-\frac{1}{2}\right)(*x)+\frac{\left(-\frac{1}{2}\right)\times\left(-\frac{3}{2}\right)}{2}(*x)^2...$

or $1+\left(-\frac{1}{2}\right)(\pm 2x)+\frac{\left(-\frac{1}{2}\right)\left(-\frac{3}{2}\right)}{2!}(\pm 2x)^2$ condoning missing/invisible brackets.

If no intermediate form is seen award for $1\pm x\pm\frac{3}{2}x^2$

A1: Correct simplified or unsimplified expression for $(1-2x)^{-\frac{1}{2}}$.

The correct simplified form $1+x+\frac{3}{2}x^2$ scores M1, A1. Condone additional terms

dM1: Multiplies their binomial expansion by $(2+3x)$. It is dependent upon the previous M.

Note that this is a proof with a given answer so individual terms must be seen, and not just the simplified expansion

Look for 4 correct terms of the 5 for their $(2+3x)(1+ax+bx^2+) = 2+2ax+2bx^2+3x+3ax^2+....$

A1*: $2+5x+6x^2$ Correct answer only and it must follow all M1, A1, dM1.

There must be no extra terms

(b)

M1: Sub $x = \frac{1}{20}$ into **both sides** of the given expression AND sets equal. Condone missing brackets.

So allow $\frac{2+3\times\frac{1}{20}}{\sqrt{1-2\times\frac{1}{20}}} = 2+5\times\frac{1}{20}+6\times\frac{1}{20}^{2}$

It is acceptable to have partially simplified or indeed simplified expressions.

E.g. $\frac{43/20}{\sqrt{9/10}} = \frac{453}{200}$ or $\frac{43\sqrt{10}}{60} = \frac{453}{200}$

dM1: For an allowable method of proceeding to an answer for $\sqrt{10}$ as a fraction

Examples of allowable methods are

- simplifying the lhs to $\frac{43\sqrt{10}}{60}$ and then multiplying their $\left(2+5\times\frac{1}{20}+6\times\frac{1}{20}^{2}\right)$ by $\frac{60}{43}$ o.e
- simplifying the lhs to $\frac{43}{6\sqrt{10}}$ o.e. and then dividing $\frac{43}{6}$ o.e by their $\left(2+5\times\frac{1}{20}+6\times\frac{1}{20}^{2}\right)$

A1: Accept $\sqrt{10} = \frac{1359}{430}$ or $\sqrt{10} = \frac{4300}{1359}$

Question Number	Scheme	Marks
5.	One of $\frac{dA}{dt}=\frac{\pi}{20}$, $\frac{dA}{dx}=2\pi x$, $\frac{dV}{dx}=18\pi x^2$	B1
	Two of $\frac{dA}{dt}=\frac{\pi}{20}$, $\frac{dA}{dx}=2\pi x$, $\frac{dV}{dx}=18\pi x^2$	B1
	All three of $\frac{dA}{dt}=\frac{\pi}{20}$, $\frac{dA}{dx}=2\pi x$, $\frac{dV}{dx}=18\pi x^2$	B1
Main	Full attempt to find $\frac{dV}{dt}$ E.g. $\frac{dV}{dt}=\frac{dV}{dx}\times\frac{dx}{dA}\times\frac{dA}{dt}=18\pi x^2\times\frac{1}{2\pi x}\times\frac{\pi}{20}$	M1
	Finds $\frac{dV}{dt}$ at $x=2\Rightarrow$ $\frac{dV}{dt}=18\pi 2^2\times\frac{1}{80}=\frac{9}{10}\pi$	dM1 A1 **(6 marks)**
	Note that the M1 may be found in two steps: E.g.I Finds $\frac{dx}{dt}$ from $\frac{dA}{dt}=\frac{dA}{dx}\times\frac{dx}{dt}$ followed by $\frac{dV}{dt}=\frac{dV}{dx}\times\frac{dx}{dt}$ E.g II Finds $\frac{dV}{dA}$ from $\frac{dV}{dx}=\frac{dV}{dA}\times\frac{dA}{dx}$ followed by $\frac{dV}{dt}=\frac{dV}{dA}\times\frac{dA}{dt}$	
Alt	$\frac{dA}{dt}=\frac{\pi}{20}$	B1
	$V=6\pi x^3, A=\pi x^2\Rightarrow V=6\pi\left(\frac{A}{\pi}\right)^{\frac{3}{2}}$ $\frac{dV}{dA}=9\left(\frac{A}{\pi}\right)^{\frac{1}{2}}$	B1, B1
	$\frac{dV}{dt}=\frac{dV}{dA}\times\frac{dA}{dt}\Rightarrow\frac{dV}{dt}=9\left(\frac{A}{\pi}\right)^{\frac{1}{2}}\times\frac{\pi}{20}$	M1
	$x=2\Rightarrow A=4\pi$ $\Rightarrow \left.\frac{dV}{dt}\right\|_{A=4\pi}=\frac{9}{10}\pi$	dM1A1 **(6 marks)**

Main method:

Condone the use of other letters such as *S* for *A* or *r* for *x*

Ignore any reference to units

The marks have now changed in this question to B1, B1, B1, M1, dM1, A1

B1: States or uses one of $\frac{dA}{dt}=\frac{\pi}{20}$, $\frac{dA}{dx}=2\pi x$, $\frac{dV}{dx}=18\pi x^2$

B1: States or uses two of $\frac{dA}{dt}=\frac{\pi}{20}$, $\frac{dA}{dx}=2\pi x$, $\frac{dV}{dx}=18\pi x^2$

B1: States or uses all three of $\frac{dA}{dt}=\frac{\pi}{20}$, $\frac{dA}{dx}=2\pi x$, $\frac{dV}{dx}=18\pi x^2$

Note that the circumference of the circle is $2\pi x$. You should not be awarding B1 for sight of $2\pi x$ unless you can see it set equal to, or implied equal to $\frac{dA}{dx}$

M1: For a full attempt at finding $\frac{\mathrm{d}V}{\mathrm{d}t}$. There are many ways to do this including

- In one step: Uses $\frac{\mathrm{d}V}{\mathrm{d}t}=\frac{\mathrm{d}V}{\mathrm{d}x}\times\frac{\mathrm{d}x}{\mathrm{d}A}\times\frac{\mathrm{d}A}{\mathrm{d}t}$ with $\frac{\mathrm{d}A}{\mathrm{d}t}=\frac{\pi}{20}$, $\frac{\mathrm{d}A}{\mathrm{d}x}=px$ and $\frac{\mathrm{d}V}{\mathrm{d}x}=qx^2$
- In two steps: Finds $\frac{\mathrm{d}x}{\mathrm{d}t}$ from $\frac{\mathrm{d}A}{\mathrm{d}t}=\frac{\mathrm{d}A}{\mathrm{d}x}\times\frac{\mathrm{d}x}{\mathrm{d}t}$ with $\frac{\mathrm{d}A}{\mathrm{d}t}=\frac{\pi}{20}$ and $\frac{\mathrm{d}A}{\mathrm{d}x}=px$

  followed by finding $\frac{\mathrm{d}V}{\mathrm{d}t}$ from $\frac{\mathrm{d}V}{\mathrm{d}t}=\frac{\mathrm{d}V}{\mathrm{d}x}\times\frac{\mathrm{d}x}{\mathrm{d}t}$ with $\frac{\mathrm{d}V}{\mathrm{d}x}=qx^2$ and their $\frac{\mathrm{d}x}{\mathrm{d}t}$

Condone slips when rearranging the chain rules but they must at least be correct to start with.

Condone slips on the coefficients of x and x^2 of $\frac{\mathrm{d}A}{\mathrm{d}x}=px$ and $\frac{\mathrm{d}V}{\mathrm{d}x}=qx^2$ respectively

If they state the chain rule $\frac{\mathrm{d}A}{\mathrm{d}t}=\frac{\mathrm{d}A}{\mathrm{d}x}\times\frac{\mathrm{d}x}{\mathrm{d}t}$ then make an algebraic error they may be awarded this method mark

dM1: For a full attempt at finding the value of $\frac{\mathrm{d}V}{\mathrm{d}t}$ at $x=2$ It is dependent upon the previous M

A1: $\frac{9}{10}\pi$ or 0.9π or $\frac{18}{20}\pi$ ……or k =0.9 etc

Alt method: Solution obtained directly via $\frac{\mathrm{d}V}{\mathrm{d}A}$

B1: States or uses $\frac{\mathrm{d}A}{\mathrm{d}t}=\frac{\pi}{20}$

B1: Differentiates their $V=\alpha A^{\frac{3}{2}}\rightarrow\frac{\mathrm{d}V}{\mathrm{d}A}=rA^{\frac{1}{2}}$

B1: A correct $\frac{\mathrm{d}V}{\mathrm{d}A}=9\left(\frac{A}{\pi}\right)^{\frac{1}{2}}$ o.e such as $\frac{\mathrm{d}V}{\mathrm{d}A}=\frac{9}{\sqrt{\pi}}A^{\frac{1}{2}}$

M1: For a full attempt at finding $\frac{\mathrm{d}V}{\mathrm{d}t}$ using $\frac{\mathrm{d}V}{\mathrm{d}t}=\frac{\mathrm{d}V}{\mathrm{d}A}\times\frac{\mathrm{d}A}{\mathrm{d}t}$.

To award this, candidates must be using $\frac{\mathrm{d}A}{\mathrm{d}t}=\frac{\pi}{20}$ and $\frac{\mathrm{d}V}{\mathrm{d}A}=rA^{\frac{1}{2}}$

dM1: Finds the value of $\frac{\mathrm{d}V}{\mathrm{d}t}$ at $A=4\pi$ It is dependent upon the previous M

A1: $\frac{9}{10}\pi$ or 0.9π or $\frac{18}{20}\pi$ ……or k =0.9 etc

Question Number	Scheme	Marks
6.(a)	$x=\frac{3}{2}\Rightarrow a=\frac{\pi}{6}$	B1
	$\int y^2\mathrm{d}x=\int y^2\frac{\mathrm{d}x}{\mathrm{d}t}\mathrm{d}t=\int(2\sin 2t)^2\,3\cos t\,(\mathrm{d}t)$	M1
	Uses $\sin 2t=2\sin t\cos t\ \Rightarrow\int(4\sin t\cos t)^2\,3\cos t\ \mathrm{d}t$	dM1
	Volume = $\int\pi y^2\mathrm{d}x=48\pi\int_0^{\left(\frac{\pi}{6}\right)}\sin^2 t\cos^3 t\ \mathrm{d}t$	A1
		(4)
(b)	$u=\sin t\Rightarrow\frac{\mathrm{d}u}{\mathrm{d}t}=\cos t$	B1
	$k\int\sin^2 t\cos^3 t\,\mathrm{d}t=k\int u^2\cos^2 t\,\mathrm{d}u$	
	$=k\int u^2(1-\sin^2 t)\,\mathrm{d}u=k\int u^2(1-u^2)\,\mathrm{d}u$	M1
	$=k\left[\frac{u^3}{3}-\frac{u^5}{5}\right]$	dM1
	Volume = $48\pi\left[\frac{u^3}{3}-\frac{u^5}{5}\right]_0^{\frac{1}{2}}=\frac{17\pi}{10}$	ddM1A1
		(5)
		(9 marks)

(a)

B1: $x=\frac{3}{2}\Rightarrow a=\frac{\pi}{6}$. This may be seen as the top limit on the integral

M1: Attempts $y^2\times\frac{\mathrm{d}x}{\mathrm{d}t}$

It will usually be seen within $\int y^2\frac{\mathrm{d}x}{\mathrm{d}t}\mathrm{d}t\rightarrow\int(\ldots\sin 2t)^2\,(\pm)\delta\cos t\mathrm{d}t$, but you can condone bracketing issues and the loss of the integral signs as well as the dt

dM1: Uses $\sin 2t=2\sin t\cos t$ within their answer to $\int y^2\frac{\mathrm{d}x}{\mathrm{d}t}\mathrm{d}t\rightarrow\lambda\int\sin^2 t\cos^3 t\ \mathrm{d}t$

Note that the previous M mark must have been scored.

Condone $\sin^2 2t\rightarrow 2\sin^2 t\cos^2 t$ for this mark

The form of the answer is given so expect to see both the integral sign and the dt

A1: Volume = $48\pi\int_0^a \sin^2 t\cos^3 t\ \mathrm{d}t$. CSO

You can follow through on their value of *a*, $a \neq \frac{3}{2}$, but a value (not necessarily correct) must be present.

The form of the answer is given so any integrals should include d*x*'s and d*t*'s correctly placed

(b) Using the substitution

B1: States $\frac{\mathrm{d}u}{\mathrm{d}t} = \cos t$ or equivalent. It can be awarded for replacing the $\mathrm{d}t$ by $\frac{\mathrm{d}u}{\cos t}$

M1: Substitutes fully using $u = \sin t$ producing an integral just in terms of *u*. Accept $\cos^2 t = \pm 1 \pm \sin^2 t$

So award for the form $\pm k\int u^2(\pm 1 \pm u^2)\ \mathrm{d}u$

dM1: Multiplies out to form a polynomial expression of the form $\pm au^2 \pm bu^4$ and integrates each term with correct powers for their expression

ddM1: All previous method marks must have been scored in (b).
It is for using correct limits within a suitable expression
It is for substituting $\left[\frac{1}{2}, 0\right]$ into an acceptable expression and subtracting either way around.

Alternatively, it is for substituting $\left[\frac{\pi}{6}, 0\right]$ into an acceptable expression in *t* if *u* is replaced by $\sin t$

A1: $V = \frac{17\pi}{10}$ oe such as $V = \frac{51\pi}{30}$

(b) Otherwise

B1: Writes their $k\int \sin^2 t\cos^3 t\,\mathrm{d}t$ as $k\int \sin^2 t\left(1-\sin^2 t\right)\cos t\,\mathrm{d}t$

M1: Multiplies out into a form that can be integrated $\pm\ldots\sin^2 t\cos t \pm\ldots\sin^4 t\cos t$ allowing for $\cos^2 t = \pm 1 \pm \sin^2 t$

dM1: Correct integration. Look for the form $\ldots\sin^3 t \pm \ldots\sin^5 t$

ddM1: Dependent upon both previous M's in part (b).

Scored for substituting $\left[\frac{\pi}{6}, 0\right]$ into an acceptable expression in t

A1: $V = \frac{17\pi}{10}$ oe such as $V = \frac{51\pi}{30}$

Question Number	Scheme	Marks
7(a)	$\frac{1}{(4-x)(2-x)} = \frac{A}{(4-x)} + \frac{B}{(2-x)} \Rightarrow 1 \equiv A(2-x) + B(4-x) \Rightarrow A = \ldots \text{ or } B = \ldots$	M1
	$A = -\frac{1}{2}, B = \frac{1}{2}$ giving $\frac{-\frac{1}{2}}{(4-x)} + \frac{\frac{1}{2}}{(2-x)}$	A1
		[2]
(b)	$\frac{\mathrm{d}x}{\mathrm{d}t} = k(4-x)(2-x),\ t \geqslant 0 \Rightarrow \int \frac{1}{(4-x)(2-x)}\,\mathrm{d}x = \int k\,\mathrm{d}t$	
	$\frac{1}{2}\ln(4-x) - \frac{1}{2}\ln(2-x) = kt\ (+c)$	M1, A1
	$\{t=0, x=0 \Rightarrow\}\ \frac{1}{2}\ln 4 - \frac{1}{2}\ln 2 = 0 + c\ \left\{\Rightarrow c = \frac{1}{2}\ln 2\right\}$	M1
	$\frac{1}{2}\ln(4-x) - \frac{1}{2}\ln(2-x) = kt + \frac{1}{2}\ln 2 \Rightarrow \ln\left(\frac{4-x}{4-2x}\right) = 2kt$	
	$\frac{4-x}{4-2x} = \mathrm{e}^{2kt}$	M1
	$4-x = 4\mathrm{e}^{2kt} - 2x\mathrm{e}^{2kt} \Rightarrow 4 - 4\mathrm{e}^{2kt} = x - 2x\mathrm{e}^{2kt}$	
	$\Rightarrow 4 - 4\mathrm{e}^{2kt} = x(1 - 2\mathrm{e}^{2kt}) \Rightarrow x = \frac{4-4\mathrm{e}^{2kt}}{1-2\mathrm{e}^{2kt}}\ (*)$	dM1, A1*
		[6]
(c)	$1 = \frac{4-4\mathrm{e}^{0.2t}}{1-2\mathrm{e}^{0.2t}} \Rightarrow 2\mathrm{e}^{0.2t} = 3$	M1
	$\Rightarrow 0.2t = \ln\frac{3}{2} \Rightarrow t = \text{awrt } 2.03$	A1
		[2]
		10 marks

(a)

M1: For forming a correct identity leading to one value of A or B.

For example, $1 \equiv A(2-x) + B(4-x)$ from $\frac{1}{(4-x)(2-x)} = \frac{A}{(4-x)} + \frac{B}{(2-x)}$ and finds at least one of $A = \ldots$ or $B = \ldots$.

This would be implied using cover up rule and reaching one correct fraction

A1: $\frac{-\frac{1}{2}}{(4-x)} + \frac{\frac{1}{2}}{(2-x)}$ or any equivalent form. **It is not scored for just the values**

ISW after sight of a correct answer. It may be awarded in part (b)

(b)

M1: Integrates to the form $\pm\lambda\ln(4-x) \pm \mu\ln(2-x),\ \lambda \neq 0, \mu \neq 0$

Note that versions such as $\pm\lambda\ln(8-2x) \pm \mu\ln(4-2x),\ \lambda \neq 0, \mu \neq 0$ ARE correct

A1: Fully correct integration of both left and right-hand side condoning a missing constant of integration.

Look for $\frac{1}{2}\ln(4-x)-\frac{1}{2}\ln(2-x)=kt$ o.e. such as $\frac{1}{2k}\left(\ln(4-x)-\ln(2-x)\right)=t$

Note that you may see $\frac{-\frac{1}{2}}{(4-x)}$ being integrated to $\frac{1}{2}\ln(8-2x)$

Similarly, $\frac{\frac{1}{2}}{(2-x)}$ being integrated to $-\frac{1}{2}\ln(4-2x)$. These are both correct

M1: Using both $t=0$ and $x=0$ in an integrated equation containing a constant of integration and finds the value of *c*. If the *k* is 'moved' to the LHS, *c* will be found in terms of *k*.
It is dependent upon having integrated to a form equivalent to
$\pm\lambda\ln(4-x)\pm\mu\ln(2-x)=f(t)+c$ o.e.

M1: Starting from an equation of the form $\pm\lambda\ln(4-x)\pm\mu\ln(2-x)=\pm kt+c$, λ, μ, k, $c\neq 0$ o.e. and applies a fully correct method to eliminate their logarithms. To score this

- the lns must be correctly combined
- all exponential work must be correct at the point when the logarithms are removed

For example, $\ln(4-x)-\ln(2-x)=kt+\ln 2\Rightarrow(4-x)-(2-x)=e^{kt+\ln 2}$ is M0

AND $\ln(4-x)-\ln(2-x)=kt+\ln 2\Rightarrow\ln\frac{(4-x)}{(2-x)}=kt+\ln 2\Rightarrow\frac{(4-x)}{(2-x)}=e^{kt+\ln 2}$ is M1 BUT $\frac{(4-x)}{(2-x)}=e^{kt}+2$ is M0

There must be a constant of integration but it need not have been evaluated.
(See below for this type of solution)

dM1: D**ependent on the previous M mark.** A complete method of rearranging to make *x* the subject. It can be awarded when the two terms in *x* are on one side of the equation and the terms independent of *x* are on the other.
So, following the award of the previous mark, look for

- cross multiplication leading to two terms in *x* and two terms independent of *x*
- collecting two *x* terms one side of the equation and two terms independent of *x* on the other

There must be a constant of integration but it need not have been evaluated.
(See below for this type of solution)

A1*: CSO. **Note that this is a given answer and all steps should be seen before awarding this mark.**

Condone a line where a bracket is missed e.g. $\ln 2-x \leftrightarrow \ln(2-x)$ as long as it is replaced in subsequent lines

If a candidate reaches $x-2xe^{2kt}=4-4e^{2kt}$ it is acceptable to just write down $x=\dfrac{4-4e^{2kt}}{1-2e^{2kt}}$

However, $2xe^{2kt}-x=4e^{2kt}-4$ must proceed to the given answer via $x=\dfrac{4e^{2kt}-4}{2e^{2kt}-1}$ o.e. such as $(2e^{2kt}-1)x=4e^{2kt}-4$ to score the A1*

Alt (b) and the order of scoring the marks

M1, A1: $\dfrac{1}{2}\ln(4-x)-\dfrac{1}{2}\ln(2-x)=kt+c$

$\ln(4-x)-\ln(2-x)=2kt+C$

$\ln\dfrac{(4-x)}{(2-x)}=2kt+C\Rightarrow\dfrac{(4-x)}{(2-x)}=e^{2kt+C}$ ← 3rd M1 scored at this stage

As $e^{2kt+C}=e^{2kt}\times e^{C}=Ae^{2kt}$

$(4-x)=(2-x)Ae^{2kt}\Rightarrow Axe^{2kt}-x=2Ae^{2kt}-4\Rightarrow x=\dfrac{2Ae^{2kt}-4}{Ae^{2kt}-1}$ 4th M1 scored at this stage

Uses $t=0,\ x=0\ \Rightarrow 0=\dfrac{2A-4}{A-1}\Rightarrow A=2$ ← 2nd M1 scored at this stage

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(c)

M1: Substitutes $x=1$ and $k=0.1$ into the given equation in part (c) and proceeds to $pe^{0.2t}=q,\ pq>0$

A1: Proceeds to awrt 2.03 (Note that M1 must have been awarded to award this mark)

Alternatives exist via $\dfrac{4-x}{4-2x}=e^{2kt}$ but essentially the same method applies

SC: Answers without (sufficient) working

– 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.

An answer of 2.03 with little or no valid working meriting the M1 mark can score SC 1,0

Question Number	Scheme	Marks
8(a)	A and B are where $y = 0$ so $t^3 - 9t = 0 \Rightarrow t(t^2 - 9) = 0 \Rightarrow t = 3 \quad (0 \text{ and } -3)$ Substitutes $t = 3$ in $x = 3^2 + 2\times 3 = 15$ $B(15, 0)$ $A = (3, 0)$	M1 A1* B1 **(3)**
8(a) ALT	Uses answer $x = 15$: $t^2 + 2t = 15 \Rightarrow t = 3$ (-5) Substitutes $t = 3$ in $y = t^3 - 9t = 27 - 27 = 0$ ✓ $B(15, 0)$ $A = (3, 0)$	M1 A1* B1 **(3)**
(b)	$\dfrac{dy}{dx} = \dfrac{dy/dt}{dx/dt} = \dfrac{3t^2 - 9}{2t + 2}$ Substitutes $t = 3$ into $\dfrac{dy}{dx} = \dfrac{3t^2 - 9}{2t + 2} \Rightarrow \dfrac{dy}{dx} = \dfrac{9}{4}$ Uses their $\dfrac{9}{4}$ with $(15, 0)$ to produce tangent equation $9x - 4y - 135 = 0$	M1 A1 dM1 A1 **(4)**
(c)	Substitutes $x = t^2 + 2t$, $y = t^3 - 9t$, into their $9x - 4y - 135 = 0$ $\Rightarrow 9(t^2 + 2t) - 4(t^3 - 9t) - 135 = 0$ $\Rightarrow 4t^3 - 9t^2 - 54t + 135 = 0$ $\Rightarrow (t^2 - 6t + 9)(4t + 15) = 0$ $t = -\dfrac{15}{4}$ Coordinates of X are $\left(\dfrac{105}{16}, -\dfrac{1215}{64}\right)$	M1 dM1 A1 dM1A1 **(5)** **(12 marks)**

(a)

M1: States $t^3 - 9t = 0$ o.e. such as $y = 0 \Rightarrow t = 3$

No working needs to be seen for solving the equation and other values may be present including 0 and -3

A1*: Substitutes $t = 3$ in $x = t^2 + 2t$ to show that the x coordinate of B is 15 (and the y coordinate is 0)

This can be stated e.g. sub $t = 3$ in $x = t^2 + 2t \Rightarrow x = 15$

or else you need see some working such as 9 + 6, $3^2 + 2\times 3$ o.e

It is a given answer so **you must see evidence** followed by a statement *B* = (15, 0) o.e. such as *B* $x = 15, y = 0$

So just stating $t = 3$ followed by $x = 15$ and *B* = (15, 0) will score M1, A0*

B1: States $A = (3,0)$ (need not see working)

Alt (a)

C. M1: Sets $t^2 + 2t = 15 \Rightarrow t = 3$

A1*: Substitutes $t = 3$ in $y = t^3 - 9t = 27 - 27 = 0$ and makes a comment that *B* is on the *x*-axis

B1: States $A = (3,0)$ (need not see working)

(b)

M1: Attempts to find the value of $\frac{dy}{dx}$ at $t = \pm 3$

or *t* = – 5. $\frac{dy}{dx}$ must be attempted via $\frac{dy/dt}{dx/dt} = \frac{\text{Quadratic function}}{\text{Linear function}}$

A1: Achieves $\frac{dy}{dx}$ = 9/4 following M1

dM1: Uses (15,0) with the value of their gradient found using a correct method to find an equation
of the tangent.
It is dependent upon the previous M mark

A1: Achieves $9x - 4y - 135 = 0$ or any integer multiple of this

(c)

M1: Substitutes $x = t^2 + 2t,\ y = t^3 - 9t$ into their $9x - 4y - 135 = 0$ to form a simplified cubic equation in just *t*

dM1: This is dependent upon the previous M mark. It is for an attempt at using a non-calculator method to solve a cubic equation using the fact that $t = 3$ is a root. So, look for an attempt to divide their simplified cubic equation by (*t* – 3) or $t^2 - 6t + 9$

A1: Achieves $t = -\frac{15}{4}$ o.e. following correct cubic and correct factorisation. Look for prior working of

- $(t^2 - 6t + 9)(4t + 15) = 0,$ which may or may not be followed by $(t-3)^2(4t+15) = 0$
- $(t-3)(4t^2 + 3t - 45) = 0$ followed by a solution of the quadratic that could be via a calculator

Note that $4t^3 - 9t^2 - 54t + 135 = 0 \Rightarrow (t-3)^2(4t+15) = 0$ is dM0, A0 unless an explanation

is given alluding to the fact that $t=3$ is a double root, so $(t-3)^2$ is a factor, and so

$4t^3-9t^2-54t+135=(t-3)^2(At+B)=0$

giving $A = 4$ and $B = 15$ via inspection

dM1: Uses their value of t to find **either** the x or y co-ordinate of X.

It is dependent upon the FIRST M only and achieving a correct value of t for their equation.

It can be implied by a 'correct' value

A1: Coordinates of X are $\left(\frac{105}{16},-\frac{1215}{64}\right)$ or exact equivalent, for example, $x = 6.5625$, $y = -18.984375$

We are likely to see solutions without sight of the necessary steps required by the question

Solutions lacking necessary steps are scored as follows

Alternative 1; Via a simplified equation in t

Substitutes $x=t^2+2t,\ y=t^3-9t,$ into $9x-4y-135=0$

$\Rightarrow 9(t^2+2t)-4(t^3-9t)-135=0$

$\Rightarrow 4t^3-9t^2-54t+135=0 \Rightarrow t=-3.75$.

So, $X = \left(\frac{105}{16},-\frac{1215}{64}\right)$

Scores SC 1, 0, 0, 1, 1

M1: method shown

dM0: method not shown as presumably done via a calculator

A0: correct value for t but following dM0

dM1: For one correct coordinate (allowing either of $(6.56,-18.98)$ to 2dp) as it implies a correct method

A1: For exact answer $\left(\frac{105}{16},-\frac{1215}{64}\right)$

Alternative 2; Scores SC 0, 0, 0, 1, 1

No simplified equation in t

Substitutes $x=t^2+2t,\ y=t^3-9t,$ into $9x-4y-135=0$

$\Rightarrow 9(t^2+2t)-4(t^3-9t)-135=0$

$\Rightarrow t=-3.75$.

So $X = \left(\frac{105}{16},-\frac{1215}{64}\right)$ but allow $(6.56,-18.98)$ via this method

See Alternative 1 for the award of the final two marks

Question Number	Scheme	Marks
9(a)	$A(1, a, 5)$, $B(b, -1, 3)$, $l: \mathbf{r} = -\mathbf{i} - 4\mathbf{j} + 6\mathbf{k} + \lambda(2\mathbf{i} + \mathbf{j} - \mathbf{k})$ Either $A: \lambda = 1$ or $B: \lambda = 3$ leading to $a = -3,\ b = 5$	M1 A1, A1 **(3)**
(b)	$\overrightarrow{AB} = = \pm\left(('5\mathbf{i}' - \mathbf{j} + 3\mathbf{k}) - (\mathbf{i}\ '- 3\mathbf{j}' + 5\mathbf{k})\right); = 4\mathbf{i} + 2\mathbf{j} - 2\mathbf{k}$	M1, A1 **(2)**
(c)	$\overrightarrow{AC} = \overrightarrow{OC} - \overrightarrow{OA} = \begin{pmatrix} 4 \\ -3 \\ 2 \end{pmatrix} - \begin{pmatrix} 1 \\ -3 \\ 5 \end{pmatrix} = \begin{pmatrix} 3 \\ 0 \\ -3 \end{pmatrix}$ or $\overrightarrow{CA} = \begin{pmatrix} -3 \\ 0 \\ 3 \end{pmatrix}$	M1
	$\cos C\hat{A}B = \dfrac{\begin{pmatrix} 4 \\ 2 \\ -2 \end{pmatrix} \bullet \begin{pmatrix} 3 \\ 0 \\ -3 \end{pmatrix}}{\sqrt{(4)^2 + (2)^2 + (-2)^2} . \sqrt{(3)^2 + (0)^2 + (-3)^2}}$	dM1
	$\cos C\hat{A}B = \dfrac{12 + 0 + 6}{\sqrt{24} . \sqrt{18}} = \dfrac{\sqrt{3}}{2} \Rightarrow C\hat{A}B = 30^\circ$	A1 **(3)**
(d)	$\text{Area } CAB = \dfrac{1}{2}\sqrt{24}\sqrt{18}\sin 30^\circ; = 3\sqrt{3}$	M1, A1 **(2)**
(e)	For one of $\overrightarrow{OD_1} = \begin{pmatrix} -1 \\ -4 \\ 6 \end{pmatrix} + 5\begin{pmatrix} 2 \\ 1 \\ -1 \end{pmatrix} = \begin{pmatrix} 9 \\ 1 \\ 1 \end{pmatrix}$ or $\overrightarrow{OD_2} = \begin{pmatrix} -1 \\ -4 \\ 6 \end{pmatrix} - 3\begin{pmatrix} 2 \\ 1 \\ -1 \end{pmatrix} = \begin{pmatrix} -7 \\ -7 \\ 9 \end{pmatrix}$	M1, A1
	For both of $\overrightarrow{OD_1} = \begin{pmatrix} -1 \\ -4 \\ 6 \end{pmatrix} + 5\begin{pmatrix} 2 \\ 1 \\ -1 \end{pmatrix} = \begin{pmatrix} 9 \\ 1 \\ 1 \end{pmatrix}$ and $\overrightarrow{OD_2} = \begin{pmatrix} -1 \\ -4 \\ 6 \end{pmatrix} - 3\begin{pmatrix} 2 \\ 1 \\ -1 \end{pmatrix} = \begin{pmatrix} -7 \\ -7 \\ 9 \end{pmatrix}$	M1, A1 **(4)** **(14 marks)**

(a)
M1: Finds the value of λ at *A* or *B* but is implied by a correct value for *a* or *b*
A1: At least one of *a* or *b* correct
A1: Both *a* and *b* correct

(b)
M1: Attempts to subtract the components either way around.

If no method is shown it is implied by two correct coordinates/components (±) for their *A* and *B*

A1: Correct vector and with correct notation. Allow column vector approach, so $\begin{pmatrix} 4 \\ 2 \\ -2 \end{pmatrix}$ is fine but $\begin{pmatrix} 4\mathbf{i} \\ 2\mathbf{j} \\ -2\mathbf{k} \end{pmatrix}$ is not.

(c) M1: Attempts vector *AC* or *CA* by subtracting $\begin{pmatrix} 4 \\ -3 \\ 2 \end{pmatrix}$ and their $\begin{pmatrix} 1 \\ a \\ 5 \end{pmatrix}$ either way around.

Condone the coordinate form here, so $(-3, 0, 3)$ for vector *AC*.

If the method is not explicitly seen then award for two correct components (f.t. on their *a*)

dM1: Uses the scalar product of $\pm\overrightarrow{AB}$ and $\pm\overrightarrow{AC}$ to find the value of $\cos C\hat{A}B$

To score this mark

- Both vectors, *AB* and *AC* must have been attempted via subtraction
- The scalar product must have been attempted correctly
- The magnitudes of the vectors must have initially been attempted via a correct method

Alternatively, the cosine rule could be used following the calculation of all three sides of triangle *ABC*

A1: Correctly proceeds to $C\hat{A}B = 30^\circ$ or $\frac{\pi}{6}$ radians. Note that $\cos C\hat{A}B = -\frac{\sqrt{3}}{2}$ followed by 150° or 30° is A0

(d)

M1: Applies $\frac{1}{2}\left|\overrightarrow{AB}\right|\left|\overrightarrow{AC}\right|\sin' 30^\circ '$. The magnitudes of the vectors must have been found using a correct method.

For angles that haven't exact trig ratios, some work must be seen or implied. The demand is for an exact value for the area, so if $\cos C\hat{A}B = k$ is found in part (c) then $\sin C\hat{A}B = \sqrt{1-k^2}$ must be attempted here.

A1: $3\sqrt{3}$ but must follow correct sides with angle *CAB* = 30° or 150°

(e) There are a few different ways to achieve these coordinates so look carefully at what has been attempted

The diagram may help interpret the method used. Note that 0,0,1,1 is not possible

M1: A correct method to find one possible position of point *D*

Method 1: via the equation of *l*

Substitutes $\lambda = 5$ ie. $\lambda = \lambda_B + (\lambda_B - \lambda_A)$ OR $\lambda = -3$ ie. $\lambda = \lambda_A - 2(\lambda_B - \lambda_A)$ into the equation of line *l*

Method II: via vector *AB*

Attempts $\overrightarrow{OB} + \overrightarrow{AB} = \begin{pmatrix} 5 \\ '-1' \\ 3 \end{pmatrix} + \begin{pmatrix} 4 \\ 2 \\ -2 \end{pmatrix} =$ OR attempts $\overrightarrow{OA} + 2 \times \overrightarrow{BA} = \begin{pmatrix} 1 \\ '-3' \\ 5 \end{pmatrix} + 2 \times \begin{pmatrix} -4 \\ -2 \\ 2 \end{pmatrix} =$

Amongst many other alternatives include $\overrightarrow{OA} + 2 \times \overrightarrow{AB}$ and $\overrightarrow{OA} - 2 \times \overrightarrow{AB}$ (Use handy diagram)

Method III: Via modulus approach

Letting $\overrightarrow{OD} = \begin{pmatrix} -1 \\ -4 \\ 6 \end{pmatrix} + \lambda \begin{pmatrix} 2 \\ 1 \\ -1 \end{pmatrix}$ and using $(AD^2) = 4 \times (AB^2)$

gives $(2\lambda - 2)^2 + (\lambda - 1)^2 + (-\lambda + 1)^2 = 4 \times '24'$

This leads to $6\lambda^2 - 12\lambda + 6 = 96 \Rightarrow \lambda^2 - 2\lambda - 15 = 0 \Rightarrow \lambda = 5, -3$

The M's can only be scored if $(AD^2) = 4 \times (AB^2)$ is applied with AD^2 and AB^2 found using the sum of the differences squared. The resulting λ's must then be substituted into

$\overrightarrow{OD} = \begin{pmatrix} -1 \\ -4 \\ 6 \end{pmatrix} + \lambda \begin{pmatrix} 2 \\ 1 \\ -1 \end{pmatrix}$

for the M's to be scored. It is unlikely, under this method for 1,1,0,0 to be scored.

Method IV: via an area approach

This is similar to method III except candidates start with

$\text{area } ACD = \frac{1}{2} \times AC \times AD \times \sin BAC = 2 \times \text{"ans to } (d)\text{"}$

If the earlier parts of question are correct you should see

$\frac{1}{2} \times \sqrt{18} \times \sqrt{(2\lambda - 2)^2 + (\lambda - 1)^2 + (1 - \lambda)^2} \times \frac{1}{2} = 2 \times 3\sqrt{3}$ leading to $(2\lambda - 2)^2 + (\lambda - 1)^2 + (1 - \lambda)^2 = 96$ as before. Correct processing when forming the equation in lambda is expected via this method

As with method III you should expect to see the squaring applied correctly and M's are only awarded when the resulting λ's are substituted into $\overrightarrow{OD} = \begin{pmatrix} -1 \\ -4 \\ 6 \end{pmatrix} + \lambda \begin{pmatrix} 2 \\ 1 \\ -1 \end{pmatrix}$

A1: One correct coordinate, either $D(9,1,1)$ **or** $D'(-7,-7,9)$ but condone the vector forms

M1: A correct method to find BOTH possible positions of point *D*.

Note that via method III both values of λ are found when the equation is solved

A1: Both possible coordinates, $D(9,1,1)$ **and** $D'(-7,-7,9)$ but condone the vector forms

Alternative route for (c) and (d)

Triangle *ABC* can be shown to be right angled at C via use of Pythagoras. This will only work if they have the correct values of *a* and *b*.

So as $\left(\sqrt{24}\right)^2 = \left(\sqrt{18}\right)^2 + \left(\sqrt{6}\right)^2 \Rightarrow$ Angle C is $90°$

Hence angle *A* = invsin $\frac{\sqrt{6}}{\sqrt{24}} = \frac{1}{2}$ which gives angle $A = 30°$

AND area *ABC* = $\frac{1}{2} \times \sqrt{18} \times \sqrt{6} = 3\sqrt{3}$

Score (c)

M1: For $\overrightarrow{AC}$ or $\overrightarrow{CA}$ which may be implied within an attempt at $\left|\overrightarrow{AC}\right|$

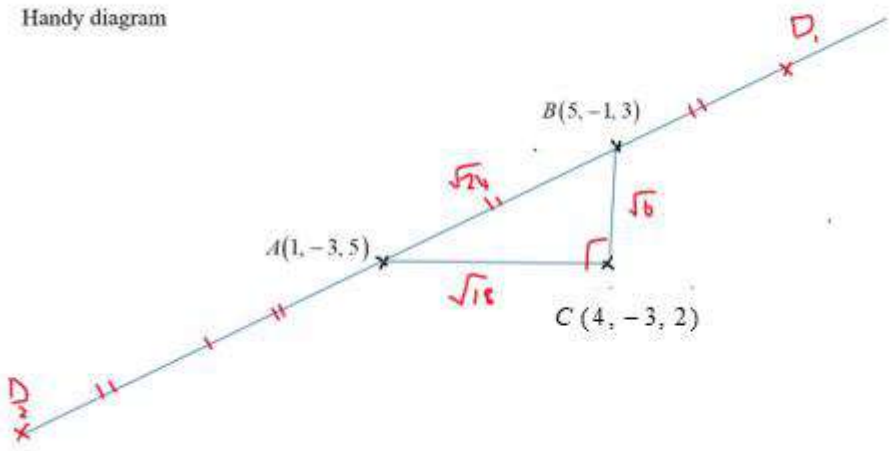
M1: Proves angle *A* is a right angle via Pythagoras' Theorem and uses a correct trigonometric identity (implied)

A1: Correct answer

Part (d)

M1: Use of $\frac{1}{2}bh$ but it must follow a proof of angle *A* being a right angle

A1: Correct answer



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 28 October 2025

Afternoon (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 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

$$(2 + 5x)^{-2}$$

giving each term in simplest form.

(5)

(b) State the range of values of x for which this expansion is valid.

(1)

(c) Given that x is sufficiently small, find the values of a, b and c such that

$$\left(\frac{4}{2 + 5x}\right)^2 \approx a + bx + cx^2$$

(1)

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Question 1 continued

(Total for Question 1 is 7 marks)

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2.

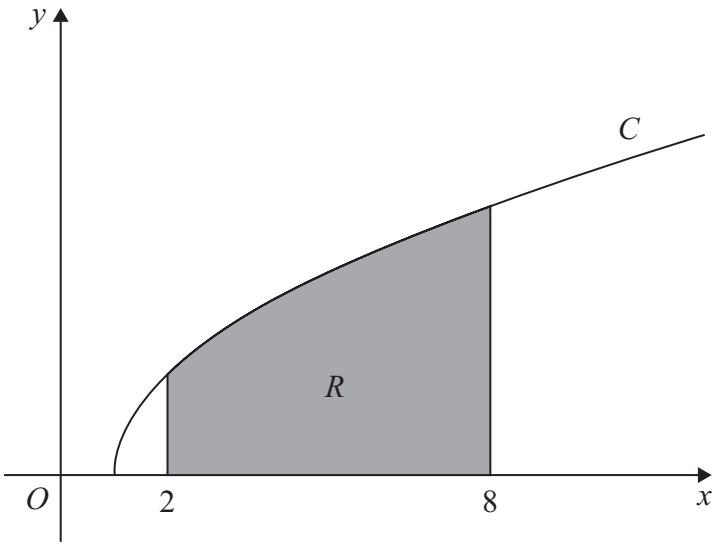

Figure 1

Figure 1 shows a sketch of the curve C with equation

$$y = \frac{5}{3}\sqrt{x-1}$$

The region R, shown shaded in Figure 1, is bounded by C, the line with equation $x = 2$, the x-axis and the line with equation $x = 8$

This region is then rotated through 2π radians about the x-axis to form a solid.

Use algebraic integration to find the exact volume of this solid.

(5)

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Question 2 continued

(Total for Question 2 is 5 marks)

3. A curve has parametric equations

$$x = \frac{t + 15}{t + 4} \qquad y = \frac{5}{t + 2} \qquad t \geqslant 0$$

(a) Show that a Cartesian equation of the curve is $y = g(x)$ where

$$g(x) = \frac{ax + b}{cx + d} \qquad e < x \leqslant f$$

and a, b, c, d, e and f are constants to be found.

(5)

(b) State the range of g.

(2)

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Question 3 continued

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Question 3 continued

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Question 3 continued

(Total for Question 3 is 7 marks)

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

The curve C has equation

$$4x^2 + y^2 - 2xy = 24x$$

(a) Find $\frac{dy}{dx}$ giving your answer in simplest form in terms of x and y.

(5)

The point P lies on C.

Given that

- the gradient of C at P is 2
- P has coordinates (a, b) where $a > 0$ and $b > 0$

(b) find the value of a and the value of b.

(5)

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Question 4 continued

Question 4 continued

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Question 4 continued

(Total for Question 4 is 10 marks)

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5. The line l_1 has equation

$$\mathbf{r} = \begin{pmatrix} 2 \\ -1 \\ 3 \end{pmatrix} + \lambda \begin{pmatrix} 1 \\ 4 \\ 2 \end{pmatrix}$$ where λ is a scalar parameter

The line l_2 has equation

$$\mathbf{r} = \begin{pmatrix} -1 \\ \beta \\ 6 \end{pmatrix} + \mu \begin{pmatrix} 2 \\ -1 \\ 7 \end{pmatrix}$$ where β is a constant and μ is a scalar parameter

Given that l_1 and l_2 intersect at the point P

(i) find the value of β

(ii) find the coordinates of P

(6)

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Question 5 continued

(Total for Question 5 is 6 marks)

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

Use the substitution $u = 3 + \cos\theta$ to show that

$$\int_0^{\frac{\pi}{2}} \frac{\sin 2\theta}{\sqrt{3 + \cos\theta}} \, \mathrm{d}\theta = a\sqrt{3} + b$$

where a and b are constants to be found.

(7)

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Question 6 continued

(Total for Question 6 is 7 marks)

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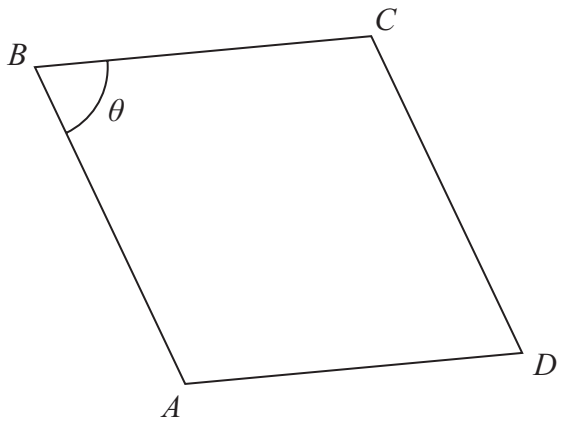

Figure 2

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 a parallelogram $ABCD$.

Given that

- $\overrightarrow{AB} = 6\mathbf{i} - 2\mathbf{j} + 3\mathbf{k}$
- $\overrightarrow{BC} = -4\mathbf{i} + 3\mathbf{j} - 5\mathbf{k}$
- angle $ABC = \theta$, $0 < \theta < 90°$

(a) find the exact value of $\cos\theta$, giving your answer in simplest form.

(3)

(b) Show that the area of parallelogram $ABCD$ is $5\sqrt{k}$, where k is an integer to be found.

(3)

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Question 7 continued

(Total for Question 7 is 6 marks)

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8. A container initially contains 6 litres of water.

Water starts to flow into the container.

The rate at which the water flows into the container is modelled by the differential equation

$$\frac{dV}{dt} = 12te^{-t}$$

where V litres is the volume of water in the container, t minutes after water starts flowing into the container.

(a) Solve the differential equation and use the initial condition to find an equation for V in terms of t

(5)

Given that the capacity of the container is 20 litres,

(b) determine, according to the model, whether or not the container will ever become full, giving a reason for your answer.

(1)

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Question 8 continued

(Total for Question 8 is 6 marks)

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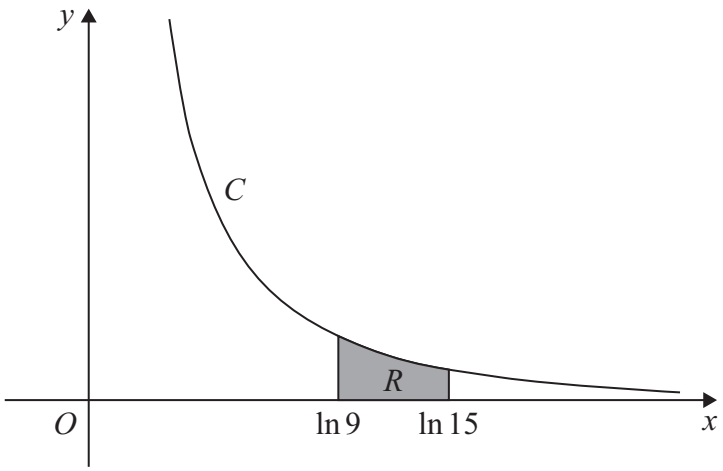

Figure 3

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

Figure 3 shows a sketch of the curve C with parametric equations

$$x = \ln(2t + 5) \qquad y = \frac{1}{t+1} \qquad t > -1$$

A point P lies on C.

Given that the gradient of C at P is -4

(a) use calculus to find the exact y coordinate of P.

(6)

The region R, shown shaded in Figure 3, is bounded by C, the line with equation $x = \ln 9$, the x-axis and the line with equation $x = \ln 15$

(b) (i) Show that the area of R is given by

$$\int_a^b \frac{k}{(t+1)(2t+5)}\,\mathrm{d}t$$

where a, b and k are constants to be found.

(ii) Hence, using algebraic integration, find the exact area of R.

Write your answer in the form $\frac{1}{3}\ln\alpha$, where α is a rational number.

(9)

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Question 9 continued

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Question 9 continued

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Question 9 continued

(Total for Question 9 is 15 marks)

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10. (a) Statement X: "If x^2 is an odd square number, then x is an odd number."

A student was asked to prove Statement X using proof by contradiction.

The student begins by writing the following.

> Assume that x^2 is an odd square number and x is an even number.
>
> If x is an even number it can be expressed in the form $x = 2m \quad m \in \mathbb{N}$

Complete the proof.

(2)

(b) Use proof by contradiction to show that

"There are no integers a and b such that $a^2 - 4b = 27$"

You may assume Statement X without further justification.

(4)

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Question 10 continued

Question 10 continued

(Total for Question 10 is 6 marks)

TOTAL FOR PAPER IS 75 MARKS

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Mark Scheme (Results)

October 2025

International Advanced Level in Pure Mathematics P4

WMA14/01

Edexcel and BTEC Qualifications

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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
- ⌊ 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 $x = \ldots$

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

2. Formula

Attempt to use correct formula (with values for a, b and c)

3. Completing the square

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

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	$(2+5x)^{-2}$	
(a)	$(2+5x)^{-2}=\frac{1}{4}\left(1+\frac{5}{2}x\right)^{-2}$	B1
	$\left(1+\frac{5}{2}x\right)^{-2}=1+(-2)\times\left(\frac{5}{2}x\right)+\frac{(-2)\times(-3)}{2}\times\left(\frac{5}{2}x\right)^2+\frac{(-2)\times(-3)\times(-4)}{3!}\times\left(\frac{5}{2}x\right)^3$	M1A1
	$(2+5x)^{-2}=\frac{1}{4}-\frac{5}{4}x+\frac{75}{16}x^2-\frac{125}{8}x^3$	A1A1
		(5)
(b)	$\lvert x\rvert<\frac{2}{5}$	B1
		(1)
(c)	$\left(\frac{4}{2+5x}\right)^2\approx 4-20x+75x^2$ or $a=4, b=-20$ and $c=75$	B1ft
		(1)
		(7 marks)

(a) Note that B1M1A0A1A0 is a possible mark trait

B1: For taking out a common factor of $\frac{1}{4}$ (or 0.25 or accept 2^{-2}) so score for $\frac{1}{4}(1+kx)^{-2}$ or $0.25(1+kx)^{-2}$. It cannot be for just $\frac{1}{4}$ on its own

M1: Attempts the binomial expansion with index -2

Score for the correct binomial coefficient for the 3rd or 4th term with the correct power of *x*

Look for $\frac{(-2)\times(-3)}{2}\times(...x)^2$ oe or $\frac{(-2)\times(-3)\times(-4)}{3!}\times(...x)^3$ oe If no working is shown then the coefficient must be consistent with their *k*. Condone invisible or poor bracketing for this mark.

Do not allow notation such as $\binom{-2}{1}, \binom{-2}{2}$ unless interpreted correctly in further work.

A1: Correct binomial expansion for $\left(1+\frac{5}{2}x\right)^{-2}$ up to the 4th term. This may be left unsimplified. May be implied by four correct terms. Isw if they subsequently simplify incorrectly. Invisible brackets may be implied by further work.

A1: Three correct and **simplified terms** from $\frac{1}{4}-\frac{5}{4}x+\frac{75}{16}x^2-\frac{125}{8}x^3$ May be written as decimal equivalents e.g. $0.25-1.25x+4.6875x^2-15.625x^3$. May be seen as a list or written on different lines. Condone $-\frac{5}{4}x^1$ for this mark.

A1: $\frac{1}{4}-\frac{5}{4}x+\frac{75}{16}x^2-\frac{125}{8}x^3$ oe See notes above for decimal equivalent forms. May be seen as a list or written on different lines. Isw once the four correct terms are seen unless they attempt to multiply by e.g. 16 Do not accept $-\frac{5}{4}x^1$

Alt(a) Direct expansion

$$(2\pm 5x)^{-2}=2^{-2}+(-2)\left(2^{-3}\right)(\pm 5x)+\frac{(-2)(-3)}{2}\left(2^{-4}\right)(\pm 5x)^2+\frac{(-2)(-3)(-4)}{6}\left(2^{-5}\right)(\pm 5x)^3+\ldots$$

B1: For 2^{-2} oe seen as the constant term e.g. $=\frac{1}{4}+\ldots x+\ldots$

M1: For the correct 3rd or 4th term of the expansion. Condone missing brackets on $(\pm 5x)^2$ or $(\pm 5x)^3$

A1: Correct expansion up to the 4th term which may be left unsimplified. May be implied by four correct terms. Isw if they subsequently simplify incorrectly. Invisible brackets may be implied by further work.

A1: As above in main scheme notes

A1: As above in main scheme notes

(b)

B1: $|x| < \frac{2}{5}$ oe e.g. $-\frac{2}{5} < x < \frac{2}{5}$ or e.g. $\left(-\frac{2}{5}, \frac{2}{5}\right)$ isw once a correct inequality is seen.

Condone $|x| < \left|-\frac{2}{5}\right|$

(c)

B1ft: $\left(\frac{4}{2+5x}\right)^2 \approx 4 - 20x + 75x^2$ but follow through on $16 \times "\left(\frac{1}{4} - \frac{5}{4}x + \frac{75}{16}x^2\right)"$. Must be a three- term quadratic but ignore any terms in x^3 or higher.

May just state e.g. $a = "4", b = "-20", c = "75"$

They must all be values (not unevaluated expressions)

Question Number	Scheme	Marks
2	Volume = $\int_{(2)}^{(8)} \frac{25\pi(x-1)}{9}(\mathrm{d}x)$ oe e.g. $\frac{25\pi}{9}\int_{(2)}^{(8)} x-1(\mathrm{d}x)$	B1
	$(\pi)\int \frac{25(x-1)}{9}\mathrm{d}x = (\pi)\frac{25(x-1)^2}{18}$ or $(\pi)\left(\frac{25x^2}{18}-\frac{25x}{9}\right)$	M1A1
	Volume = $\left[\frac{25\pi(x-1)^2}{18}\right]_2^8 = \left(\frac{25\pi(8-1)^2}{18}-\frac{25\pi(2-1)^2}{18}\right)=\frac{200}{3}\pi$	M1A1
		(5) **(5 marks)**

B1: Correct expression for the volume ignoring limits

May see e.g. $\frac{25\pi}{9}\int x-1(\mathrm{d}x)$ or $\int \frac{25\pi x}{9}-\frac{25\pi}{9}(\mathrm{d}x)$ May be unsimplified so allow $\pi\int\left(\frac{5}{3}\sqrt{x-1}\right)^2(\mathrm{d}x)$ Condone omission of dx. It cannot be scored if they make errors before the integral expression is written. π may appear later in a correct integral or integrand. Alternatively may use substitution e.g. $u^2=x-1$ and proceeding to $\pi\int\left(\frac{50}{9}u^3\right)(\mathrm{d}u)$ oe

M1: Correct attempt at integrating $(x-1)$. Look for $A(x-1)^2$ or Bx^2-Cx where *A*, *B* and C are non zero constants (indices do not need to be processed for this mark). Do not award this mark if this is only part of a sum of integrals. If using the substitution $u^2=x-1$ then look for $u^3\to u^4$

A1: $(\pi)\frac{25(x-1)^2}{18}$ or $(\pi)\left(\frac{25x^2}{18}-\frac{25x}{9}\right)$ oe (or using the substitution $u^2=x-1\Rightarrow$ $(\pi)\frac{25}{18}u^4$ oe)

Ignore any reference to π which could even appear as 2π

M1:Uses the limits of 2 and 8 within their integrated expression of the form $...(x-1)^2$ or $...x^2-...x$ and subtracts either way round. Allow $\left[\frac{25\pi(x-1)^2}{18}\right]_2^8=(\pm)\frac{200}{3}\pi$ to score this mark but if their integration is incorrect then we must see evidence of using limits not just a final answer. May be partially evaluated which you may need to check. Ignore the absence of π

If using the substitution $u^2=x-1$ then they need to use the limits $\sqrt{7}$ and 1 on an expression of the form $...u^4$

A1: $\frac{200}{3}\pi$ or exact equivalent e.g. $66\frac{2}{3}\pi$. If they subtract the wrong way round to achieve $-\frac{200}{3}\pi$ they cannot ignore the negative sign but must subsequently state e.g. volume = $\frac{200}{3}\pi$. Ignore units.

Question Number	Scheme	Marks
3 (a)	$x=\dfrac{t+15}{t+4}\Rightarrow t=\dfrac{15-4x}{x-1}$	M1
	$y=\dfrac{5}{t+2}\Rightarrow y=\dfrac{5}{\dfrac{15-4x}{x-1}+2}$	M1
	$y=\dfrac{5(x-1)}{15-4x+2(x-1)}$	dM1
	$\mathrm{g}(x)=\dfrac{5x-5}{13-2x}\qquad 1<x,,\dfrac{15}{4}$	A1B1
		(5)
(b)	$0<\mathrm{g}(x),,\dfrac{5}{2}$	M1A1
		(2)
		(7 marks)

(a)

M1: Attempts to get *t* in terms of *x* or *t* in terms of *y*. FYI $y=\dfrac{5}{t+2}\Rightarrow t=\dfrac{5}{y}-2$

Look for an equation of the form $t=\dfrac{A+Bx}{C+Dx}$ oe or $t=\dfrac{E}{y}+F$ oe where *A*,*B*, *C*, *D*, *E*, *F* $\neq 0$

If they get *t* in terms of *x* in one and *t* in terms of *y* in the other then just look for one of the equations to be of the required forms.

M1: Substitutes their *t* in terms of *x* (or *y*) in *y* (or *x*) however poorly manipulated and proceeds to an equation linking *x* and *y*. Condone slips substituting in provided the intention is clear.

FYI: $y=\dfrac{5}{t+2}\quad x=\dfrac{\dfrac{5}{y}-2+15}{\dfrac{5}{y}-2+4}=\dfrac{\dfrac{5}{y}+13}{\dfrac{5}{y}+2}$

Rearranging both equations to get *t* in terms of *x* in one and *t* in terms of *y* in the other and then equating scores this mark. Condone $y=\ldots$ or $x=\ldots$ to be implied as long as it is clearly their *y* or *x*

dM1: Proceeds to an equation of the form $y=\dfrac{ax+b}{cx+d}$ **which may be unsimplified.**

e.g. $y=\dfrac{5(x-1)}{15-4x+2(x-1)}$. It is dependent on the previous two method marks. There should be no fractions in the numerator or denominator but brackets do not need to be multiplied out. Condone slips provided they

achieved the required form. Condone $y = \ldots$ to be implied as long as it is clearly their *y*

A1: $g(x) = \frac{5x-5}{13-2x}$ o.e. Must be a single fraction in the correct form e.g. $g(x) = \frac{5-5x}{2x-13}$ Condone $y = \ldots$ Note the fraction may not be in its lowest terms e.g. $g(x) = \frac{10x-10}{26-4x}$

The $y = \ldots$ or $g(x) = \ldots$ can be seen on an earlier line

B1: States the values separately $e = 1,\ f = 3.75$. Accept $1 < x$,, $\frac{15}{4}$ oe (condone $1 < x \leqslant \frac{15}{4}$ as this was given in the question

(b)

M1: One correct end. e.g. $g(x)$,, $\frac{5}{2}$ oe. Do not be concerned over the inequality being strict or inclusive.

A1: $0 < g(x)$,, $\frac{5}{2}$ o.e. Condone use of *y* or g but not *x* e.g. $0 < y$,, $\frac{5}{2}$ and alternative equivalent notation e.g. $\left(0, \frac{5}{2}\right]$ $0 < g(x), \frac{5}{2} \ldots g(x)$ $0 < g(x) \cap \frac{5}{2} \ldots g(x)$ or $0 < g(x)$ AND $\frac{5}{2} \ldots g(x)$ but do not accept "OR" or use of $\cup$

Special case: $0 < x$,, $\frac{5}{2}$ oe score M1A0

Question Number	Scheme	Marks
4 (a)	Attempt at chain rule $y^2 \to ...y\frac{dy}{dx}$	M1
	Attempt at product rule $2xy \to \alpha x\frac{dy}{dx}+\beta y$	M1
	Correct differentiation $8x+2y\frac{dy}{dx}-2y-2x\frac{dy}{dx}=24$ oe	A1
	Collects terms in $(2y-2x)\frac{dy}{dx} = 24-8x+2y$	M1
	$\left(\frac{dy}{dx} =\right) \frac{12-4x+y}{y-x}$ oe	A1
		(5)
(b)	Sets $\frac{12-4x+y}{y-x}=2 \Rightarrow y=12-2x$ or $x=6-\frac{1}{2}y$	M1
	Substitute $y=12-2x$ or $x=6-\frac{1}{2}y$ into $4x^2+y^2-2xy=24x$	dM1
	$x^2-8x+12=0$ oe or $y^2-8y=0$	A1
	Solves $x=6, y=0$ or $x=2, y=8$	ddM1
	Chooses $a(x)=2, b(y)=8$ or states $(2, 8)$ only	A1
		(5)
		(10 marks)

(a) **Allow use of y' for $\frac{dy}{dx}$**

M1: Attempt at chain rule $y^2 \to ...y\frac{dy}{dx}$ where ... is a constant

M1: Attempt at product rule $2xy \to \alpha x\frac{dy}{dx}+\beta y$ where α, β ... are non-zero constants.

Condone $-2xy \to \pm\alpha x\frac{dy}{dx}\pm\beta y$

A1: Correct differentiation $8x+2y\frac{dy}{dx}-2y-2x\frac{dy}{dx}=24$ oe

M1: Collects their two different terms in $\frac{dy}{dx}$ which must have come from differentiating y^2 and $2xy$ (however poorly the differentiation was carried out) on one side of the equation with the remaining terms on the other side proceeding to $(...\pm...)\frac{dy}{dx}=.....$. May be implied by a correct answer.

Ignore a spurious $\frac{dy}{dx}$ e.g. on the left hand side as long as it is not included in the collecting of terms.

A1: $\left(\frac{dy}{dx} =\right) \frac{12-4x+y}{y-x}$ oe including $\left(\frac{dy}{dx} =\right) \frac{4x-y-12}{x-y}$ **Must be in simplest form and seen in (a)**

(b) May work in terms of *a* and *b* which is acceptable

M1: Sets their $\frac{dy}{dx} = 2$ and proceeds to a linear equation in *x* and *y*. May be unsimplified. Alternatively, substitutes in $\frac{dy}{dx} = 2$ into the given equation $8x+2y\times 2-2y-2x\times 2=24 \left(\Rightarrow 4x+2y=24\right)$

dM1: Substitutes their linear equation in *x* and *y* in the equation for C **and proceeds to a quadratic equation in *x* or *y***. Do not be concerned by the mechanics of their rearrangement. Terms should be collected but all terms do not need to be on the same side of the equation. (if all on one side then = 0 must be seen or may be implied by further work). It is dependent on the previous method mark.

A1: Correct quadratic in *x* or *y*. $x^2-8x+12=0$ oe or $y^2-8y=0$ oe terms should be collected but all terms do not need to be on the same side of the equation. (if all on one side then = 0 may be implied by further work)

ddM1: Solves their quadratic in *x* or *y* and proceeds to a pair of coordinates for *P*. Allow any valid method (usual rules apply). If via a calculator to find *x* then they must have rearranged to a three term quadratic with all terms on one side. You may need to check their roots are correct for their quadratic. It is dependent on both of the previous method marks.

Note when finding a value for *b* they may substitute into C resulting in false solutions.
e.g. $("6", "0"), ("6", "6")$ or $("2", "8"), ("2", "-4")$ which is acceptable for this mark.

A1: $P(2,8)$ only but allow other forms such as $a=2, b=8$. Condone if labelled as *x* and *y*.

If they find the coordinates $(6,0)$ then they must clearly identify $(2,8)$ as their chosen answer.

Question Number	Scheme	Marks
5. (i)	Attempts to solve $2+\lambda=-1+2\mu$ and $3+2\lambda=6+7\mu$	M1
	Correct solution $\lambda=-9,\ \mu=-3$	A1
	Substitutes their $\lambda=-9,\ \mu=-3$ into $-1+4\lambda=\beta-\mu$	dM1
	$\beta=-40$	A1
(ii)	E.g. Substitutes their $\lambda=-9$ into $\mathbf{r}=\begin{pmatrix}2\\-1\\3\end{pmatrix}+\lambda\begin{pmatrix}1\\4\\2\end{pmatrix}$	dM1
	$(-7,-37,-15)$	A1
		(6)
		(6 marks)

(i)

M1: Attempts to write down and solve equations (1) and (3) to find the value of either λ or μ

Do not be concerned by the mechanics of the rearrangement in solving.

May be implied by $\lambda=-9$ or $\mu=-3$.

A1: Correct solution **for both** $\lambda=-9,\ \mu=-3$

dM1: Substitutes their values for λ and μ into equation (2) and solves to find a value for β

Do not be concerned by the mechanics of the rearrangement in solving. It is dependent on the previous method mark.

A1: $\beta=-40$

(ii)

dM1: Scored for either substituting their $\lambda=-9$ into $\mathbf{r}=\begin{pmatrix}2\\-1\\3\end{pmatrix}+\lambda\begin{pmatrix}1\\4\\2\end{pmatrix}$ or

substituting their $\mu=-3$ and $\beta=-40$ into $\mathbf{r}=\begin{pmatrix}-1\\\beta\\6\end{pmatrix}+\mu\begin{pmatrix}2\\-1\\7\end{pmatrix}$ **and**

proceeding to find coordinates for *P*. Do not allow this mark to be scored if they then do some further manipulation.

It is dependent upon the attempt to find either λ or both of μ and β. May be implied by 2 correct coordinates for their λ or both of μ and β.

A1: $(-7,-37,-15)$ or position vector e.g. $-7\mathbf{i}-37\mathbf{j}-15\mathbf{k}$ or $\begin{pmatrix}-7\\-37\\-15\end{pmatrix}$ condone $(-7\mathbf{i},-37\mathbf{j},-15\mathbf{k})$

Allow $x=-7,\ y=-37,\ z=-15$ or condone $-7,-37,-15$. Do not isw if they calculate two different sets of coordinates using μ and β for one and then λ for the other unless they select the correct answer.

Question Number	Scheme	Marks
6	$u = 3 + \cos\theta \Rightarrow \dfrac{\mathrm{d}u}{\mathrm{d}\theta} = -\sin\theta$	B1
	$\displaystyle\int \frac{\sin 2\theta}{\sqrt{3+\cos\theta}}\,\mathrm{d}\theta = \int -\frac{2(u-3)}{\sqrt{u}}\,\mathrm{d}u$	M1 A1
	$= -\dfrac{4}{3}u^{\frac{3}{2}} + 12u^{\frac{1}{2}}$	dM1A1
	Uses limits of 3 and 4 within their attempted integration	ddM1
	$= 8\sqrt{3} - \dfrac{40}{3}$	A1
		(7 marks)

Condone the omission of du to be implied

B1: States or uses $\dfrac{\mathrm{d}u}{\mathrm{d}\theta} = -\sin\theta$ o.e. This may be seen within the integrand. Note that B0 will mean that no A marks will be scored.

M1: Simplifies $\dfrac{\sin 2\theta}{\sqrt{3+\cos\theta}}\mathrm{d}\theta$ to a function in terms of u using

- the double angle formula for $\sin 2\theta$ Allow/condone $\sin 2\theta = \kappa \sin\theta\cos\theta$
- the given substitution condoning $\cos\theta = \pm 3 \pm u$
- $\dfrac{\mathrm{d}u}{\mathrm{d}\theta} = \pm\sin\theta$
- $\sqrt{u}$ in the denominator

Expect to see a form $\displaystyle\int k\frac{(\pm u \pm 3)}{\sqrt{u}}(\mathrm{d}u)$ oe condone missing du provided the integral is of the required form. Condone $\mathrm{d}\theta$ for du as a slip for this mark. Condone $k = \pm 1$

A1: $\displaystyle\int -\frac{2(u-3)}{\sqrt{u}}(\mathrm{d}u)$ from correct work. Ignore limits for this mark but allow $\displaystyle\int_3^4 \frac{2(u-3)}{\sqrt{u}}(\mathrm{d}u)$ if the limits are written on the integral (3 and 4) and are the opposite way round. Condone missing du but do not allow $\mathrm{d}\theta$

Do not withhold this mark once a correct expression is seen from correct work.

dM1: Integrates to a form $\alpha u^{\frac{3}{2}} + \beta u^{\frac{1}{2}}$. It is dependent on the previous method mark.

A1: Correct integration, $-\frac{4}{3}u^{\frac{3}{2}} + 12u^{\frac{1}{2}}$ oe Ignore limits but allow e.g. $\frac{4}{3}u^{\frac{3}{2}} - 12u^{\frac{1}{2}}$ if the limits (3 and 4) are the opposite way round– send to review if unsure. May have a constant of integration. **All previous marks should have been scored condoning only $\mathrm{d}\theta$ instead of d*u* as a slip on their integral expression.**

ddM1: Uses limits of 3 and 4 (or alternative 0 and $\frac{\pi}{2}$ if substituted $u = 3 + \cos\theta$) and subtracts either way round within their attempted integration. The expression is sufficient. We must see some evidence of the use of limits for this mark. May be partially evaluated but cannot just be the final answer. It is dependent on both of the previous method marks.

A1: $8\sqrt{3} - \frac{40}{3}$ **provided all previous marks scored**. Do not accept $\frac{24\sqrt{3} - 40}{3}$ as this is not in the required form.

Question Number	Scheme	Marks
7. (a)	Attempts $\overrightarrow{BA}\square\overrightarrow{BC}$ $\begin{pmatrix}-6\\2\\-3\end{pmatrix}\bullet\begin{pmatrix}-4\\3\\-5\end{pmatrix}=24+6+15=45$	M1
	Attempts to apply $\mathbf{a}\bullet\mathbf{b}=\lvert\mathbf{a}\rvert\lvert\mathbf{b}\rvert\cos\theta\Rightarrow 45=7\times\sqrt{50}\cos\theta$	dM1
	$\cos\theta=\frac{9\sqrt{2}}{14}$ oe	A1
		(3)
(b)	Attempts $\sin\theta=\sqrt{1-\left(\frac{9\sqrt{2}}{14}\right)^2}$	M1
	Attempts to apply $\lvert\mathbf{a}\rvert\lvert\mathbf{b}\rvert\sin\theta=7\times\sqrt{50}\times\frac{\sqrt{34}}{14}$	M1
	Area $ABCD = 5\sqrt{17}$	A1
		(3)
		(6 marks)

(a)

M1: Attempts $\overrightarrow{BA}\bullet\overrightarrow{BC}$. Look for $\pm\begin{pmatrix}6\\-2\\3\end{pmatrix}\bullet\pm\begin{pmatrix}4\\-3\\5\end{pmatrix}=\pm24\pm6\pm15$ The expression is sufficient but may be implied by ±45. Condone slips but at least two products should be correct.

dM1: Uses $\mathbf{a}\bullet\mathbf{b}=\lvert\mathbf{a}\rvert\lvert\mathbf{b}\rvert\cos\theta$ with either of $\lvert\mathbf{a}\rvert$ or $\lvert\mathbf{b}\rvert$ found using a correct method. Either length may be implied by "$\sqrt{49}$" oe or "$\sqrt{50}$" oe. It is dependent on the previous method mark.

A1: $\cos\theta=\frac{9\sqrt{2}}{14}$ o.e such as $\cos\theta=\frac{9}{7\sqrt{2}}$ **Must be exact**

Note that $\cos\theta=-\frac{9\sqrt{2}}{14}$ or $\cos\theta=\frac{9\sqrt{2}}{14}$ from $\mathbf{a}\bullet\mathbf{b}=-45$ is M1dM1A0

Alt (a) using the cosine rule

M1: Attempts to find $\lvert\overrightarrow{AC}\rvert$, $\lvert\overrightarrow{AB}\rvert$ and $\lvert\overrightarrow{BC}\rvert$ (or $\lvert\overrightarrow{AC}\rvert^2$, $\lvert\overrightarrow{AB}\rvert^2$ and $\lvert\overrightarrow{BC}\rvert^2$) using a correct method with at least two lengths correct. May be seen within the cosine rule formula.

dM1: Uses the cosine rule to form a correct equation using their lengths in the correct positions. It is dependent on the previous method mark.

e.g. $\cos\theta = \dfrac{7^2 + (5\sqrt{2})^2 - 3^2}{2(7)(5\sqrt{2})}$

A1: $\cos\theta = \dfrac{9\sqrt{2}}{14}$ o.e such as $\cos\theta = \dfrac{9}{7\sqrt{2}}$

(b) Note that finding e.g. cos *BAC* $\left(= \dfrac{4}{21}\right)$ in (a) can still lead to full marks in (b)

M1: Attempts to find the **exact value** of $\sin\theta$ examples include:

- using $\sin\theta = \sqrt{1 - \left("\dfrac{9\sqrt{2}}{14}"\right)^2}$ oe May be implied by their $\dfrac{\sqrt{34}}{14}$ or exact equivalent or score for a correct expression for $\sin\theta$ with their $\cos\theta = \dfrac{9\sqrt{2}}{14}$ substituted. Condone invisible brackets.
- drawing a right-angled triangle to find the opposite side and then using $\sin\theta = \dfrac{\text{opp}}{\text{hyp}}$

If an exact expression is not seen somewhere in their solution then M0M0A0 but allow a candidate to write exact values but then use decimals in intermediate working provide exact values are recovered before the final answer.

Do not accept $\sin\theta = \sin\left(\cos^{-1}\left("\dfrac{9\sqrt{2}}{14}"\right)\right)$ for this mark.

M1: Attempts to apply $|\mathbf{a}||\mathbf{b}|\sin\theta$. The expression is sufficient. Look for e.g.

$"7"\times"\sqrt{50}"\times"\dfrac{\sqrt{34}}{14}"$

Condone $"7"\times"\sqrt{50}"\times\sin\left(\cos^{-1}\left("\dfrac{9\sqrt{2}}{14}"\right)\right)$ for this mark or

$"7"\times"\sqrt{50}"\times\sin(\text{awrt } 24.6)$

Note there are other methods to find the area. Send to review if you see something that you think is credit worthy.

A1: $5\sqrt{17}$ following an exact value for $\sin\theta$ **seen**, both previous method marks scored and $\cos\theta = \pm\dfrac{9\sqrt{2}}{14}$ o.e. (units not required)

Note: There are other valid methods which if seen then send to review:

Heron's formula

$$\left(s = \frac{7+5\sqrt{2}+3}{2} = 5+\frac{5\sqrt{2}}{2} \right) \Rightarrow A = 2\sqrt{s(s-7)(s-5\sqrt{2})(s-3)} = 5\sqrt{17}$$

Cross product e.g.

$$\left\| \begin{matrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ -6 & 2 & -3 \\ -4 & 3 & -5 \end{matrix} \right\| = \left| -\mathbf{i} - 18\mathbf{j} - 10\mathbf{k} \right| = \sqrt{(-1)^2 + (-18)^2 + (-10)^2} = 5\sqrt{17}$$

Question Number	Scheme	Marks
8 (a)	$\int te^{-t}\,dt = -te^{-t} + \int e^{-t}\,dt, = -te^{-t} - e^{-t}$	M1dM1
	$\frac{dV}{dt} = 12te^{-t} \Rightarrow V = -12te^{-t} - 12e^{-t} + c$	A1
	$t = 0, V = 6 \Rightarrow 6 = 0 - 12 + c \Rightarrow c = ...$	M1
	$V = 18 - 12te^{-t} - 12e^{-t}$	A1
		(5)
(b)	No, because e.g. upper limit of volume is 18 (litres)	B1 ft
		(1)

(a) **Note that differentiating using the product rule scores 0 marks**

M1: Uses integration by parts to achieve $\int te^{-t}\,dt = \alpha te^{-t} \pm \beta \int e^{-t}\,(dt)$ where $\alpha, \beta \neq 0$ but may be equal to each other (you do not need to be concerned about how they arrive at this) May be implied by further work.

dM1: Uses a correct method to integrate an expression of the form $\int te^{-t}\,(dt) = \alpha te^{-t} \pm \gamma e^{-t}$ where $\beta, \gamma \neq 0$. It is dependent on the previous method mark.

A1: Solves the differential equation with or without a constant of integration e.g. $\frac{dV}{dt} = 12te^{-t} \Rightarrow V = -12te^{-t} - 12e^{-t}(+c)$ o.e. May be written in an equivalent form e.g. $...V = ...\left(te^{-t} + e^{-t}\right)(+c)$

Watch out for the DI method

	D	I
+	$12t$	e^{-t}
−	12	$-e^{-t}$
+	0	e^{-t}

Giving correct integration e.g. $\int te^{-t}\,dt = -12te^{-t} - 12e^{-t}$

M1: Ether states $t = 0, V = 6$ and states a value for c or uses the initial conditions for their integral to find the value of c. You do not need to be concerned by the mechanics of the rearrangement. Whilst not dependent on the earlier method marks, there must have been some attempt to solve the differential equation however poor (but not clearly differentiation)
May alternatively substitute in limits *V* and 6 and *t* and 0 onto each side of their integrated expression so the constant of integration is within the calculation.

A1: $V = 18 - 12te^{-t} - 12e^{-t}$ oe Condone if seen in (b)

(b)

B1ft: No, because upper limit of volume is 18 (litres) oe Ft on their $V = "18" - Ate^{-t} - Be^{-t}$
where *A*, *B* > 0

May set $V = 20$ and show that the equation cannot be solved.
e.g. $-2 = 12e^{-t}(t+1)$ and explains that $e^{-t} > 0$ and $t + 1 > 0$ so cannot be negative
If their $"18" > 20$ then they need to conclude yes with a reason.

Question Number	Scheme	Marks
9 (a)	$\frac{dy}{dt}=\frac{-1}{(t+1)^2}$, $\frac{dx}{dt}=\frac{2}{2t+5}$ $\Rightarrow\left(\frac{dy}{dx}=\right)-\frac{2t+5}{2(t+1)^2}$	M1A1
	Sets $-\frac{2t+5}{2(t+1)^2}=-4\Rightarrow 8t^2+14t+3=0$	M1A1
	$\Rightarrow(4t+1)(2t+3)=0\Rightarrow t=-\frac{1}{4}\Rightarrow(y=)\ \frac{4}{3}$	dM1A1
		(6)
(b) (i)	$a=2, b=5$	B1
	Area $=\int y\frac{dx}{dt}\,dt=\int_2^5\frac{1}{t+1}\times\frac{2}{2t+5}\,dt=\int_2^5\frac{2}{(t+1)(2t+5)}\,dt$	M1A1
(ii)	$\frac{2}{(t+1)(2t+5)}\equiv\frac{A}{(t+1)}+\frac{B}{(2t+5)}\Rightarrow A=...,\ B=...$	M1
	$=\frac{2/3}{(t+1)}-\frac{4/3}{(2t+5)}$	A1
	$\int\frac{2/3}{(t+1)}-\frac{4/3}{(2t+5)}\,dt=\frac{2}{3}\ln\lvert t+1\rvert-\frac{2}{3}\ln\lvert 2t+5\rvert$	M1A1ft
	$\int_2^5\frac{2}{(t+1)(2t+5)}\,dt=\left(\frac{2}{3}\ln 6-\frac{2}{3}\ln 15\right)-\left(\frac{2}{3}\ln 3-\frac{2}{3}\ln 9\right)$ $=\frac{2}{3}\ln\left(\frac{6}{5}\right)=\frac{1}{3}\ln\left(\frac{36}{25}\right)$	dM1A1
		(9) **(15 marks)**

(a)

M1: Attempts to find $\frac{dy}{dx}$ by dividing their $\frac{dy}{dt}$ by their $\frac{dx}{dt}$. Both must be attempts at differentiation, however poor. Do not allow e.g. $\frac{2}{2t+5}\rightarrow...\ln(2t+5)$ as this is clearly integration.

A1: $\left(\frac{dy}{dx}=\right)-\frac{2t+5}{2(t+1)^2}$ which may be unsimplified and may be implied by further work

M1: Sets their "$-\frac{2t+5}{2(t+1)^2}$" $=\pm 4$ and proceeds to a 3TQ in t. Do not be concerned by the mechanics of the rearrangement.

A1: $8t^2+14t+3=0$ o.e. e.g. $t^2+\frac{7}{4}t+\frac{3}{8}=0$ The = 0 may be implied by further work if the three terms are on the same side of the equation.

dM1: Dependent upon both previous M's, score for solving their 3TQ AND finding a value for *y*. Allow any valid attempt to solving the quadratic including via a calculator. You may need to check this if just a value for *t* is stated. Condone a *y* value being found from a value of *t* such that $t<-1$.

A1: $(y=)\ \frac{4}{3}$ oe only (ignore the *x* coordinate if found)

See alt below – send to review if unsure

9 (a)	$y=\frac{2}{e^x-3} \Rightarrow \frac{dy}{dx}=\frac{-2e^x}{(e^x-3)^2}$	M1A1
	Sets $\frac{-2e^x}{(e^x-3)^2}=-4 \Rightarrow 2(e^x)^2-13e^x+18=0=0$	M1A1
	$\Rightarrow \left(2e^x-9\right)\left(e^x-2\right)=0 \Rightarrow e^x=\frac{9}{2} \Rightarrow t=-\frac{1}{4} \Rightarrow y=\frac{4}{3}$	dM1A1
		(6)

(b)(i)

B1: Correct values for *a* and *b*. Must be correctly paired or indicated on the integral. If there is a contradiction between the two then the values on the integral sign take precedence.

M1: For attempting $y\frac{dx}{dt}$ with their $\frac{dx}{dt}$ in the form $\frac{k}{2t+5}$ where *k* is a constant.

Must see either the general expression $y\frac{dx}{dt}$ stated or written as e.g. $\frac{1}{t+1}\times\frac{k}{2t+5}$ oe. There needs to be an intermediate stage of working before writing $\frac{a}{(t+1)(2t+5)}$.

It cannot be implied by $\int_a^b \frac{2}{(t+1)(2t+5)}\,\mathrm{d}t$

A1: Area $R = \int_a^b \frac{2}{(t+1)(2t+5)}\,\mathrm{d}t$ with or without correct values for a and b. **The dt only needs to be present in the final answer.** Allow if seen at the start of (b)(ii). Allow slips in working to be recovered provided it is before the final answer. This mark cannot be scored without the previous M mark being scored i.e. we need to see an intermediate stage of working.

Note allow $\int_a^b \frac{-2}{(t+1)(2t+5)}\,\mathrm{d}t$ only if their limits are clearly stated as being the other way round.

(b)(ii)

M1: Attempts to write $\frac{k}{(t+1)(2t+5)}$ as $\frac{A}{(t+1)}+\frac{B}{(2t+5)}$. May be implied by a correct value for A or B (but not e.g. $A=1,\ B=1$ without a valid method seen) May have taken a factor outside of the integral.

A1: $\frac{2}{(t+1)(2t+5)} \equiv \frac{2/3}{(t+1)} - \frac{4/3}{(2t+5)}$. May have taken a factor outside of the integral so allow e.g. $\frac{1/3}{(t+1)} - \frac{2/3}{(2t+5)}$ oe to score. Must see the partial fractions written or implied by their integration.

M1: Correct attempt at integration. Look for $\pm\alpha\ln|t+1| \pm\beta\ln|2t+5|$ oe where $\alpha,\ \beta \neq 0$ They must have separated into partial fractions first. Condone brackets instead of moduli and condone the omission of brackets to be implied by further work. Allow this mark to be scored if they miscopy their partial fractions (e.g. a sign slip or a coefficient slip) so they will still integrate to a similar form.

A1ft: $\int \frac{2/3}{(t+1)} - \frac{4/3}{(2t+5)}\,\mathrm{d}t = \frac{2}{3}\ln|t+1| - \frac{2}{3}\ln|2t+5|$ oe so allow $\frac{1}{3}\ln|t+1| - \frac{1}{3}\ln|2t+5|$ oe but ft on their *A* and *B*. May have taken a factor of 2 outside of the integral. Condone brackets instead of moduli and invisible brackets to be implied by further work. Ignore any constant of integration if present.

dM1: Attempts to use their limits and subtract either way round. They must use at least one law to combine at least two terms. They cannot proceed directly to the final answer. It is dependent on the previous method mark.

A1: $\frac{1}{3}\ln\left(\frac{36}{25}\right)$ o.e. in the required form $\frac{1}{3}\ln a$ where *a* is a rational number. Do not accept $\frac{1}{3}\ln\left(\frac{6}{5}\right)^2$

Question Number	Scheme	Marks
10 (a)	Requires a minimum of • $x^2=(2m)^2=4m^2$ • which is even so contradiction, so proven	 B1 dB1 **(2)**
(b)	e.g. $a^2-4b=27\Rightarrow a^2=27+4b$ which is odd e.g. If a^2 is odd then *a* is odd and can be written in the form $a=2m+1$ e.g. $(2m+1)^2=27+4b\Rightarrow b=...$ Requires a full explanation and conclusion e.g. • $b=m^2+m-\frac{13}{2}$ which is not an integer • so contradiction, hence proven *	M1 A1 dM1 A1* **(4)** **(6 marks)**

(a)

B1: States that $x^2=4m^2$

dB1: Dependent on the previous B mark. Explains or concludes that $4m^2$ is **even** (or condone not odd) and either states contradiction/so proven or rewrites statement X (condone omission of some of the words provided the general conclusion is clear). Do not allow if the contradiction is not based on the assumption that x^2 is odd and $4m^2$ is even.

(b) Note that there many ways of showing this – send to review if you think it might be credit worthy

M1: $a^2-4b=27\Rightarrow a^2=27+4b$ oe with an indication that this is odd. Allow writing in the form $2(2b+13)+1$ to imply this.

A1: **States** a^2 is odd (then *a* is odd) and writes in the form $a=2m+1$

dM1: Attempts $(2m+1)^2=27+4b$ and rearranges to $b=...$ or $2b=...$ or a form where a contradiction can be deduced such as $m^2+m=b+\frac{13}{2}$ where m^2 and *m* will both be integers but $b+\frac{13}{2}$ is not. It is dependent on the

previous method mark. Expect to see the brackets multiplied out and terms collected condoning slips.

A1*: cso requires a correct statement showing that there is a contradiction with a conclusion

Pearson Edexcel International Advanced Level

Friday 17 October 2025

Morning (Time: 1 hour 30 minutes)

Paper reference **WST01/01A**

Mathematics

International Advanced Subsidiary/Advanced Level
Statistics S1
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. A medical researcher is studying the relationship between age (x years) and volume of blood (y ml) pumped by each contraction of the heart.

The researcher obtained the following data from a random sample of 8 patients.

Age (x)	20	25	30	45	55	60	65	70
Volume (y)	74	76	77	72	68	67	64	62

[You may use $\sum x = 370$, $S_{xx} = 2587.5$, $\sum y = 560$, $\sum y^2 = 39418$, $S_{xy} = -710$]

(a) Calculate S_{yy}

(2)

(b) Calculate the product moment correlation coefficient for these data.

(2)

(c) Interpret your value of the correlation coefficient.

(1)

The researcher believes that a linear regression model may be appropriate to describe these data.

(d) State, giving a reason, whether or not your value of the correlation coefficient supports the researcher's belief.

(1)

(e) Find the equation of the regression line of y on x, giving your answer in the form $y = a + bx$

(4)

Jack is a 40-year-old patient.

(f) (i) Use your regression line to estimate the volume of blood pumped by each contraction of Jack's heart.

(ii) Comment, giving a reason, on the reliability of your estimate.

(2)

(Total for Question 1 is 12 marks)

2. The discrete random variable X has probability function $\mathrm{p}(x)$ and cumulative distribution function $\mathrm{F}(x)$ given in the table below.

x	1	2	3	4	5
$\mathrm{p}(x)$	0.10	a	0.28	c	0.24
$\mathrm{F}(x)$	0.10	0.26	b	0.76	d

(a) Write down the value of d

(1)

(b) Find the values of a, b and c

(3)

(c) Write down the value of $\mathrm{P}(X > 4)$

(1)

Two independent observations, X_1 and X_2, are taken from the distribution of X.

(d) Find the probability that X_1 and X_2 are both odd.

(2)

Given that X_1 and X_2 are both odd,

(e) find the probability that the sum of X_1 and X_2 is 6
Give your answer to 3 significant figures.

(3)

(Total for Question 2 is 10 marks)

3. Two youth clubs, *Eastyou* and *Westyou*, decided to raise money for charity by running a 5 km race.

All the members of the youth clubs took part and the time, in minutes, taken for each member to run the 5 km was recorded.

The times for the *Westyou* members are summarised in Figure 1.

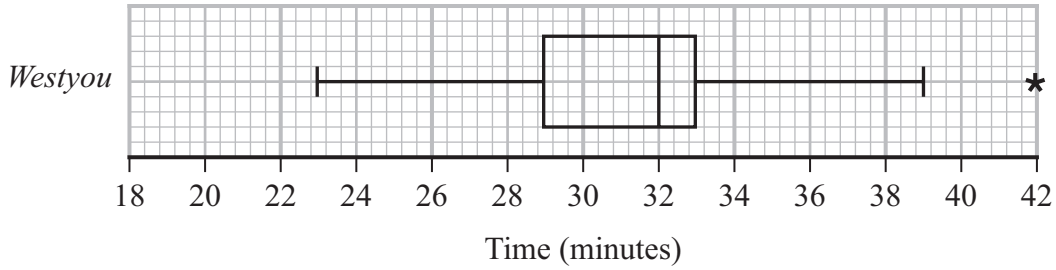

Figure 1

(a) Write down the time that is exceeded by 75% of *Westyou* members.

(1)

The times for the *Eastyou* members are summarised by the stem and leaf diagram below.

Steam	Leaf	
2	0 2 3 4	(4)
2	5 6 8 8 8 9 9	(7)
3	0 0 0 0 0 1 1 1 2 2 2 2 3 4	(14)
3	5 5 5 7 9	(5)

Key: 2 | 0 means 20 minutes

(b) Find the value of the median and interquartile range for the *Eastyou* members.

(3)

An outlier is a value that falls either

more than $1.5 \times (Q_3 - Q_1)$ above Q_3

or more than $1.5 \times (Q_3 - Q_1)$ below Q_1

(c) On the grid on page 11 of the Answer Book, draw a box plot to represent the times of the *Eastyou* members.

(4)

(d) State the skewness of each distribution. Give reasons for your answers.

(3)

(Total for Question 3 is 11 marks)

4. At a school athletics day, the distances, in metres, achieved by students in the long jump are modelled by the normal distribution with mean 3.3 m and standard deviation 0.6 m

(a) Using standardisation, find an estimate for the proportion of students who jump less than 2.5 m

(2)

The long jump competition consists of 2 jumps.

All the students can take part in the first jump and the 40% who jump the greatest distance in their first jump qualify for the second jump.

(b) Using standardisation, find an estimate for the minimum distance achieved in the first jump in order to qualify for the second jump.
Give your answer correct to 4 significant figures.

(3)

(c) Find an estimate for the median distance achieved in the first jump by those who qualify for the second jump.
Show your working clearly.

(3)

The distance of the second jump is independent of the distance of the first jump and is modelled with the same normal distribution.

Students who jump a distance greater than 4.1 m in their second jump receive a certificate.

At the start of the long jump competition, a student is selected at random.

(d) Find the probability that this student will receive a certificate.

(3)

(Total for Question 4 is 11 marks)

5. A bag contains 19 red beads and 1 blue bead only.

Linda selects a bead at random from the bag. She notes its colour and replaces the bead in the bag.

She then selects a second bead at random from the bag and notes its colour.

Find the probability that

(a) both beads selected are blue,

(1)

(b) exactly one bead selected is red.

(2)

In another bag there are 9 beads, 4 of which are green and the rest are yellow.

Linda selects 3 beads from this bag at random without replacement.

(c) Find the probability that 2 of these beads are yellow and 1 is green.

(3)

Linda replaces the 3 beads and then selects another 4 at random without replacement.

(d) Find the probability that at least 1 of the beads is green.

(3)

(Total for Question 5 is 9 marks)

6. The discrete random variable X has probability distribution

x	–4	–3	1	2	5
$P(X = x)$	a	b	a	b	0.2

(a) Find $E(X)$ in terms of a and b

(1)

For this probability distribution, $\text{Var}(X) = E(X^2)$

(b) (i) Write down the value of $E(X)$

(ii) Find the value of a and the value of b

(5)

(c) Find $\text{Var}(1 - 3X)$

(3)

Given that $Y = 1 - X$, find

(d) (i) $P(Y < 0)$

(ii) the largest possible value of k such that $P(Y < k) = 0.2$

(4)

(Total for Question 6 is 13 marks)

7. Yujie is investigating the weights of 10 young rabbits. She records the weight, x grams, of each rabbit and the results are summarised below.

$$\sum x = 8360 \qquad \text{and} \qquad \sum (x - \bar{x})^2 = 63\,840$$

(a) Calculate the mean and the standard deviation of the weights of these rabbits.

(3)

Given that the median weight of these rabbits is 815 grams,

(b) describe, giving a reason, the skewness of these data.

(2)

Two more rabbits weighing 776 grams and 896 grams are added to make a group of 12 rabbits.

(c) State, giving a reason, how the inclusion of these two rabbits would affect the mean.

(2)

(d) By considering the change in $\sum (x - \bar{x})^2$, state what effect the inclusion of these two rabbits would have on the standard deviation.

(2)

(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

Friday 17 October 2025

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 ▶

P87486A

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M:1/

P 8 7 4 8 6 A 0 1 2 8

Pearson

Question 1

Write the answer to Question 1 on these 4 pages

DO NOT WRITE IN THIS AREA

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

Question 1 continued

Question 1 continued

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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 12 marks)

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Question 2

Write the answer to Question 2 on these 4 pages

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Question 2 continued

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)

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Question 3

Write the answer to Question 3 on these 4 pages

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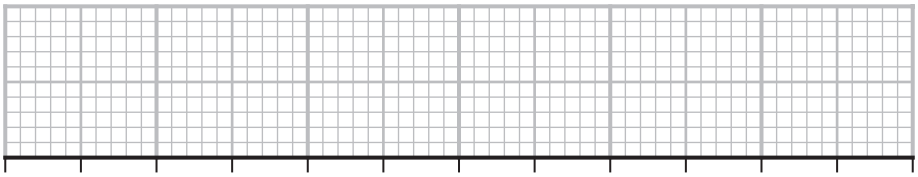
Question 3 continued



Use this grid for your answer to part (c) if you make a mistake cross through this grid and use the spare grid on page 13

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Question 3 continued

DO NOT WRITE IN THIS AREA

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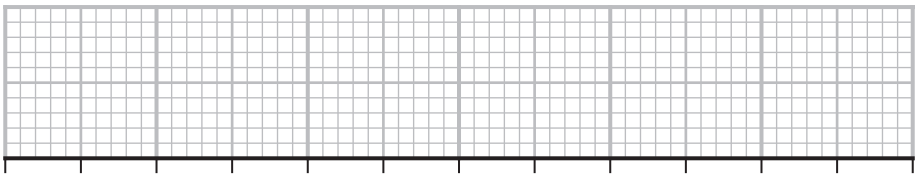
Question 3 continued

Only use this grid if you have made a mistake on the first grid.



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

(Total for Question 3 is 11 marks)

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Question 4

Write the answer to Question 4 on these 4 pages

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Question 4 continued

Question 4 continued

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Question 4 continued

This is the end of Question 4 answer space. Please turn the page for Question 5 answer space.

(Total for Question 4 is 11 marks)

Question 5

Write the answer to Question 5 on these 4 pages

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Question 5 continued

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 9 marks)

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Question 6

Write the answer to Question 6 on these 4 pages

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Question 6 continued

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DO NOT WRITE IN THIS AREA

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 13 marks)

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Question 7

Write the answer to Question 7 on these 3 pages

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

Question 7 continued

Question 7 continued

(Total for Question 7 is 9 marks)

TOTAL FOR PAPER IS 75 MARKS

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DO NOT WRITE IN THIS AREA

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Mark Scheme (Results)

October 2025

International Advanced Level in Statistics S1

WST01/01A

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October 2025
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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: 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
   - ⌐ 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.

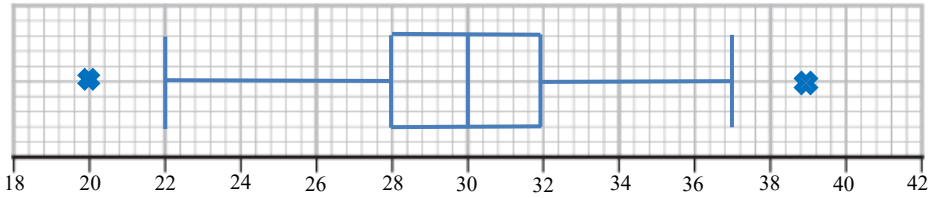
7. Ignore wrong working or incorrect statements following a correct answer

Question Number	Scheme	Marks
1(a)	$S_{yy} = 39418 - \frac{560^2}{8}$	M1
	= 218	A1
		(2)
(b)	$[r =] \frac{-710}{\sqrt{"218" \times 2587.5}}$	M1
	= –0.945344... awrt –0.945	A1
		(2)
(c)	As **age increases**, **volume/blood** [pumped] **decreases** (o.e.)	B1
		(1)
(d)	**Yes** as r is close to **–** 1 (if $r <$ **–** 0.5) or **Yes** as r is close to 1 (if $r >$ 0.5) [If **–** 0.5 $\leq r \leq$ 0.5 allow "**no** since r is close to 0"]	B1ft
		(1)
(e)	$b = \frac{-710}{2587.5} = -0.27439...$ $\left(\text{allow } \frac{-284}{1035}\right)$ awrt –0.27	M1A1
	$a = \frac{560}{8} - "b" \times \frac{370}{8} [= 82.690...]$	M1
	$y = 82.7 - 0.274x$	A1
		(4)
(f)(i)	[$y = 82.7 - 0.274 \times 40$ =] 71.74.. awrt 72	B1ft
(ii)	Should be reliable since interpolation (o.e.)	B1
		(2)
	Notes	**Total 12**

(a)	**M1**	For a correct expression for S_{yy} May be implied by 218
	A1	218 (Condone 218.0)
(b)	**M1**	for attempt at correct formula. Must have their S_{yy} and given S_{xx} , S_{xy} in the correct places. Condone missing – sign awrt – 0.945 scores M1A1 but award M1A0 for awrt –0.95 with no expression seen
	A1	Awrt –0.945
(c)	**B1**	Must mention "age" and "volume/blood" No ft
(d)	**B1ft**	A correct statement with a correct reason ft their r (provided that $\lvert r \rvert < 1$) Allow 'my value / it's' to imply r. 'points lie close to a line' is B0 since there is no evidence of this
(e)	**M1**	For a correct expression for b Condone missing – sign May be implied by awrt –0.27 or an exact fraction
	A1	Awrt –0.27 Allow an exact fraction
	M1	For a correct method to find a Ft their value of b May be implied by awrt 82.7
	A1	For a correct equation for y and x with a = awrt 82.7 and b = awrt –0.274 No fractions. Both values must be 3 sf or better
(f)(i)	**B1ft**	Awrt 72 ft their regression line
(ii)	**B1**	For a comment that suggests that it is reliable since 40 is within the range of the data or interpolation e.g. Reliable since 40 is close to $\bar{x}$ / 46.25 Do not allow Reliable since awrt 72 is within the range of the data oe Condone extra non-relevant comments

Question Number	Scheme			Marks
2(a)	1			B1
				(1)
(b)	$a = 0.26 - 0.1$	$b = 0.26 + 0.28$ or 'a' + 0.38 or $0.76 -$ 'c'	$c = 0.76 -$ 'b' or $1 - (0.62 +$ 'a')	M1
	$a = 0.16$	$b = 0.54$	$c = 0.22$	A1A1
				(3)
(c)	0.24			B1
				(1)
(d)	P(X is an odd number) = 0.1 + 0.28 + 0.24= 0.62			
	P(X_1 and X_2 are both odd) = 0.62^2 or $0.1^2 + 0.28^2 + 0.24^2 + 2\times0.1\times0.28 + 2\times0.1\times0.24 + 2\times0.24\times0.28$			M1
	= 0.3844		awrt 0.384	A1
				(2)
(e)	[P($X_1 + X_2 = 6$ | both are odd) =] $\frac{P(X_1 + X_2 = 6 \cap X_1 \text{ and } X_2 \text{ are odd})}{P(X_1 \text{ and } X_2 \text{ are odd})}$			M1
	$= \frac{0.1\times0.24 + 0.28\times0.28 + 0.24\times0.1}{'d'} = \frac{0.1264}{'d'}$			A1ft
	= 0.32882….		awrt 0.329	A1
				(3)

	Notes	Total 10
(a)	**B1**	Cao
(b)	**M1**	For any correct calculation (may be implied by one correct answer) ft their values for a, b or c provided these result in a probability
	A1	For one correct value
	A1	For all 3 correct answers
(c)	**B1**	Cao
(d)	**M1**	For a complete correct expression ft their values for a and c e.g. $(1 - ('a' + 'c'))^2$ May be implied by awrt 0.384 or $\frac{961}{2500}$
	A1	Awrt 0.384 or $\frac{961}{2500}$
(e)	**M1**	For a correct conditional probability expression may be implied by a correct numerator awrt 0.126 or $\frac{79}{625}$ and a denominator ft part d. May be stated in words e.g. $\frac{P(\text{sum} = 6 \cap \text{odd})}{P(\text{odd})}$ oe Do not allow P($X_1 + X_2 = 6$ | both are odd) on its own
	A1ft	For a correct numerator (may be implied by awrt 0.126 or $\frac{79}{625}$) and denominator ft their part d
	A1	Awrt 0.329 or $\frac{316}{961}$

Question Number	Scheme	Marks
3(a)	29	B1
		(1)
(b)	Median = 30	B1
	IQR = 32 – 28	M1
	= 4	A1
		(3)
(c)	'32' + 1.5('4') = '38' and '28' – 1.5('4') = '22'	M1
		B1 B1ft A1
		(4)
(d)	***Westyou***: $[Q_2 - Q_1 = 3,\ Q_3 - Q_2 = 1 \text{ or } (Q_2 - Q_1) > (Q_3 - Q_2)] \Rightarrow$ -ve [skew]	B1B1ft
	Eastyou: $[Q_2 - Q_1 = 2,\ Q_3 - Q_2 = 2 \text{ or } (Q_2 - Q_1) = (Q_3 - Q_2)] \Rightarrow$ No skew	B1ft
		(3)

	Notes	Total 11
(a)	**B1**	Allow 28.9
(b)	**B1**	Cao (Condone no label, but incorrect label is B0) Must be seen in part b
	M1	For UQ – LQ (at least one correct)
	A1	Cao (Must be in part (b)) Allow 4 with no working shown, but do not allow 4 from incorrect working
(c)	**M1**	Sight of $"32"+1.5("4")$ or "38" or $"28"-1.5("4")$ or "22" ft their UQ and LQ. May be implied by a fully correct box plot with both outliers plotted
	B1	Box with 2 whiskers (Must be one either side of the box)
	B1ft	Lower whisker plotted at 22 (allow their 22 or the next biggest number if more than 1 outlier identified or allow 20 if no outlier identified), LQ plotted at their 28, Median plotted at their 30, UQ plotted at their 32 and Upper whisker plotted at 37 (allow their 38 or their next smallest value if more than 1 outlier identified or allow 39 if no outlier identified) **NB** We only ft their 28 and their 32 if stated/shown in part b
	A1	2 outliers plotted at 20 and 39 and no extras
		NB If no scale given then the maximum this may score is M1B1B0A0
(d)	**B1**	***Westyou*** negative [skew] Must be clear indication that it is associated with *Westyou* e.g W
	B1ft	***Eastyou*** no skew/zero skew oe Condone symmetrical/symmetric. Must be clear indication that it is associated with *Eastyou* e.g. E Do not allow even skew or normal/normally distributed etc ft their box plot
	B1ft	Justification for both of the given statements or use of the box plot in their explanation This mark is independent of the given statements ft their box plot Do not allow contradictory justifications
		NB SC if only one comment is made then assume it is about *Eastyou* and B0B1B0 is possible

Question Number	Scheme	Marks
4(a)	[Let J = the length of a jump] P(J < 2.5) = $\mathrm{P}\left(Z < \frac{2.5-3.3}{0.6}\right)$	M1
	[= P(Z < −1.333…) = 1 − 0.9082] = 0.0912 to 0.0918	A1
		(2)
(b)	$\left[\mathrm{P}(J > d) = 0.4 \Rightarrow\right]$ $\frac{d-3.3}{0.6} = 0.2533$ or $\frac{3.3-d}{0.6} = -0.2533$	M1A1
	d = 3.45198 awrt 3.452	A1
		(3)
(c)	$\left[\mathrm{P}(J > m \mid J > d) \Rightarrow\right]$ $\frac{\mathrm{P}(J > m)}{0.4} = 0.5$ or P(J > m) = 0.2	M1
	$\frac{m-3.3}{0.6} = 0.8416$ or $\frac{3.3-m}{0.6} = -0.8416$	M1
	m = 3.80496 (calc 3.80497…) awrt 3.8[0]	A1
		(3)
(d)	P(J > 4.1) = 0.0918 (same as (a))	B1ft
	So P(certificate) = $0.4\times$"(a)"	M1
	= 0.036 to 0.037	A1
		(3)

	Notes		Total 11
(a)	**M1**	For standardising with 2.5, 3.3 and 0.6 Allow ± and ignore inequality Must show the standardisation	
	A1	For an answer in the range 0.0912 to 0.0918 **NB** calc gives 0.09121128…	
(b)	**M1**	For standardising with d (allow any letter for d), 3.3 and 0.6 and setting equal to z where 0.2 < |z| < 0.3 Must show the standardisation	
	A1	For a correct equation with z = ± 0.25 or better (allow any letter for d) z value must be compatible with their standardisation	
	A1	For awrt 3.452 (calc gives 3.45200… use of 0.2533 gives 3.4519…)	
(c)	**M1**	For a correct probability statement involving J and m (median) only Allow any letter for J and m May be implied by awrt 3.8[0]/3.81 or 2nd M mark	
	M1	For $\frac{m-3.3}{0.6} = z$ where 0.84 ≤ z < 0.85 or $\frac{3.3-m}{0.6} = z$ where −0.85 < z ≤ −0.84 May be implied by awrt 3.8[0]/3.81 Allow any letter for m	
	A1	Awrt 3.8[0] (accept 3.805)	
(d)	**B1ft**	For an answer in the range 0.0912 to 0.0918 or same as part (a) for P(J > 4.1) Allow any letter for J	
	M1	For 0.4 × their P(J > 4.1)	
	A1	For answer in the range 0.036 to 0.037 **NB** 0.4 × 0.0918 = 0.036712 and 0.4 × 0.0912 = 0.03648	

Question Number	Scheme	Marks
5(a)	[P(Both blue) $= 0.05 \times 0.05 =$]0.0025 oe	B1
		(1)
(b)	P(Exactly 1 red)$=2 \times 0.05 \times 0.95$	M1
	$=0.095$	A1
		(2)
(c)	P(2 yellow and 1 green)$=3 \times \frac{4}{9} \times \frac{5}{8} \times \frac{4}{7}$	B1M1
	$= \frac{10}{21}$	A1
		(3)
(d)	[P(All beads are yellow)] = $\frac{5}{9} \times \frac{4}{8} \times \frac{3}{7} \times \frac{2}{6}$	M1
	[P(At least 1 bead is green)$=1 - $P(all beads are yellow)=] $1 - \frac{5}{9} \times \frac{4}{8} \times \frac{3}{7} \times \frac{2}{6}$	M1
	$= \frac{121}{126}$	A1
		(3)
	Notes	**Total 9**

(a)	**B1**	oe e.g. $\frac{1}{400}$
(b)	**M1**	oe e.g. $\frac{1}{20} \times \frac{19}{20} + \frac{19}{20} \times \frac{1}{20}$
	A1	oe e.g. $\frac{19}{200}$
(c)	**B1**	For 3 × … or the sum of exactly 3 identical products. Allow equivalent expressions for 3 × … e.g. ${}^3C_2$
	M1	For $\frac{4}{9} \times \frac{5}{8} \times \frac{4}{7}$ oe e.g. $\frac{5 \times 4 \times 4}{9 \times 8 \times 7}$ May be implied by $\frac{10}{63}$
	A1	For $\frac{10}{21}$ oe (allow awrt 0.476 from correct working)
(d)	**M1**	For $\frac{5}{9} \times \frac{4}{8} \times \frac{3}{7} \times \frac{2}{6}$ oe e.g. $\frac{5 \times 4 \times 3 \times 2}{9 \times 8 \times 7 \times 6}$ It must be on its own or clear that they are finding P(All beads are yellow) and not embedded in a list of possible outcomes or a list of all 15 outcomes May be implied by 2nd M1 (YYYG)×4 [(YYGY), (YGYY), (GYYY)] May be implied by $4 \times \frac{5 \times 4 \times 3 \times 4}{9 \times 8 \times 7 \times 6}$ oe (YYGG)×6 [(YGYG), (YGGY), (GYYG), (GYGY), (GGYY)] May be implied by $6 \times \frac{5 \times 4 \times 4 \times 3}{9 \times 8 \times 7 \times 6}$ oe (YGGG) ×4 [(GGGY), (GGYG), (GYGG)] May be implied by $4 \times \frac{5 \times 4 \times 3 \times 2}{9 \times 8 \times 7 \times 6}$ oe (GGGG) May be implied by $\frac{4 \times 3 \times 2 \times 1}{9 \times 8 \times 7 \times 6}$ oe
	M1	Use of $1 - p$ (where p is a product of 4 probabilities) or the sum of all 15 correct probabilities
	A1	$\frac{121}{126}$ oe (allow awrt 0.96 – must be from correct working)
		SC If M0M0A0 then award M1M0A0 for 15 probabilities with no extras listed with at least 3 correct products

Question Number	Scheme	Marks
6(a)	$\mathrm{E}(X) = -4a + (-3b) + a + 2b + 5\times 0.2 [= -3a - b + 1]$	B1
		(1)
(b)(i)	$[\mathrm{E}(X) =] 0$	B1
(ii)	$a + b + a + b + 0.2 = 1$	B1
	$2a + 2b = 0.8$ $3a + b = 1$ $\Rightarrow$ e.g. $4a = 1.2$ or $4b = 0.4$	M1
	Solving simultaneously to give $a = 0.3$ $b = 0.1$	A1A1
		(5)
(c)	$\mathrm{Var}(1-3X) = 9\mathrm{Var}(X)$ $\quad$ y : 13 10 −2 −5 −14	M1
	$\mathrm{E}(X^2) = (-4)^2 a + (-3)^2 b + a$ $+(2^2)b + 25\times 0.2 [= 11.4]$ $\quad$ $\mathrm{Var}(1-3X) = \begin{pmatrix} 13^2\times 0.3 + 10^2\times 0.1 + \\ (-2)^2\times 0.3 + (-5)^2\times 0.1 \\ +(-14)^2\times 0.2 \end{pmatrix} - 1^2$	M1
	$\mathrm{Var}(1-3X) = 102.6$ $\quad$ awrt 103	A1
		(3)
(d)(i)	$[\mathrm{P}(Y<0) = \mathrm{P}(1-X<0) =]$ $\mathrm{P}(X>1) = "0.1" + 0.2 = 0.3$ $\quad$ [y : 5 4 0 −1 −4] $\mathrm{P}(Y<0) = "0.1" + 0.2 = 0.3$	M1A1ft
(ii)	$[\mathrm{P}(Y<k) = \mathrm{P}(1-X<k) =] \mathrm{P}(X>(1-k)) = 0.2$ or $1-k=2$ $\quad$ $\mathrm{P}(Y<-1) = 0.2$	M1
	$k = -1$	A1
		(4)
	Notes	**Total 13**
(a)	**B1**	For a correct expression for E(X) need not be simplified. May be seen in part (b) Do not ISW e.g. $\frac{-4a + (-3b) + a + 2b + 5\times 0.2}{5}$ oe
Mark (i) and (ii) together as one part		
(b)(i)	**B1**	For 0 Condone E(X)^2 = 0
(ii)	**B1**	For using sum of probabilities = 1 to form an equation in a and b May be seen in (i)
	M1	For eliminating one variable only ft their 2 equations if working is shown. May be implied by $a = 0.3$ or $b = 0.1$
	A1	For $a = 0.3$ or $b = 0.1$
	A1	For both $a = 0.3$ and $b = 0.1$
(c)	**M1**	For 3^2Var(X) or 3^2E(X^2) or for all 5 correct y values seen or used
	M1	For a correct algebraic expression for E(X^2) or Var(X) e.g. $17a + 13b + 5$ or a correct numerical expression ft their a and their b May be seen in part (b) or a fully correct expression for Var(1 − 3X) including the -1^2
	A1	Awrt 103 Allow $\frac{513}{5}$
(d)(i)	**M1**	For P(X > 1) or for X = 2 and X= 5 only or for Y = −1 and Y = −4 or $"b"+0.2$ Allow b + 0.2 if no b value stated in part b
	A1ft	Ft their b provided b and b + 0.2 are probabilities
(ii)	**M1**	For P(X > (1 − k)) = 0.2 or 1 − k = 2 or P(Y < −1)=0.2 May be implied by k = −1
	A1	Cao

Question Number	Scheme		Marks
7(a)	$[\mu \text{ or } \bar{x} =]\frac{8360}{10} = 836$		B1
	$(\sigma =)\sqrt{\frac{\sum(x-\bar{x})^2}{10}} = \sqrt{\frac{63840}{10}}$	$(s =)\sqrt{\frac{\sum(x-\bar{x})^2}{9}} = \sqrt{\frac{63840}{9}}$	M1
	= 79.89993... awrt 79.9	= 84.22192... awrt 84.2	A1
			(3)
(b)	Mean > Median		B1
	So positive skew		dB1
			(2)
(c)	$\frac{776+896}{2} = 836$ which is the same as $\bar{x}$ **or** one is 60 above $\bar{x}$, one 60 below		B1
	So no change in the mean		dB1
			(2)
(d)	$896-836 = 836-776 = 60 < 79.9/84.2$ or $(896-836)^2 = (776-836)^2 = 60^2 = 3600 < 6384$ or $\left[\frac{\sum(x-\bar{x})^2}{12} \rightarrow\right] \frac{63840+2\times60^2}{12} = \frac{71040}{12} = 5920 < \frac{63840}{10}$ or $\sqrt{5920} = 76.9 < 79.9/84.2$		B1
	So standard deviation will reduce		dB1
			(2)
	Notes		**Total 9**
(a)	**B1**	Cao Allow a correct fraction	
	M1	for a correct expression for σ or σ^2 or s or s^2 (ignore labels). NB $\sum x^2 = 7052800$ but must see at least $\sigma^2 = \frac{7052800}{10} - (\text{"836"})^2$ for M1	
	A1	Awrt 79.9 or awrt 84.2 if s is calculated cao scores M1A1 Do not allow $4\sqrt{399}$	
(b)	**B1**	For a correct comparison of mean and median (allow 836 > 815 or 815 < 836) May see $\frac{k(\text{mean}-\text{median})}{\sigma \text{ or } \sigma^2}$ (o.e.) if so just check sign of answer (provided denom > 0)	
	dB1	Dependent on 1st B1 for positive skew. Positive correlation is B0 **SC** If their mean is < 815 award B0B1 for the comparison **and** statement of negative skew	
(c)	**B1**	For a suitable calculation to show mean of these two rabbits (or all 12) is the same e.g. new $\sum x = 8360+776+896 = 10032$, so mean = $\frac{10032}{12} = 836$ **NB We must see a calculation**	

	dB1	Dependent on a suitable calculation or reason for stating no change oe
(d)	**B1**	For a suitable calculation showing 60 and comparing with 79.9/84.2 or a suitable calculation showing 3600 and comparing with 6384 or calculation of new variance 5920 and comparing with 6384 or calculation of new standard deviation 76.9 and comparing with 79.9/84.2
	dB1	Dependent on 1st B1 for stating standard deviation reduces oe

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 17 October 2025

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 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 8 4 8 4 2 A 0 1 2 8

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1. A biologist is studying horses.

The biologist records the height, h cm, and the weight, w kg, of 8 horses.

The table below shows the biologist's results.

Height	140	145	150	157	138	140	148	142
Weight	500	521	539	554	492	497	532	525

[You may use $\sum h = 1160$ $\sum w = 4160$ $\sum hw = 604135$ $\sum w^2 = 2166\,600$ $S_{hh} = 286$]

(a) Calculate the value of S_{hw} and the value of S_{ww}

(3)

(b) Calculate the value of the product moment correlation coefficient between h and w

(2)

(c) Show that the equation of the regression line of w on h can be written as

$$w = 46.0 + 3.27h$$

where the values of the intercept and gradient are given to 3 significant figures.

(3)

(d) Give an interpretation, in context, of the gradient of the regression line.

(1)

Using the equation of the regression line in part (c), estimate the weight of a horse with a height of

(e) (i) 153 cm

(ii) 170 cm

(2)

(f) State, giving a reason, which of the two estimates found in part (e) would give the more reliable estimate.

(1)

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Question 1 continued

Question 1 continued

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Question 1 continued

(Total for Question 1 is 12 marks)

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2. The weights, to the nearest kilogram, of 35 rugby players from club A are summarised in the stem and leaf diagram below.

Weight (kg)											Totals
7	2										(1)
8	4	9									(2)
9	0	0	1	1	5	5	5	6	7		(9)
10	0	0	4	4	5	5	7	8	9	9	(10)
11	1	1	2	2	2	2	5				(7)
12	0	2	4	6	7						(5)
13	9										(1)

Key: 7 | 2 represents 72 kg

(a) Find the lower quartile and the upper quartile of the weights of these rugby players.

(2)

An outlier is defined as an observation that is

greater than $Q_3 + 1.5 \times (Q_3 - Q_1)$ or less than $Q_1 - 1.5 \times (Q_3 - Q_1)$

(b) Show that there is only one outlier for these data.

(3)

Figure 1 on page 7 shows a box plot for the weights of rugby players from club B

(c) On the same grid, draw a box plot to represent the weights of rugby players from club A

(4)

(d) Describe and interpret the skew of the distribution for **club B**, shown in Figure 1

(2)

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Question 2 continued

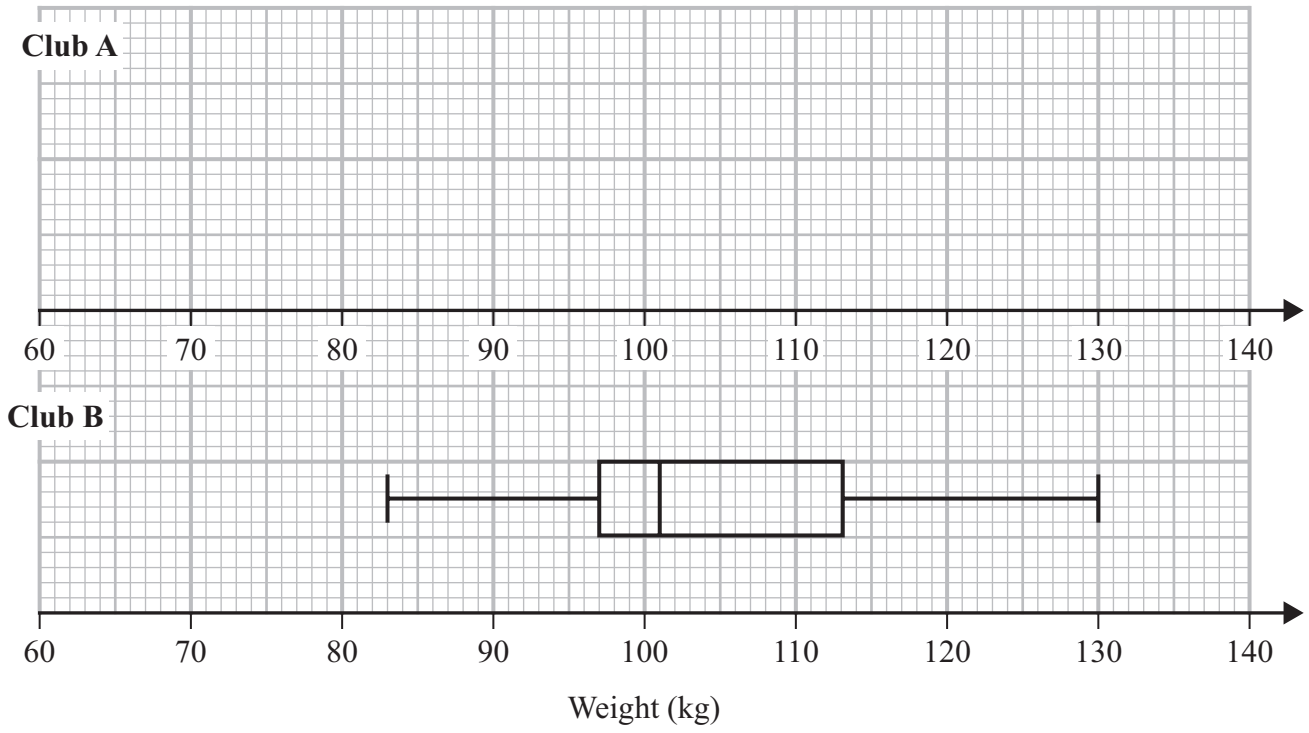

Figure 1

Turn over for a spare grid if you need to redraw your box plot.

Question 2 continued

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Question 2 continued

Only use this grid if you need to redraw your box plot.

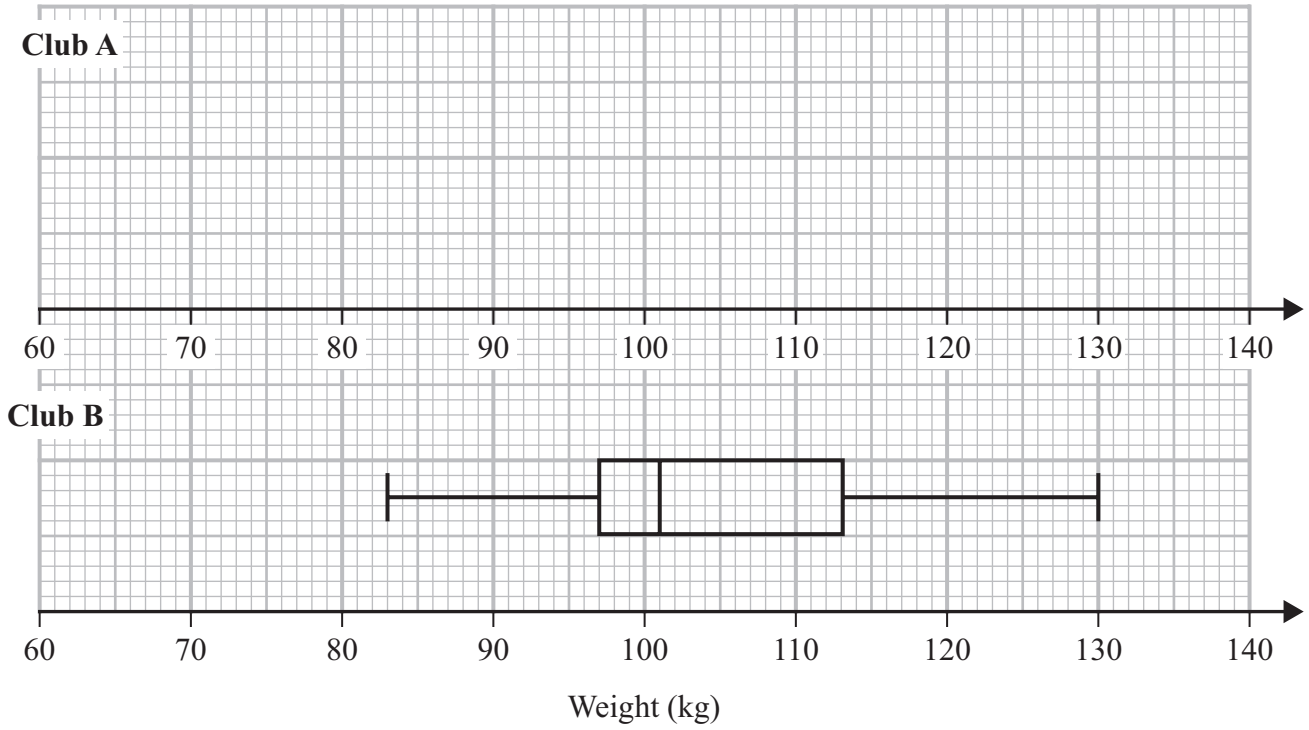

Figure 1

(Total for Question 2 is 11 marks)

3. A fair 6-sided die is rolled.

The random variable Y represents the score on the uppermost face.

(a) Write down the probability function of Y

(2)

(b) State the name of the distribution of Y

(1)

(c) Find $E(4Y + 3)$

(3)

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Question 3 continued

(Total for Question 3 is 6 marks)

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4. A discrete random variable X has the probability distribution given in the table below, where a and b are constants.

x	–1	0	1	2	3
$P(X = x)$	0.05	0.1	a	b	0.35

Given that $E(X) = 1.8$

(a) find the value of a and the value of b

(3)

(b) Specify the cumulative distribution function $F(x)$ for $x = –1, 0, 1, 2$ and 3

(2)

(c) Find $P(2X < 1)$

(1)

(d) Find $\text{Var}(5 – 3X)$
You must show your working.

(4)

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Question 4 continued

Question 4 continued

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Question 4 continued

(Total for Question 4 is 10 marks)

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5. The weights, x grams, of 300 medium-sized apples are summarised in the table below.

Weight	Frequency
$105 \leqslant x < 115$	28
$115 \leqslant x < 125$	42
$125 \leqslant x < 130$	75
$130 \leqslant x < 140$	63
$140 \leqslant x < 150$	52
$150 \leqslant x < 170$	40

A histogram is drawn (not shown) to represent these data.

The bar that represents the class $125 \leqslant x < 130$ is 1.8 cm wide and 12 cm high.

(a) Calculate the width and the height of the bar that represents the class $150 \leqslant x < 170$

(3)

(b) Use linear interpolation to estimate the median of x
Give your answer to one decimal place.

(2)

The weights, w grams, of 300 large apples are coded using $y = \dfrac{w - 200}{2}$

These coded data are summarised by

$$\sum y = 6000 \qquad \sum y^2 = 150\,000$$

(c) Calculate

(i) the mean of w

(2)

(ii) the variance of w

(3)

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Question 5 continued

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Question 5 continued

(Total for Question 5 is 10 marks)

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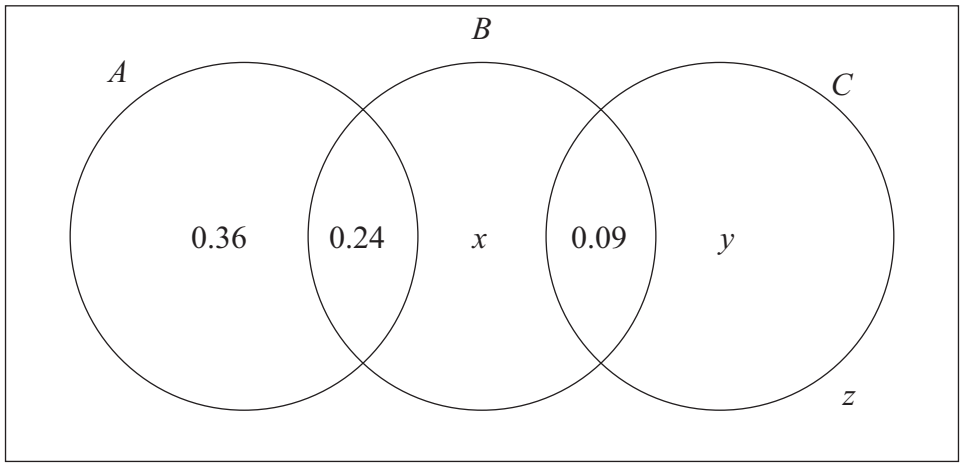
6. The Venn diagram, where x, y and z are probabilities, represents the events A, B and C and their associated probabilities.



Given that the events A and B are independent,

(a) find the value of x

(3)

Given also that $\mathrm{P}(B \mid C') = \dfrac{31}{75}$

(b) find the value of z

(2)

(c) Hence find the value of y

(2)

(d) Find

(i) $\mathrm{P}\left((B \cup C)' \cap A\right)$

(ii) $\mathrm{P}\left((A \cup B) \cap C'\right)$

(2)

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Question 6 continued

(Total for Question 6 is 9 marks)

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7. The wingspans, W mm, of Speckled Wood butterflies are normally distributed, with $W \sim N(51, 1.7^2)$

A Speckled Wood butterfly is selected at random.

(a) Use standardisation to find the probability that this butterfly has a wingspan between 48.45 mm and 54.40 mm.

(3)

Given that this butterfly has a wingspan between 48.45 mm and 54.40 mm,

(b) find the probability that the wingspan of this butterfly is greater than 53.55 mm.
You must show your working.

(3)

The wingspans, X mm, of Large White butterflies are also normally distributed, with $X \sim N(\mu, \sigma^2)$

Given that $P(X < 64.58) = 0.30$ and $P(X > 69.46) = 0.10$

(c) calculate the value of μ and the value of σ
You must show your working.

(4)

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Question 7 continued

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Question 7 continued

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Question 7 continued

(Total for Question 7 is 10 marks)

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8. When Paul goes to work, he travels by car **or** by bicycle **or** he walks.

- the probability that he travels by car is $\frac{1}{2}$
- the probability that he travels by bicycle is $\frac{1}{6}$
- the probability that he walks is $\frac{1}{3}$

Given that Paul

- travels by car, the probability that he is late is $\frac{1}{5}$
- travels by bicycle, the probability that he is late is $\frac{1}{10}$
- walks, the probability that he is late is $\frac{1}{20}$

(a) Show that on any day that Paul goes to work, the probability that he is late is $\frac{2}{15}$

(1)

Given that Paul is late on a day that he goes to work,

(b) show that the probability that he travels to work by car is $\frac{3}{4}$

(2)

(c) Hence complete the tree diagram on page 28, to represent the given information.

(4)

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Question 8 continued

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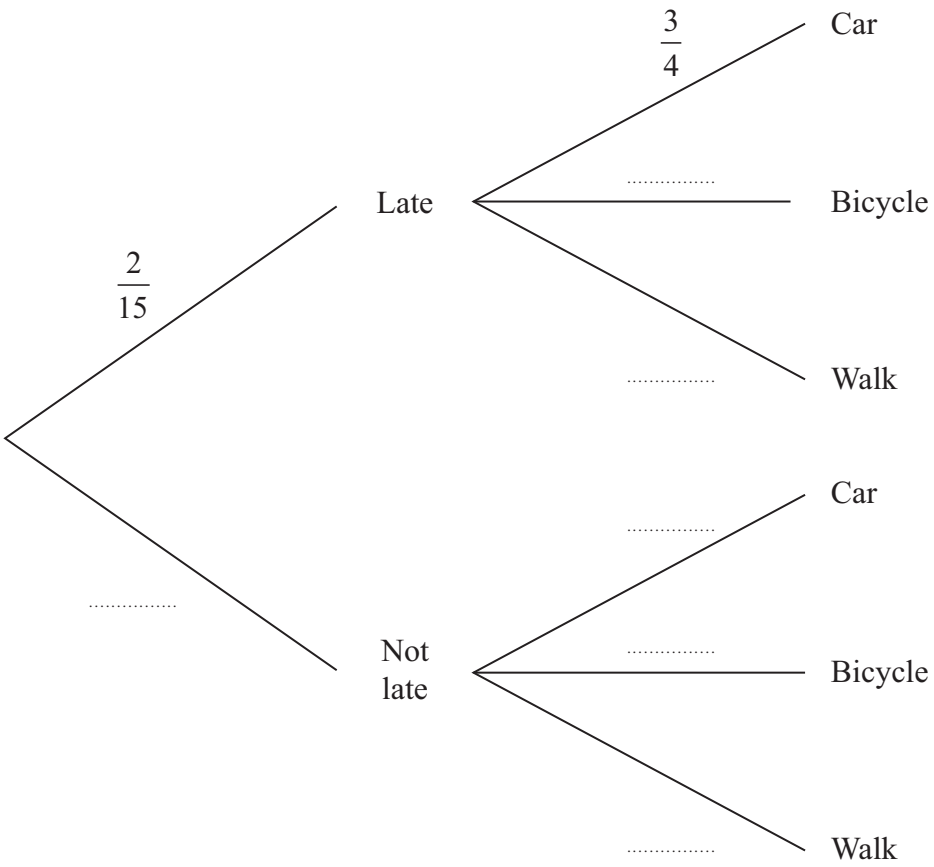
Question 8 continued



(Total for Question 8 is 7 marks)

TOTAL FOR PAPER IS 75 MARKS

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Mark Scheme (Results)

October 2025

International Advanced Level in Statistics S1

WST01/01

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October 2025
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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: 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
   - ⌐ 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.

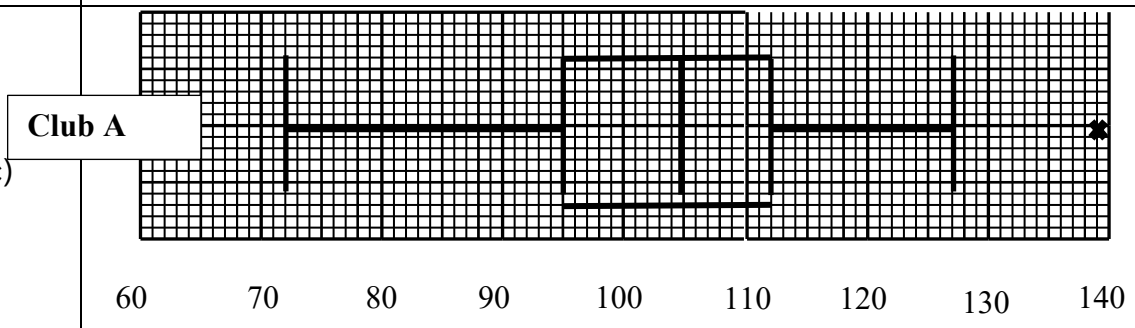
6. If a candidate makes more than one attempt at any question:
   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer

Question Number	Scheme	Marks
1(a)	$[S_{hw} =] 604135 - \frac{1160 \times 4160}{8}$ or $[S_{ww} =] 2166600 - \frac{4160^2}{8}$	M1
	$[S_{hw} =] 935$	A1
	$[S_{ww} =] 3400$	A1
		(3)
(b)	$r = \frac{"935"}{\sqrt{286 \times "3400"}} = 0.9481...$ awrt **0.948**	M1A1
		(2)
(c)	$b = \frac{"935"}{286} [= 3.269...]$	M1
	$a = \frac{4160}{8} - "3.269..." \times \frac{1160}{8} [= 45.96...]$	M1
	$w = 46.0 + 3.27h$ *	A1*
		(3)
(d)	[On average] for **each/1** [cm] increase in **height/*h*** the **weight/*w* increases** by "**3.27**"[kg]	B1
		(1)
(e)(i)	546.31 awrt **546**	B1
(ii)	601.9 awrt **602**	B1
		(2)
(f)	The 1st estimate is more reliable estimate since… • The 1st estimate is an **interpolation**/The 2nd is an **extrapolation** • 153(height) is within data range/170 is not within data range • 153 is closer to the mean(height)/170 is further from the mean	B1
		(1)

	Notes		Total 12
(a)	**M1**	for a correct expression for S_{hw} or S_{ww} implied by either correct answer	
	A1	935 cao	
	A1	3400 cao	
(b)	**M1**	for a valid attempt at *r* allow ft their values from (a)	
	A1	awrt 0.948 correct answer scores 2 out of 2	
(c)	**M1**	for a correct numerical expression to find the value of *b*	
	M1	for a correct method to find the value of *a* ft their *b* Allow $w - 520 = "3.269..."(h - 145)$ oe for this mark	
	A1*	correct solution with both method marks and correct given equation stated. do not award this mark if there is incorrect working **seen** e.g. *a* =	

		45.85 rounding to a = 46.0 do not allow $w=46+3.27h$
(d)	**B1**	for a correct numerical interpretation which includes **height/*h*** and **weight/*w*** if units are stated then they must be correct
(e)(i)	**B1**	awrt 546
(ii)	**B1**	awrt 602
(f)	**B1**	for 1st estimate oe **and** a correct supporting reason. ignore extraneous non-contradictory comments. for 2nd/3rd reason, do not allow comments that refer to **weights**

Question Number	Scheme	Marks
2(a)	[LQ =] 95	B1
	[UQ =] 112	B1
		(2)
(b)	"95"−1.5×("112"−"95") or "112"+1.5×("112"−"95")	M1
	"95"−1.5×("112"−"95") **and** "112"+1.5×("112"−"95")	A1ft
	So only outlier is 139	A1
		(3)
(c)		M1M1 M1A1ft
		(4)
(d)	(Club B has) positive (skew)	M1
	So club B weights are more varied above the median (than below the median)	A1
		(2)
	Notes	**Total 11**

(a)	**B1**	correct lower quartile 95 cao
	B1	correct upper quartile 112 cao
(b)	**M1**	a correct method to find either the lower or upper outlier boundary ft their values from (a)
	A1ft	correct attempt to find both the lower and upper outlier boundary ft their values from (a) this mark is for both correct ft expressions which need not be evaluated but may be implied by both of 69.5 and 137.5
	A1	(dep on M1 only) for identifying 139 as an outlier
(c)	**M1**	for a box with 1 upper whisker and 1 lower whisker
	M1	for lower whisker plotted at 72 and upper whisker plotted at 127 or '137.5 (condone 137 to 138)'
	M1	for quartiles plotted at 'Q_1', 105 and 'Q_3'
	A1ft	for a fully correct boxplot with 1 outlier marked at 139 only ft 'Q_1', 'Q_3' and '137.5'
(d)	**M1**	for identifying positive (skew) ignore comments about the skewness of Club A positive correlation is M0
	A1	for a correct contextual interpretation of positive skew indicating that there is greater variation above the median

Question Number	Scheme		Marks
3(a)	$\left[\mathrm{P}(Y=y)=\right]\frac{1}{6}$ [y =] 1, 2, 3, 4, 5, 6		B1dB1
			(2)
(b)	[Discrete] **uniform** [distribution]		B1
			(1)
(c)	$\mathrm{E}(Y)=\frac{6+1}{2}[=3.5]$ or $\mathrm{E}(Y)=\frac{1+2+3+4+5+6}{6}[=3.5]$	$4Y+3$: 7, 11, 15, 19, 23, 27	M1
	$\mathrm{E}(4Y+3)=4\times"3.5"+3$	$\mathrm{E}(4Y+3)=\frac{"7"+"27"}{2}$ or $\frac{"7"+"11"+"15"+"19"+"23"+"27"}{6}$	M1
	17		A1
			(3)
			Total 6

(a)	**B1**	for identifying $\mathrm{P}(Y=y)=\frac{1}{6}$ as the only probability Ignore labels. (May be seen in a table). Must be seen in part (a). Stating or using Normal, Binomial (or other distribution) is B0
	dB1	Dep on previous B1 for y = 1, 2, 3, 4, 5, 6 Ignore labels. (May be seen in a table) Must be seen in part (a).
	SC	Use of inaccurate value for $\frac{1}{6}$ can score B0B1 if otherwise fully correct e.g.

1	2	3	4	5	6
0.167	0.167	0.167	0.167	0.167	0.167

(b)	**B1**	do not allow continuous uniform [distribution] do not allow Normal uniform
(c)	**M1**	a correct method to find E(Y) (implied by 3.5) **or** sight of 7, 11, 15, 19, 23, 27 (allow one slip) $1\times\frac{1}{6}+2\times\frac{2}{6}+3\times\frac{3}{6}+4\times\frac{4}{6}+5\times\frac{5}{6}+6\times\frac{6}{6}$ is M0
	M1	use of $4\mathrm{E}(Y)+3$ ft their $\mathrm{E}(Y)$ must be clear that they are using their E(Y) e.g. $4\left(\frac{1}{6}\right)+3$ is M0

		or a correct method to find E(4*Y* + 3) ft their 7, 11, 15, 19, 23, 27
	A1	cao 17 scores 3/3

Question Number	Scheme	Marks
4(a)	$0.05 + 0.1 + a + b + 0.35 = 1$ [$a + b = 0.5$]	M1
	$-0.05 + a + 2b + 1.05 = 1.8$ [$a + 2b = 0.8$]	M1
	$b = 0.3$ $a = 0.2$	A1
		(3)
(b)	<table><tr><td>[x]</td><td>−1</td><td>0</td><td>1</td><td>2</td><td>3</td></tr><tr><td>[F(x)]</td><td>0.05</td><td>0.15</td><td>0.35</td><td>0.65</td><td>1</td></tr></table>	B1B1ft
		(2)
(c)	0.15	B1
		(1)
(d)	$\mathrm{E}(X^2) = 1\times0.05 + 1\times"0.2" + 4\times"0.3" + 9\times0.35[= 4.6]$	$\mathrm{E}(5-3X) = 8\times0.05 + 5\times0.1 + 2\times"0.2" - 1\times"0.3" - 4\times0.35[= -0.4]$ or $\mathrm{E}(5-3X) = 5 - 3\times1.8[= -0.4]$ M1
	$\mathrm{Var}(X) = "4.6" - 1.8^2 = 1.36$	$\mathrm{E}(5-3X)^2 = 64\times0.05 + 25\times0.1 + 4\times"0.2" + 1\times"0.3" + 16\times0.35[= 12.4]$ M1
	Var(5 – 3X) = 9 × "1.36" = 12.24	Var(5 – 3X) = "12.4" – ("−0.4")^2 = 12.24 M1
	awrt **12.2**	A1
		(4)

	Notes	Total 10
(a)	**M1**	for either correct equation in a and b
	M1	for both correct equations in a and b
	A1	both $a = 0.2$ oe and $b = 0.3$ oe correct answers score 3 out of 3 unless from obvious incorrect working
In part (b) and (d) working labelled in script takes priority. Look out for working shown under the table which can be marked if it does not contradict the working in the script.		
(b)	**B1**	for 3 correct values of x and their associated cumulative probabilities
	B1ft	for a fully correct cdf ft their a and b provided both are probabilities and $a + b = 0.5$
(c)	**B1**	0.15 oe
(d)	**M1**	for method to find $\mathrm{E}(X^2)$ with at least 3 correct (ft) non-zero products (may be implied by 4.6) only allow ft products which use **probabilities** or a method to find E(5 – 3X) with at least 3 correct (ft) non-zero products (may be implied by −0.4) or use of E(5 – 3X) = 5 – 3E(X)
	M1	for a correct method to find Var(X) ft their $\mathrm{E}(X^2)$ (may be implied by 1.36) or a correct method to find E(5 – 3X)^2 (may be implied by 12.4)

	M1	for use of $3^2\text{Var}(X)$ ft their Var(X) or use of E(5 – 3X)^2 – (E(5 – 3X))^2
	A1	awrt 12.2 working must be shown Answer only send to review.

Question Number	Scheme	Marks
5(a)	Width = 7.2	B1
	Area of 21.6 for a frequency of 75 so $\frac{21.6}{75}\times 40 = 11.52$ for a frequency of 40 or $w \times h = 11.52$ or fd = 15	M1
	$\left[h = \frac{11.52}{7.2} \text{ or } \frac{2}{15}\times 12 =\right] 1.6$	A1
		(3)
(b)	$[Q_2 = 130+]\frac{5}{63}\times 10$ or $[Q_2 = 130+]\frac{5.5}{63}\times 10$ or $\frac{x-130}{140-130} = \frac{150-145}{208-145}$ or $\frac{140-x}{140-130} = \frac{208-150}{208-145}$	M1
	= awrt 130.8 or awrt 130.9	A1
		(2)
(c)(i)	$[\bar{y} =]\frac{6000}{300}[=20]$ and $[\bar{w} =] 2\times "20" + 200$	M1
	$= 240$	A1
		(2)
(c)(ii)	$[\text{Var}(y) =]\frac{150000}{300} - "20"^2 [= 100]$	M1
	$[\text{Var}(w) =] 4\times "100" = 400$	M1A1
		(3)

	Notes	Total 10
(a)	**B1**	7.2 or exact equivalent
	M1	for sight of 11.52 or $w \times h = 11.52$ or fd = 15 May be implied by $h = 1.6$
	A1	1.6 or exact equivalent
(b)	**M1**	for any valid method to find the median allow use of $n+1$ allow working backwards $[140 -]\frac{58}{63}\times 10$ or $[140 -]\frac{57.5}{63}\times 10$
	A1	awrt 130.8 allow awrt 130.9 if using $(n+1)$ No fractions
(c)(i)	**M1**	for a correct method to find the mean of w Alt: $\sum w = 6000\times 2 + 300\times 200 [= 72000]$ and $\bar{w} = \frac{"72000"}{300}$
	A1	cao correct answer is 2/2
(c)(ii)	**M1**	for a correct method to find Var(y) or for $\sum w^2 = 17\,400\,000$
	M1	for a correct method to find Var(w) ft their Var(y) $2\times "100" + 200 = 400$ is M0A0 or for $\text{Var}(w) = \frac{17\,400\,000}{300} - "240"^2$
	A1	cao answer only with no working shown scores M1M0A0
	SC	If no marks scored in (ii), allow M1(M0A0) for

		$\sqrt{\frac{150000}{300}-"20"^2}$

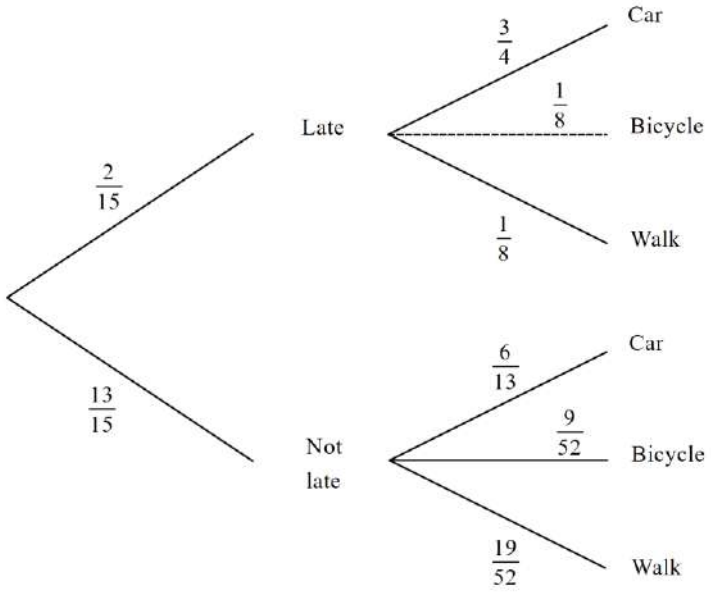
Question Number	Scheme	Marks
6(a)	$\mathrm{P}(A)=0.6 \quad \mathrm{P}(B)=0.24+0.09+x \quad \mathrm{P}(A\cap B)=0.24$	M1
	$0.6(0.33+x)=0.24$	M1
	$x = 0.07$	A1
		(3)
(b)	$\mathrm{P}(B\mid C')=\dfrac{0.24+"0.07"}{0.6+"0.07"+z}=\dfrac{31}{75}$	M1
	$z = 0.08$	A1
		(2)
(c)	$y = 1 - 0.36 - 0.24 - "0.07" - 0.09 - "0.08"$	M1
	$y = 0.16$	A1ft
		(2)
(d)(i)	0.36	B1
(ii)	0.67	B1ft
		(2)

	Notes	Total 9
(a)	**M1**	for at least 2 of the 3 correct probabilities/probability expressions seen or used (implied by 2nd M1) $0.24+0.09+x$ may be implied by embedded working e.g. x = "P(B)" – 0.24 – 0.09
	M1	for use of $\mathrm{P}(A\cap B)=\mathrm{P}(A)\times\mathrm{P}(B)$ oe to form a correct equation in x
	A1	oe correct answer scores 3/3
(b)	**M1**	for a correct conditional probability equation ft "their x" substituted or just x allow $\mathrm{P}(B\mid C')=\dfrac{0.24+"0.07"}{1-0.09-y}=\dfrac{31}{75}$
	A1	oe correct answer scores 2 out of 2
(c)	**M1**	for a correct expression to find y ft their x and their z values substituted where x and z are probabilities do not allow blank/no answers for x and/or z as zero may be implied by $x + y + z = 0.31$ with x, y, and z as probabilities
	A1ft	ft their x and their z $x + y + z = 0.31$ where x, y, and z are probabilities
(d)(i)	**B1**	oe
(ii)	**B1ft**	0.67 oe or 0.6 + "their x" ft "their x" where "their x" and 0.6 + "their x" are probabilities

Question Number	Scheme	Marks
7(a)	$[\mathrm{P}(48.45 < W < 54.4) =]\mathrm{P}\left(Z < \frac{54.4-51}{1.7}\right) - \mathrm{P}\left(Z < \frac{48.45-51}{1.7}\right)$	M1M1
	$[0.9772 - 0.0668] = 0.9104$ Cal: 0.91044... awrt 0.910	A1
		(3)
(b)	$[\mathrm{P}(53.55 < W < 54.4) =]"0.9772" - (1 - "0.0668")$ [= 0.044] Calc:0.044057....	M1
	$[\mathrm{P}(W > 53.55 \mid 48.45 < W < 54.4) =]\frac{"0.044"}{"0.9104"}$	M1
	= 0.04833 awrt 0.0483/0.0484	A1
		(3)
(c)	$\frac{64.58-\mu}{\sigma} = -0.5244$ (Calc: – 0.524400...)	M1
	$\frac{69.46-\mu}{\sigma} = 1.2816$ (Calc: 1.281551)	M1
	$4.88 = 1.806\sigma \Rightarrow \sigma = 2.702...$ awrt 2.7 $\mu = 65.996...$ awrt 66	dM1A1
		(4)
	Notes	**Total 10**

(a)	**M1**	Standardising with 54.4, 51 and 1.7 (implied by ±2) or standardising with 48.45, 51 and 1.7 (implied by ±1.5) using 1.7^2 is M0
	M1	Standardising with 54.4, 51 and 1.7 **and** 48.45, 51 and 1.7 **and** attempt to find correct probability using $p - q$ oe (where $0.5 < p < 1$ and $0 < q < 0.5$) or $p - (1 - r)$ oe (where $0.5 < p < 1$ and $0.5 < r < 1$) If 1st M1 scored, then may be implied by correct answer
	A1	awrt 0.910 condone 0.91 correct answer with no working scores 0
(b)	**M1**	for a valid attempt to find $\mathrm{P}(53.55 < W < 54.4)$ e.g. $"0.9772" - (1 - "0.0668")$ May be implied by awrt 0.044/0.0441
	M1	for a conditional probability in the form $\frac{p}{"0.9104"}$ where $0 < p <$ "0.9104" assuming independence is M0 e.g. $\frac{p \times "0.9104"}{"0.9104"}$
	A1	awrt 0.0483/0.0484 No fractions
(c)	**M1**	for standardising 64.58 and setting equal to z value where $0.5 < \lvert z \rvert < 0.6$ **or** for standardising 69.46 and setting equal to z value where $1 < \lvert z \rvert < 1.5$
	M1	for standardising 64.58 and setting equal to z value where $-0.6 < z < -0.5$ oe with compatible signs **and** for standardising 69.46

		and setting equal to z value where $1 < z < 1.5$ oe with compatible signs
	dM1	Dep on 1st M1 for attempting to solve their two linear equations (using substitution or elimination) leading to an equation in one variable Implied by either $\sigma = \text{awrt } 2.7$ or $\mu = \text{awrt } 66$
	A1	both $\sigma = \text{awrt } 2.7$ **and** $\mu = \text{awrt } 66$ **and** both 0.5244 (or better) **and** 1.2816 (or better) seen

Question Number	Scheme	Marks
8(a)	$\frac{1}{2}\times\frac{1}{5}+\frac{1}{6}\times\frac{1}{10}+\frac{1}{3}\times\frac{1}{20}=\frac{2}{15}*$	B1*
		(1)
(b)	$\frac{\frac{1}{2}\times\frac{1}{5}}{\frac{2}{15}}\left[=\frac{\frac{1}{10}}{\frac{2}{15}}\right]=\frac{3}{4}*$ or $1-\frac{\frac{1}{6}\times\frac{1}{10}+\frac{1}{3}\times\frac{1}{20}}{\frac{2}{15}}=\frac{3}{4}*$	M1A1*
		(2)
(c)		B1B1 M1A1
		(4)
	Notes	**Total 7**
(a)	**B1*** for a correct expression which is the sum of three products of probabilities leading to the given answer allow $\frac{1}{10}+\frac{1}{60}+\frac{1}{60}=\frac{2}{15}$	
(b)	**M1** for $\frac{1}{2}\times\frac{1}{5}\left[=\frac{1}{10}\right]$ (do not award if embedded in an incorrect calculation) or use of 1 – …. with $\frac{1}{6}\times\frac{1}{10}+\frac{1}{3}\times\frac{1}{20}$	
	A1* for a fully correct expression leading to the given answer	
(c)	**B1** for $\frac{13}{15}$ oe in the correct place on the tree diagram	
	B1 for $\frac{1}{8}$ oe and $\frac{1}{8}$ oe in the correct place on the tree diagram	

	M1	for $\frac{\frac{4}{5}\times\frac{1}{2}}{\frac{13}{15}}\left[=\frac{6}{13}\right]$ oe or $\frac{\frac{1}{6}\times\frac{9}{10}}{\frac{13}{15}}\left[=\frac{9}{52}\right]$ oe or $\frac{\frac{1}{3}\times\frac{19}{20}}{\frac{13}{15}}\left[=\frac{19}{52}\right]$ oe implied by 1 correct probability in the correct place on tree diagram
	A1	for $\frac{6}{13}$ oe and $\frac{9}{52}$ oe and $\frac{19}{52}$ oe in the correct place on tree diagram

Pearson Edexcel International Advanced Level

Friday 31 October 2025

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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Pearson

1. A continuous random variable X has cumulative distribution function

$$F(x) = \begin{cases} 0 & x < 2 \\ \frac{1}{20}(x^2 - 4) & 2 \leqslant x \leqslant 4 \\ \frac{1}{5}(2x - 5) & 4 < x \leqslant 5 \\ 1 & x > 5 \end{cases}$$

(a) Calculate $P(X > 4)$

(2)

(b) Find the value of a such that $P(3 < X < a) = 0.642$

(4)

(c) Find the probability density function of X, specifying it for all values of x.

(4)

(Total for Question 1 is 10 marks)

---

2. Bill owns a restaurant.

Over the next four weeks Bill decides to carry out a sample survey to obtain the customers' opinions.

(a) Suggest a suitable sampling frame for the sample survey.

(1)

(b) Identify the sampling units.

(1)

(c) Give one advantage and one disadvantage of taking a census rather than a sample survey.

(2)

Bill believes that only 30% of customers would like a greater choice on the menu.

He takes a random sample of 50 customers and finds that 20 of them would like a greater choice on the menu.

(d) Test, at the 5% significance level, whether or not the percentage of customers who would like a greater choice on the menu is more than Bill believes.
State your hypotheses clearly.

(5)

(Total for Question 2 is 9 marks)

---

3. Left-handed people make up 10% of a population.

A random sample of 60 people is taken from this population.

The discrete random variable Y represents the number of left-handed people in the sample.

(a) (i) Write down an expression for the exact value of $P(Y \leqslant 1)$

(ii) Evaluate your expression, giving your answer to 3 significant figures.

(3)

(b) Using a Poisson approximation, estimate $P(Y \leqslant 1)$

(2)

(c) Using a normal approximation and standardisation, estimate $P(Y \leqslant 1)$

(5)

(d) Give a reason why the Poisson approximation is a more suitable estimate of $P(Y \leqslant 1)$

(1)

(Total for Question 3 is 11 marks)

4. The function $f(x)$ is defined as

$$f(x) = \begin{cases} \frac{1}{9}(x+5)(3-x) & 1 \leqslant x \leqslant 4 \\ 0 & \text{otherwise} \end{cases}$$

Albert believes that $f(x)$ is a valid probability density function.

(a) Sketch $f(x)$ and comment on Albert's belief.

(3)

The continuous random variable Y has probability density function given by

$$g(y) = \begin{cases} ky(12 - y^2) & 1 \leqslant y \leqslant 3 \\ 0 & \text{otherwise} \end{cases}$$

where k is a positive constant.

(b) Use calculus to find the mode of Y

(3)

(c) Use algebraic integration to find the value of k

(3)

(d) Find the median of Y giving your answer to 3 significant figures.

(3)

(e) Describe the skewness of the distribution of Y giving a reason for your answer.

(2)

(Total for Question 4 is 14 marks)

5. Cars stop at a service station randomly at a rate of 3 every 5 minutes.

(a) Calculate the probability that in a randomly selected 10 minute period,

(i) exactly 7 cars will stop at the service station,

(ii) more than 7 cars will stop at the service station.

(4)

Using a normal approximation, the probability that more than 40 cars will stop at the service station during a randomly selected n minute period is 0.2266 correct to 4 significant figures.

(b) Find the value of n
You must show all stages of your working.

(9)

(Total for Question 5 is 13 marks)

---

6. A bag contains a large number of coins. It contains only 1p, 5p and 10p coins.

The fraction of 1p coins in the bag is q, the fraction of 5p coins in the bag is r and the fraction of 10p coins in the bag is s

Two coins are selected at random from the bag and the coin with the highest value is recorded. Let M represent the value of the highest coin.

The sampling distribution of M is given below

m	1	5	10
$P(M = m)$	$\frac{1}{25}$	$\frac{13}{80}$	$\frac{319}{400}$

(a) List all the possible samples of two coins which may be selected.

(2)

(b) Find the value of q, the value of r and the value of s

(7)

(Total for Question 6 is 9 marks)

7. The continuous random variable X is uniformly distributed over the interval $[a , b]$

(a) Find an expression, in terms of a and b, for $E(3 - 2X)$

(2)

(b) Find $P(X > \frac{1}{3}b + \frac{2}{3}a)$

(2)

Given that $E(X) = 0$

(c) find an expression, in terms of b only, for $E(3X^2)$

(3)

Given also that the range of X is 18

(d) find $Var(X)$

(2)

(Total for Question 7 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

Friday 31 October 2025

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

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

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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 10 marks)

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Question 2

Write the answer to Question 2 on these 2 pages

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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 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
DO NOT WRITE IN THIS AREA

Question 3 continued

Question 3 continued

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Question 3 continued

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

(Total for Question 3 is 11 marks)

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Question 4

Write the answer to Question 4 on these 4 pages

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Question 4 continued

Question 4 continued

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Question 4 continued

This is the end of Question 4 answer space. Please turn the page for Question 5 answer space.

(Total for Question 4 is 14 marks)

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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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Question 5 continued

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(Total for Question 5 is 13 marks)

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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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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)

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Question 7

Write the answer to Question 7 on these 3 pages

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DO NOT WRITE IN THIS AREA
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DO NOT WRITE IN THIS AREA

Question 7 continued

Question 7 continued

(Total for Question 7 is 9 marks)

TOTAL FOR PAPER IS 75 MARKS

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DO NOT WRITE IN THIS AREA

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Mark Scheme (Results)

October 2025

International Advanced Level in Statistics S2

WST02/01A

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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: 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
   - ⌈ 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)	$1-\mathrm{F}(4)=1-\frac{3}{5}=\frac{2}{5}$	$\int_4^5\left(\frac{2}{5}\right)\mathrm{d}x=2-\frac{8}{5}=\frac{2}{5}$	M1A1
			(2)
(b)	$\mathrm{F}(a)-\mathrm{F}(3)=0.642$ or $\mathrm{F}(a)-\mathrm{F}(4)=0.292$ or $\mathrm{F}(a)-0.25=0.642$ or $\mathrm{F}(a)-0.6=0.292$	From $x = 3$ to 4: $\int_3^4\left(\frac{1}{10}x\right)\mathrm{d}x=\frac{7}{20}$	M1
	$\mathrm{F}(a)=0.892=\frac{223}{250}$	From $x = 4$ to a: $\int_4^a\left(\frac{2}{5}\right)\mathrm{d}x=\left(\frac{2}{5}a-\frac{8}{5}\right)$	A1
	$\frac{1}{5}(2a-5)=\text{"0.892"}$	$\frac{7}{20}+\frac{2}{5}a-\frac{8}{5}=0.642$	M1
	$a = 4.73$		A1
			(4)
(c)	$\mathrm{f}(x)=\frac{\mathrm{d}}{\mathrm{d}x}(\mathrm{F}(x))=\frac{\mathrm{d}}{\mathrm{d}x}\left(\frac{1}{20}(x^2-4)\right)=\frac{1}{10}x$ $\mathrm{f}(x)=\frac{\mathrm{d}}{\mathrm{d}x}\left(\frac{1}{5}(2x-5)\right)=\frac{2}{5}$		M1
	$\mathrm{f}(x)=\begin{cases}\frac{1}{10}x, & 2\le x\le 4\\ \frac{2}{5}, & 4<x\le 5\\ 0, & \text{otherwise}\end{cases}$		A1A1B1
			(4)

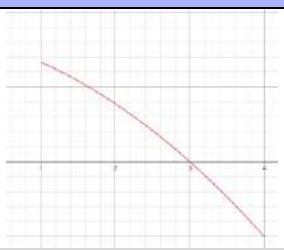
	Notes		Total 10
(a)	**M1**	For 1 – F(4) seen or used. May be implied by $\frac{2}{5}$ oe Allow1 – P($X \le 4$) or a correct integral with limits seen or used	
	A1	Oe	
(b)	**M1**	for $\mathrm{F}(a)-\mathrm{F}(3)=0.642$ seen or used or F(a) – F(4) = 0.292 seen or used or for correct attempt at area from 3 to 4 or 4 to a Allow P($X \le$ a) – P($X \le$ 3) = 0.642 or P($X \le$ a) – P($X \le$ 4) = 0.292 Allow any letter for a May be implied by $\mathrm{F}(a)=0.892$	
	A1	for $\mathrm{F}(a)=0.892$ oe or for either correct area	
	M1	For solving $\frac{1}{5}(2a-5)=\text{"0.892"}$ ft their 0.892 Allow any letter for a or for total area = 0.642 ISW e.g. $\frac{1}{20}\left(a^2-4\right)=0.892$ **SC use of a – 1 leading to 5.73 scores M1**	
	A1	Cao If 4.67 is shown as well then it must be rejected	
(c)	**M1**	For attempt at differentiation of either line of cdf $(x^n \to x^{n-1})$ May be implied by either of the first two lines of the cdf above correct	
	A1	For $\frac{1}{10}x$ (must be on its own) with correct limits	
	A1	For $\frac{2}{5}$ (must be on its own) with correct limits	
	B1	for the 3rd line of the cdf above Allow 0 for $x < 2$ and 0 for $x > 5$ for 0 otherwise Allow use of ≤/≥ for this mark only	

Question Number	Scheme	Marks
2(a)	**List** of **all** the **customers** (who eat in the restaurant)	B1
		(1)
(b)	**Customer(s)** (who ate in the restaurant)	B1
		(1)
(c)	Advantage: more/total accuracy, unbiased	B1
	Disadvantage: time consuming to obtain data and analyse it, expensive, difficult to ensure entire population is included	B1
		(2)
(d)	Let X = the number of customers who would like more choice on the menu	
	$H_0: p = 0.3$ $H_1: p > 0.3$	B1
	$X \sim B(50, 0.3)$ $P(X \geq 20) = 1 - P(X \leq 19)$ or CR $P(X \geq 21) = 1 - P(X \leq 20)$ 0.9522 $= 1 - 0.9152$ $= 1 - 0.9522$ $= 0.0848$ $X \geq 21$	M1 A1
	Do not reject H_0/ not significant/20 is not in critical region	M1
	The percentage of **customers** who would like more **choice** on the menu is not more [than 30%] or There is no evidence to reject **Bill's belief**	A1ft
		(5)

	Notes	Total 9
(a)	**B1**	Need the idea of list/register/data base and customer(s). Do not allow customer's opinions. 'ALL' may be implied. Do not allow a partial list e.g. A list of 50 customers
(b)	**B1**	Customer(s) Do not allow customer's opinion
(c)	**B1**	If not labelled, assume the response refers to a census Correct advantage (If not labelled as advantage then take the first answer as the advantage)
	B1	Correct disadvantage (If not labelled as disadvantage then take the second answer as the disadvantage)
(d)	**B1**	Both hypotheses in terms of p or π
	M1	For writing or using $1 - P(X \leq 19)$ or $1 - P(X \leq 20)$
	A1	Awrt 0.0848 or a correct CR (allow any letter)
	M1	For a correct non contextual statement. Ft their probability/CR provided a binomial distribution is used. Do not allow contradictory non contextual statements. May be implied by a correct contextual statement on its own
	A1ft	For a correct contextual statement. Must mention customers and choice or Bill and belief/believes. Ft their probability/CR

Question Number	Scheme	Marks
3(a)(i)	B(60, 0.1)	B1
	$[\mathrm{P}(Y=0)+\mathrm{P}(Y=1)=](0.9)^{60}+60(0.1)^{1}(0.9)^{59}$ oe	M1
(ii)	=0.013777... awrt 0.0138	A1
		(3)
(b)	Po(6)	B1
	$[\mathrm{P}(Y\leq 1)=]0.01735....$ or 0.0174 from tables awrt 0.0174	B1
		(2)
(c)	N(6, 5.4)	B1
	$[\mathrm{P}(Y\leq 1)\approx]\mathrm{P}\left(Z<\frac{1.5-6}{\sqrt{5.4}}\right)$	M1M1
	$=\mathrm{P}(Z<-1.936...)$	A1
	$=1-0.9738=0.0262$ (or from calc 0.02640...)	A1
		(5)
(d)	[Poisson approximation is more suitable since] *p* is not close to 0.5 or *n* is large and *p* is small or (b) is closer to the true value	B1
		(1)
	Notes	**Total 11**

(a)(i)	**B1**	For writing or using B(60, 0.1) Allow if used in (ii)
	M1	For a correct expression oe Allow use of $^{60}C_0$ oe and $^{60}C_1$ oe ISW after a correct expression. Allow if seen in (ii)
(ii)	**A1**	Awrt 0.0138 **NB** SC answer only scores B1M0A0
(b)	**B1**	For writing or using Po(6)
	B1	Awrt 0.0174
(c)	**B1**	For writing or using N(6, 5.4) May be seen in a standardisation NB 5.4 = $\left(\frac{3\sqrt{15}}{5}\right)^2$
	M1	For continuity correction 1 ± 0.5
	M1	For standardising using 1, 0.5 or 1.5 with their mean and their standard deviation Allow ±
	A1	Awrt ±1.94 May be implied by awrt 0.026
	A1	Awrt 0.026
(d)	**B1**	For a correct reason (No need to mention Poisson) Ignore any reference to $np < 10$ oe e.g. the rate is small. Do not accept mean ≈ variance since 6 is not approximately 5.4 but ignore if alongside a correct answer

Question Number	Scheme	Marks
4(a)		B1B1
	This is not a valid probability density function since f(x) < 0 for x > 3	B1
		(3)
(b)	$[g(y)=k(12y-y^3)]\Rightarrow[g'(y)]=k(12-3y^2)$	M1
	$12-3y^2=0$ so $y=2$	dM1A1
		(3)
(c)	$\int k(12y-y^3)\mathrm{d}y=k\left[6y^2-\frac{y^4}{4}\right]_1^3$	M1
	$k\left(6\times3^2-\frac{3^4}{4}-6+\frac{1}{4}\right)=1$ so $k=\frac{1}{28}$	dM1A1
		(3)
(d)	$\int_1^m "\frac{1}{28}"(12y-y^3)\mathrm{d}y="\frac{1}{28}"\left(6\times m^2-\frac{m^4}{4}-\left(6\times1^2-\frac{1^4}{4}\right)\right)=0.5$ or $\int "\frac{1}{28}"(12y-y^3)\mathrm{d}y="\frac{1}{28}"\left(6y^2-\frac{y^4}{4}\right)+c$ and use of F(3) = 1 or F(1) = 0 to find c	M1
	$m^4-24m^2+79=0$ oe so $m=1.98437...$ awrt 1.98	M1A1
		(3)
(e)	Median ≈ Mode, therefore there is no skew	M1A1ft
		(2)
	Notes	**Total 14**
(a)	**B1** For correct shape between 1 and 3. Ignore any parts of the graph that extend before x = 1 and or after x =4 Allow even if 3 is not marked on the x axis as long it crosses the x- axis between 1 and 4	
	B1 For a correct shape between 1 and 4 with 1, 3 and 4 labelled on the x-axis	
	B1 For not a density function/Albert is incorrect with supporting reason e.g. probabilities cannot be less than 0	
(b)	**M1** For expanding and attempting to differentiate (or using product rule to differentiate)	
	dM1 Dep on previous M1 For equating to 0 and attempt to solve	
	A1 Cao **NB** Answer only scores 0/3 Do not ISW	
(c)	**M1** For an attempt to integrate g(y) $\left(y^n\rightarrow y^{n+1}\right)$	
	dM1 Dep on previous M1 For equating to 1 and use of correct limits (May be implied by $\frac{135}{4}-\frac{23}{4}$)	
	A1 Oe **NB** Answer only scores 0/3	

(d)	**M1**	For writing or using $\int_1^m g(y)\mathrm{d}y = 0.5$ ft k from part c Allow any letter for m Must see limits/correct use of limits or $\int g(y)\mathrm{d}y$ and use of F(3) = 1 or F(1) =0 to find c
	M1	For $m^4 - 24m^2 + 79 = 0$ oe e.g. $\frac{3}{14}y^2 - \frac{1}{112}y^4 - \frac{23}{112} = 0.5$
	A1	Awrt 1.98 only Must reject other root(s) if seen
(e)	**M1**	For a comparison of their part (b) with their part (d) Allow comparison of the mean (1.9857..) provided the mean is calculated
	A1 ft	For no skew/zero skew oe Condone symmetrical/symmetric (allow [slight] negative [skew]) ft their part (b) and part (d) or the mean provided the mean is calculated Do not allow equal/even skew or normal/normally distributed

Question Number	Scheme	Marks
5(a)	Po(6)	
(i)	P($X = 7$) = $\mathrm{P}(X \leq 7) - \mathrm{P}(X \leq 6) = 0.7440 - 0.6063$	M1
	= 0.1377 awrt 0.138	A1
(ii)	$\mathrm{P}(X > 7) = 1 - \mathrm{P}(X \leq 7) = 1 - 0.744$	M1
	= 0.256	A1
		(4)
(b)	Let Y be the number of cars that pull into the service station	
	$Y \sim \mathrm{N}(\lambda, \lambda)$	M1
	$\lambda = 0.6n$	B1
	$\mathrm{P}(Y > 40) = 0.2266$	
	$\frac{40.5 - \lambda}{\sqrt{\lambda}} = 0.75$	M1M1B1
	$\lambda + 0.75\sqrt{\lambda} - 40.5 = 0$	A1
	$\sqrt{\lambda} = 6$	M1A1
	$n = 60$	A1
		(9)
	Notes	**Total 13**

(a)(i)	**M1**	For writing or using $\mathrm{P}(X \leq 7) - \mathrm{P}(X \leq 6)$ or use of $\frac{\mathrm{e}^{-\lambda}\lambda^7}{7!}$
	A1	Awrt 0.138
(ii)	**M1**	For writing or using $1 - \mathrm{P}(X \leq 7)$
	A1	Awrt 0.256
(b)	**M1**	Normal with mean = Var (can be letters or numbers) May be seen in a standardisation
	B1	Using $\lambda = 0.6n$ (can be seen at any stage)
	M1	Use of a continuity correction 40 ± 0.5
	M1	Standardising with 39.5, 40 or 40.5 and their mean and their standard deviation and set = to a z value where $0.74 < \lvert z \rvert < 0.76$
	B1	0.75 or better Allow – 0.75 if compatible with their standardisation
	A1	Fully correct equation in any form
	M1	Solving their 3TQ If the equation is incorrect then working must be shown. May be implied by $n = 60$
	A1	For $\sqrt{\lambda} = 6$ or $\lambda = 36$ May be implied by $n = 60$
	A1	For $n = 60$

Question Number	Scheme	Marks
6(a)	(1, 1), (1, 5)[x2] (5, 5), (1, 10)[x2], (5, 10)[x2], (10, 10)	B1B1
		(2)
(b)	[For M = 1, (1, 1)] $q \times q = \frac{1}{25}$ so $q = \frac{1}{5}$	M1A1
	[For M = 5, (1, 5), (5, 1), (5, 5)] $qr + rq + r^2 = \frac{13}{80}$	M1
	$r^2 + 2(\frac{1}{5})r - \frac{13}{80} = 0 \rightarrow r = \frac{-\frac{2}{5} + \sqrt{(\frac{2}{5})^2 - 4(-\frac{13}{80})}}{2}$ so $r = \frac{1}{4}$	M1A1
	[For M = 10, (1, 10), (10, 1), (5, 10), (10, 5), (10, 10)] $2qs + 2rs + s^2 = \frac{319}{400}$ or $q + r + s = 1$ so $s = \frac{11}{20}$	M1A1
		(7)

	Notes		Total 9
(a)	**B1**	For at least 4 correct pairs	
	B1	For all 6 correct pairs	
(b)	**M1**	For a correct equation to find q May be implied by a correct answer for q	
	A1	$\frac{1}{5}$ oe If more than one answer given then it must be rejected	
	M1	For a correct equation in terms of r and q (ft their q) May be implied by a correct answer for r	
	M1	Attempt to solve 3TQ If the equation is incorrect then working must be shown May be implied by a correct answer for r	
	A1	$r = \frac{1}{4}$ oe If more than one answer given then it must be rejected	
	M1	For a correct equation in terms of s (ft their q and their r) or use of sum of probabilities =1 May be implied by a correct answer for s	
	A1	$s = \frac{11}{20}$ oe If more than one answer given then it must be rejected	
Special Case			
(b)	**M1**	$\frac{q}{q+r+s} \times \frac{q}{q+r+s} = \frac{1}{25}$	
	A0	$q = 4$	
	M1	$\frac{qr}{(q+r+s)^2} + \frac{qr}{(q+r+s)^2} + \left(\frac{r}{q+r+s}\right)^2 = \frac{13}{80}$	
	M1	Let $y = \frac{r}{q+r+s}$ so $y^2 + 2(\frac{1}{5})y - \frac{13}{80} = 0 \rightarrow y = \frac{-\frac{2}{5} + \sqrt{(\frac{2}{5})^2 - 4(-\frac{13}{80})}}{2}$ May be implied by $y = \frac{1}{4}$	
	A0	$r = 5$	

	M1	$\frac{2qs}{(q+r+s)^2}+\frac{2rs}{(q+r+s)^2}+\left(\frac{s}{q+r+s}\right)^2=\frac{319}{400}$
	A0	$s=11$

Question Number	Scheme	Marks
7(a)	$E(3-2X)= 3-2E(X)$	M1
	$= 3-2\left(\frac{(a+b)}{2}\right)$ or $3-a-b$	A1
		(2)
(b)	$P(X > \frac{1}{3}b+\frac{2}{3}a) =$ $\frac{b-(\frac{1}{3}b+\frac{2}{3}a)}{b-a}=\frac{2}{3}$ or $1-\frac{(\frac{1}{3}b+\frac{2}{3}a)-a}{b-a}=\frac{2}{3}$	M1A1
		(2)
(c)	$E(3X^2)=\int_a^b \frac{1}{(b-a)}3x^2\,dx$ | $[\mathrm{Var}(X)=]\ \frac{(b-a)^2}{12}\left[=E(X^2)\right]$	M1
	$=\left[\frac{1}{(b-(-b))}x^3\right]_{-b}^{b}=\left(\frac{b^3-(-b^3)}{2b}\right)$ | $E(3X^2)=3\left(\frac{(b-(-b))^2}{12}\right)$	dM1
	$=b^2$	A1
		(3)
(d)	Range = $b-a=18$	M1
	Var $(X)=\frac{18^2}{12}=27$	A1
		(2)

	Notes	Total 9
(a)	**M1**	for writing or using $3-2E(X)$
	A1	For a correct expression for $3-2E(X)$ e.g. $3-(a+b)$ Need not be simplified
(b)	**M1**	for a correct expression for $P(X > \frac{1}{3}b+\frac{2}{3}a)$
	A1	for $\frac{2}{3}$
(c)	**M1**	for a correct integral for $E(3X^2)$ (ignore limits) or for a correct expression for Var(X)
	dM1	M1 Dep on 1st M mark. For correct integration and correct use of $a=-b$ or for $3E(X^2)$ and correct use of $a=-b$
	A1	Cao
(d)	**M1**	for writing or using $(b-a)=18$ May be implied by a correct answer or use of U[−9, 9]
	A1	Cao

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 31 October 2025

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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1. The captain of a large sports club wants to survey a random sample of the club's members to obtain their opinions about proposed changes to the clubhouse.

(a) Suggest a suitable sampling frame for the survey.

(1)

(b) Identify the sampling units for the survey.

(1)

(c) Give one advantage **and** one disadvantage of taking a random sample rather than a census.

(2)

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Question 1 continued

(Total for Question 1 is 4 marks)

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2. The manager of a supermarket records the number of complaints, x, the supermarket receives each day over a 50-day period. The results are summarised below.

$$\sum x = 99 \text{ and } \sum (x - \bar{x})^2 = 97.5$$

The manager believes that the number of complaints received by the supermarket each day could be modelled by a Poisson distribution.

(a) Show how the results above support the manager in his belief.

(3)

The manager uses a Poisson distribution with mean 2 to model the number of complaints received each day.

(b) For a randomly selected day, find using the manager's model, the probability that there are

(i) at least 4 complaints received,

(ii) more than 2 but less than 7 complaints received.

(4)

A working week consists of 5 consecutive days.

In a randomly selected working week, the supermarket received 17 complaints.

(c) Test, at the 5% level of significance, whether there is significant evidence that the mean number of complaints received is greater than 2 per day.
State your hypotheses clearly.

(5)

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Question 2 continued

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Question 2 continued

(Total for Question 2 is 12 marks)

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3. (a) Explain what you understand by the sampling distribution of a statistic.

(1)

A bag contains a large number of £1 coins and a large number of £2 coins only.

A random sample of 3 coins is taken from the bag.

(b) List all the possible combinations of the 3 coins that might be selected.

(2)

The probability of selecting a £1 coin from the bag is p and the probability of selecting a £2 coin from the bag is q

Let $\overline{X}$ represent the mean value of the 3 coins selected.

The sampling distribution of $\overline{X}$ is given below

$\overline{x}$	1	$\frac{4}{3}$	a	2
$P(\overline{X} = \overline{x})$	$\frac{27}{125}$	b	c	d

where a, b, c and d are constants.

(c) State the value of a

(1)

(d) Find the value of b, the value of c and the value of d

(6)

Let M represent the modal value of the 3 coins selected.

(e) Find the sampling distribution of M

(3)

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Question 3 continued

Question 3 continued

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Question 3 continued

(Total for Question 3 is 13 marks)

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4. The continuous random variable X has cumulative distribution function $\mathrm{F}(x)$ given by

$$\mathrm{F}(x) = \begin{cases} 0 & x < 1 \\ \frac{1}{24}(x-1)^2 & 1 \leqslant x \leqslant 3 \\ \frac{1}{6}(x-2) & 3 < x \leqslant 6 \\ -k\left(x^2 - 20x + 52\right) & 6 < x \leqslant 10 \\ 1 & x > 10 \end{cases}$$

where k is a positive constant.

(a) Show that $k = \frac{1}{48}$

(2)

(b) Write down the value of $\mathrm{P}(X = 4)$

(1)

(c) Find the value of

$$\mathrm{P}(2.5 < X < 4.5) + \mathrm{P}(5.5 < X < 8.5)$$

(3)

The probability density function of X is given by

$$\mathrm{f}(x) = \begin{cases} \mathrm{r}(x) & 1 \leqslant x \leqslant 3 \\ \frac{1}{6} & 3 < x \leqslant 6 \\ \mathrm{s}(x) & 6 < x \leqslant 10 \\ 0 & \text{otherwise} \end{cases}$$

(d) Find $\mathrm{r}(x)$ and $\mathrm{s}(x)$

(3)

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Question 4 continued

Question 4 continued

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Question 4 continued

(Total for Question 4 is 9 marks)

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5. It is known that a particular variety of tulip produces yellow flowers with a probability of 0.25

A random sample of 15 tulips of this variety is purchased.

(a) Find the probability that more than 4 of these tulips will produce yellow flowers.

(2)

(b) Find the least number of tulips that needs to be purchased so that the probability of at least 1 tulip producing yellow flowers exceeds 0.95

(3)

Another random sample of 100 tulips of this variety is purchased.

(c) Use a suitable approximation to find the probability that, of these 100 tulips, more than 21 but no more than 30 will produce yellow flowers.
Show your working clearly.

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

(5)

For this particular variety, it is thought that the probability of a tulip producing red flowers is 0.3

A random sample of 25 tulips of this variety was purchased. When these tulips flowered, 10 of them produced red flowers.

(d) Use this random sample of 25 tulips to test whether this variety of tulip has a probability greater than 0.3 of producing red flowers.
Use a 10% level of significance and state your hypotheses clearly.

(5)

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Question 5 continued

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Question 5 continued

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Question 5 continued

(Total for Question 5 is 15 marks)

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6. A rectangle $PQRS$ has a fixed perimeter of 40 cm.

The continuous random variable X cm represents the length of side PQ and is uniformly distributed over the interval [0, 20]

The continuous random variable A cm^2 represents the area of $PQRS$

(a) Find the value of E(A)

(6)

(b) Find the probability that the area of $PQRS$ is more than 5 times the area of a square whose side has length X cm.

(4)

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Question 6 continued

(Total for Question 6 is 10 marks)

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7. The continuous random variable X has probability density function

$$f(x) = \begin{cases} \frac{1}{4}x - \frac{1}{64}x^3 & 0 \leqslant x \leqslant 4 \\ 0 & \text{otherwise} \end{cases}$$

(a) Show that the median of X is 2.165 to 3 decimal places.

(5)

The continuous random variable Y has probability density function

$$f(y) = \begin{cases} \frac{4}{255}y^3 & 1 \leqslant y \leqslant 4 \\ 0 & \text{otherwise} \end{cases}$$

(b) Show that $\text{Var}\left(\frac{1}{Y}\right) = \frac{66}{7225}$

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

(5)

(c) Hence find $\text{Var}\left(4 - \frac{5}{Y}\right)$

(2)

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Question 7 continued

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Question 7 continued

(Total for Question 7 is 12 marks)

TOTAL FOR PAPER IS 75 MARKS

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Mark Scheme (Results)

October 2025

International Advanced Level in Statistics S2

WST02/01

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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: 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
   - ⌐ 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)	**List** of **all** the **members** [of the sports club]	B1
		(1)
(b)	Individual **members** [of the sports club]	B1
		(1)
(c)	Advantage: Less time consuming to obtain and analyse it/Less expensive	B1
	Disadvantage: May not be representative of the entire population	B1
		(2)
		Total 4

		Notes
(a)	**B1**	Idea of a list e.g. database/register of all members. All can be implied but do not allow a partial list e.g. A list of 50 members.
(b)	**B1**	Allow member. Do not allow member's opinions.
(c)	**B1**	A correct advantage of taking a sample. If not labelled, assume the response refers to sample (rather than a census).
	B1	A correct disadvantage of taking a sample. If not labelled, assume the response refers to sample (rather than a census).

Question Number	Scheme	Marks
2 (a)	Mean = 1.98	B1
	Variance = 1.95	B1
	Mean and variance are similar [no reason to doubt the manager's belief]	B1
		(3)
(b)(i)	$P(X \geq 4) = 1 - P(X \leq 3) = 1 - 0.8571$	M1
	$= 0.1429$ (Calc 0.1428765…) awrt **0.143**	A1
(ii)	$P(X \leq 6) - P(X \leq 2) = 0.9955 - 0.6767$	M1
	$= 0.3188$ (Calc 0.318789…) awrt **0.319**	A1
		(4)
(c)	$H_0 : \lambda = 2 \quad H_1 : \lambda > 2$ Allow $H_0 : \lambda = 10 \quad H_1 : \lambda > 10$	B1
	$P(X \geq 17 \mid Po(10)) = 1 - P(X \leq 16) = 1 - 0.9730$ or $P(X \geq 16 \mid Po(10)) = 1 - P(X \leq 15) = 1 - 0.9513$	M1
	= 0.0270 (Calc 0.027041….) or CR $\geqslant$ 16	A1
	Reject H_0/In the CR/Significant	M1
	There is sufficient evidence to suggest that the **mean number** of **complaints** received is **greater** than 2 per day	A1
		(5)
		Total 12

		Notes
(a)	**B1**	cao do not allow fraction
	B1	cao
	B1	Allow mean = variance ignore extraneous non-contradictory comments
(b)(i)	**M1**	For $1 - P(X \leq 3)$ or $1 - 0.8571$
	A1	awrt 0.143 correct answer scores 2/2
(ii)	**M1**	For $P(X \leq 6) - P(X \leq 2)$ or $0.9955 - 0.6767$
	A1	awrt 0.319 correct answer scores 2/2
(c)	**B1**	Both hypotheses correct. Must be attached to H_0 and H_1 in terms of λ or μ
	M1	For writing or using Po(10) **and** $1 - P(X \leq 16)$ or CR: $1 - P(X \leq 15)$ implied by awrt 0.0487 from a CR method
	A1	awrt 0.027 or CR $\geqslant$ 16
	M1	A correct statement consistent with their *p*-value and 0.05 **or** 17 and their CR – no context needed but do not allow contradicting non contextual comments
	A1	(Dep on both M marks) Correct conclusion in context with bold

		words o.e. Must include the idea of rate so either: **mean number** or **number per day**

Question Number	Scheme	Marks
3 (a)	If all possible samples are chosen from a population, then **all** the **values** of a **statistic** and their associated **probabilities** is a sampling distribution **or** a **probability distribution** of a **statistic**	B1
		(1)
(b)	111 112 (×3) 122 (×3) 222	B1 B1
		(2)
(c)	$\frac{5}{3}$	B1
		(1)
(d)	$p^3 = \frac{27}{125}$	M1
	$p = 0.6$ and $q = 0.4$	A1
	$\left[b = \mathrm{P}\left(\frac{4}{3}\right)\right] = 3 \times p^2 \times q$	M1
	$\left[c = \mathrm{P}\left(\frac{5}{3}\right)\right] = 3 \times p \times q^2$	M1
	$\left[d = \mathrm{P}(2)\right] = q^3$	M1
	$b = \frac{54}{125} = 0.432$ $c = \frac{36}{125} = 0.288$ $d = \frac{8}{125} = 0.064$	A1
		(6)
(e)	m | 1 | 2 P($M = m$) | $\frac{81}{125} = 0.648$ | $\frac{44}{125} = 0.352$	B1 M1 A1
		(3)
		Total 13

		Notes
(a)	**B1**	A correct explanation including underlined words o.e.
(b)	**B1**	For three correct combinations
	B1	All four combinations (condone permutations) with no additional incorrect ones
(c)	**B1**	Allow awrt 1.67
(d)	**M1**	For a correct method to find p
	A1	For $p = 0.6$ and $q = 0.4$ may be implied by a correct calculation
	M1	A correct method to find $\mathrm{P}\left(\frac{4}{3}\right)$ ft their p and q
	M1	A correct method to find $\mathrm{P}\left("\frac{5}{3}"\right)$ ft their p and q
	M1	A correct method to find $\mathrm{P}(2)$ ft their p and q
	A1	cao
(e)	**B1**	For $m = 1$ and $m = 2$ only

	M1	For either $\frac{27}{125}+'\frac{54}{125}'$ ft their b or $'\frac{36}{125}'+'\frac{8}{125}'$, ft their c and d
	A1	cao

Question Number	Scheme	Marks
4 (a)	$F(10)=1 \Rightarrow -k(100-200+52)=1$ **or** $F(6)=\frac{2}{3} \Rightarrow -k(36-120+52)=\frac{2}{3}$	M1
	$48k=1$ leading to $k=\frac{1}{48}$ *	A1*
		(2)
(b)	$[P(X=4)=]0$	B1
		(1)
(c)	F(4.5) – F(2.5) + F(8.5) – F(5.5)	M1
	$\frac{1}{6}(4.5-2)-\frac{1}{24}(2.5-1)^2-\frac{1}{48}(8.5^2-20\times 8.5+52)-\frac{1}{6}(5.5-2)$ $\left[=\frac{5}{12}-\frac{3}{32}+\frac{61}{64}-\frac{7}{12}\right]$	M1
	$=\frac{133}{192}$	A1
		(3)
(d)	Attempt to differentiate either function	M1
	$[r(x)=]\frac{1}{12}(x-1)=\frac{1}{12}x-\frac{1}{12}$	A1
	$[s(x)=]\frac{1}{24}(10-x)=\frac{5}{12}-\frac{1}{24}x$	A1
		(3)
		Total 9

		Notes
(a)	**M1**	For using F(10) = 1 or F(6) = $\frac{2}{3}$
	A1*	Fully correct solution with substitution seen leading to $k=\frac{1}{48}$
(b)	**B1**	cao
(c)	**M1**	For writing or using F(4.5) – F(2.5) implied by $\frac{31}{96}$ **or** F(8.5) – F(5.5) implied by $\frac{71}{192}$
	M1	For a fully correct method with values substituted into correct part of cdf
	A1	Allow awrt 0.693
(d)	**M1**	Attempt to differentiate either function with $x^n \rightarrow x^{n-1}$ (implied by either correct answer)
	A1	A correct expression for r(x) oe
	A1	A correct expression for s(x) oe

Question Number	Scheme	Marks
5 (a)	$[X \sim \mathrm{B}(15, 0.25) \quad \mathrm{P}(X > 4) =] 1 - \mathrm{P}(X \leq 4) = 1 - 0.6865$	M1
	= 0.3135 (Calc 0.313514...) awrt **0.314**	A1
		(2)
(b)	$\mathrm{P}(X \geq 1) > 0.95 \Rightarrow 1 - \mathrm{P}(X = 0) > 0.95$ so $\left[{}^{n}C_{0}(0.25)^{0} \right](0.75)^{n} < 0.05$	M1
	$n >$ 10.4(1...) or $n > \dfrac{\log(0.05)}{\log(0.75)}$ or $n > \log_{0.75}(0.05)$	M1
	$n =$ **11**	A1
		(3)
(c)	$X \sim \mathrm{B}(100, 0.25)$ so N(25, 18.75)	B1
	$\mathrm{P}(21.5 < Y < 30.5) = \mathrm{P}(Y < 30.5) - \mathrm{P}(Y < 21.5)$	M1
	$\mathrm{P}\left(Z < \dfrac{30.5 - 25}{\sqrt{18.75}}\right) - \mathrm{P}\left(Z < \dfrac{21.5 - 25}{\sqrt{18.75}}\right) = \mathrm{P}(Z < 1.27) - \mathrm{P}(Z < -0.81)$	M1 M1
	= 0.8980 – 0.2090 = 0.689 (Calc 0.688526...) awrt **0.689**	A1
		(5)
(d)	H_0: $p = 0.3$ and H_1: $p > 0.3$	B1
	$R \sim$B(25, 0.3) $\mathrm{P}(X \geq 10) = 1 - \mathrm{P}(X \leq 9) = 1 - 0.8106$ or CR method: $\mathrm{P}(X \geq 11) = 1 - \mathrm{P}(X \leq 10) = 1 - 0.9022 = 0.0978$	M1
	= 0.1894 or CR $\geqslant$ 11	A1
	Do not reject H_0/not significant/not in the CR	M1
	There is **not** significant evidence that the **proportion** of tulips producing **red** flowers is **greater than 0.3**	A1
		(5)

	Notes	**Total 15**
(a)	**M1**	For $1 - \mathrm{P}(X \leq 4)$ or $1 - 0.6865$
	A1	awrt 0.314 correct answer 2/2
(b)	**M1**	For $1 - \mathrm{P}(X = 0) > 0.95$ or $(0.75)^{n} < 0.05$ (condone =)
	M1	For $n >$ 10.41 or $n > \dfrac{\log(0.05)}{\log(0.75)}$ or $n > \log_{0.75}(0.05)$ (condone < or =) or for the 2 trials for n = 10 and 11
	A1	cao
(c)	**B1**	For writing or using N(25, 18.75) NB: Poisson approximation send to review
	M1	For writing or using 21.5 or 30.5
	M1	For either standardisation using their mean and standard deviation. Allow 20.5/21/21.5 29.5/30/30.5
	M1	For both standardisations using their mean and standard deviation. Allow 20.5/21/21.5 29.5/30/30.5

	A1	(Dep on all M marks) awrt 0.689 (Exact binomial awrt 0.685 scores 0/5)
(d)	**B1**	Both hypotheses correct. Must be attached to H_0 and H_1 in terms of *p* or π
	M1	For writing or using B(25, 0.3) **and** $1-\mathrm{P}(X \leq 9)$ or for CR : $1-\mathrm{P}(X \leq 10)$
	A1	awrt 0.189 or CR $\geqslant$ 11
	M1	A correct statement – no context needed but do not allow contradicting non contextual comments
	A1	(Dep on both M marks) Correct conclusion in context using bold word o.e.

Question Number	Scheme		Marks
6 (a)	$[A=]X(20-X)=20X-X^2$		M1
	$[\mathrm{E}(X)=]10$	$[\mathrm{E}(A)=]\frac{1}{20}\int_{[0]}^{[20]} 20x-x^2\,\mathrm{d}x$	B1
	$[\mathrm{Var}(X)=]\frac{100}{3}$	$[\mathrm{E}(A)=]\frac{1}{20}\left[10x^2-\frac{1}{3}x^3\right]_{[0]}^{[20]}$	B1
	$\mathrm{E}(X^2)=10^2+\frac{100}{3}\left[=\frac{400}{3}\right]$	Correct limits 0 and 20	M1
	$\mathrm{E}(A)=20\times 10-"\frac{400}{3}"$	$\mathrm{E}(A)=\frac{1}{20}\left(10(20^2)-\frac{1}{3}(20^3)-0\right)$	M1
		$=\frac{200}{3}$	A1
			(6)
(b)	$\left[\mathrm{P}\left(A>5X^2\right)=\right]\mathrm{P}\left("20X-X^2">5X^2\right)$		M1
	$\Rightarrow \mathrm{P}\left(X<\frac{10}{3}\right)$		M1
	$\frac{1}{20}\times"\frac{10}{3}"$		M1
	$=\frac{1}{6}$		A1
			(4)
			Total 10

		Notes
(a)	**M1**	For a correct expression for area
	B1	For 10 or correct expression for E(*A*) ignore limits
	B1	For $\frac{100}{3}$ or fully correct integration
	M1	For use of $\mathrm{E}(X^2)=\mathrm{E}(X)^2+\mathrm{Var}(X)$ ft their E(*X*) and Var(*X*) or correct limits seen or used
	M1	For use of $20\mathrm{E}(X)-\mathrm{E}(X^2)$ ft their E(*X*) and E(X^2) or complete numerical expression for E(*A*)
	A1	Allow awrt 66.7
(b)	**M1**	For $"20X-X^2">5X^2$ Allow = ft their area which must be in terms of *X*
	M1	For rearranging and attempting to solve $"20X-X^2">5X^2$ May be implied by $\frac{10}{3}$
	M1	For correct area $\frac{1}{20}\times"\frac{10}{3}"$
	A1	Allow awrt 0.167

Question Number	Scheme	Marks
7 (a)	$\int_0^m \left(\frac{1}{4}x - \frac{1}{64}x^3\right) \mathrm{d}x \left[= \frac{1}{2}\right]$	M1
	$\left[\frac{1}{8}x^2 - \frac{1}{256}x^4\right]_0^m \left[= \frac{1}{2}\right]$	A1
	$m^4 - 32m^2 + 128 = 0$ **or** for either F(2.1645) or F(2.1655)	M1
	$m^2 = 16 \pm \sqrt{128}$ ($= 4.686...$ or $27.313...$) **or** both F(2.1645) and F(2.1655)	M1
	$m = \sqrt{16 - \sqrt{128}} = 2.165$ *	A1*
		(5)
(b)	$\mathrm{E}\left(\frac{1}{Y}\right) = \frac{4}{255}\int_1^4 (y^{-1}y^3)\,\mathrm{d}y = \frac{4}{255}\int_1^4 (y^2)\,\mathrm{d}y$	M1
	$\frac{4}{255}\left[\frac{y^3}{3}\right]_1^4 = \frac{4}{255} \times \frac{63}{3}\left[= \frac{28}{85}\right]$	dM1
	$\mathrm{E}\left(\frac{1}{Y^2}\right) = \frac{4}{255}\int_1^4 (y^{-2}y^3)\,\mathrm{d}y = \int_1^4 \frac{4}{255}y\mathrm{d}y$	M1
	$\frac{4}{255}\left[\frac{y^2}{2}\right]_1^4 = \frac{4}{255} \times 7.5\left[= \frac{2}{17}\right]$	dM1
	$\mathrm{Var}\left(\frac{1}{Y}\right) = \frac{2}{17} - \left(\frac{28}{85}\right)^2 = \frac{66}{7225}$ *	A1*
		(5)
(c)	$\mathrm{Var}\left(4 - \frac{5}{Y}\right) = 25 \times \frac{66}{7225}$	M1
	$= \frac{66}{289} = 0.2283...$ awrt **0.228**	A1
		(2)

	Notes	**Total 12**
(a)	**M1**	For $\int \mathrm{f}(x)\,\mathrm{d}x$ ignore limits and $= 0.5$
	A1	For correct integration ignore limits and $= 0.5$
	M1	For substitution of limits leading to a correct equation **or** use of 2.1645 or 2.1655
	M1	Solving the equation leading to $m^2 = ...$ or substitution of both 2.1645 (= 0.499891) and 2.1655 (=0.500273)
	A1*	$m = \sqrt{16 - \sqrt{128}}$ or $0.499... < m < 0.500...$ leading to the given answer
(b)	**M1**	For $\int \frac{1}{y}\mathrm{f}(y)\,\mathrm{d}y$ Ignore limits
	dM1	Dep on previous M1. For substitution of limits into integrated expression
	M1	For $\int \frac{1}{y^2}\mathrm{f}(y)\,\mathrm{d}y$ Ignore limits

	dM1	Dep on previous M1. For substitution of limits into integrated expression
	A1*	Dep on all M marks. For use of $\mathrm{E}\left(\frac{1}{Y^2}\right)-\left(\mathrm{E}\left(\frac{1}{Y}\right)\right)^2$ leading to the given answer
(c)	**M1**	For use of $5^2\,\mathrm{Var}\left(\frac{1}{Y}\right)$
	A1	awrt 0.228