Pearson

Mark Scheme (Results)

October 2025

International Advanced Level in Pure Mathematics P2

WMA12/01A

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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 symbol $\sqrt{}$ 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 ($x^n \to x^{n-1}$)

2. Integration

Power of at least one term increased by 1 ($x^n \to x^{n+1}$)

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 $(u_3 =)\ k-\frac{8}{k-8}\ \left(=\frac{k^2-8k-8}{k-8}\right)$ oe	M1A1
		(2)
(b)	$u_3 = 6 \Rightarrow k-\frac{8}{k-8} = 6 \Rightarrow k^2-14k+40=0$	M1
	$(k-4)(k-10)=0 \Rightarrow k = ...$ or $(k=)\ \frac{14\pm\sqrt{14^2-4\times1\times40}}{2\times1}$	dM1
	$(k=)\ 4,\ 10$	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.	$\left(2-\frac{x}{2}\right)^6 = 2^6 + \binom{6}{1}2^5.\left(-\frac{x}{2}\right)+\binom{6}{2}2^4.\left(-\frac{x}{2}\right)^2 + \ldots$	M1
	$= 64-96x+60x^2+\ldots$	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
	$\{8.485 + 1.100 + 2(\ 2.502 + 1.524\ )\}$	M1
	$= \frac{1}{2}\times 3 \times\{17.637\} =$ 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. $\mathrm{f}(-3) = 13-9-(k-3)^2 = 4-(k-3)^2$ and states when $k=5$, $\mathrm{f}(-3)=0$	B1*
(a)(ii)	Uses $\mathrm{f}(-3)=0 \Rightarrow \quad (k-3)^2 = 4 \Rightarrow k=(5),1$	M1A1
		(3)
(b)(i)	$13+3x+(x+2)(x+5)^2 = 13+3x+(x+2)\left(x^2+10x+25\right) = 13+3x+x^3+....$	M1
	$= x^3+12x^2+48x+63$	A1
	Hence $\mathrm{f}(x)=(x+3)(x^2+9x+21)$	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 $\mathrm{f}(x)=0$ has one solution, -3	A1
		(2)
		(9 marks)

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

(i)

B1*: Either sets $\mathrm{f}(-3)=0$ and states or shows $k=5$, or finds $\mathrm{f}(-3)$ and states or shows that when $k=5$, $\mathrm{f}(-3)=0$ 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 $\mathrm{f}(-3)=0$

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. $b^2 - 4ac = 81-4\times1\times21\ (=-3)$ (may be embedded in the quadratic formula)
- **Attempts to use the quadratic formula**
  e.g. $(x=)\ \dfrac{-9\pm\sqrt{9^2-4\times1\times21}}{2}$ 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

<table>
<tr><th>Strategy</th><th>Correct work examples</th><th>Justification examples</th><th>Conclusion examples</th></tr>
<tr><td>Via discriminant</td><td>$b^2-4ac=-3$</td><td>$-3<0$
-3 so no (real) roots
but NOT $-3\neq 0$ so no roots</td><td rowspan="4">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]</td></tr>
<tr><td>Via using the quadratic formula</td><td>$x=\dfrac{-9\pm\sqrt{3}i}{2}$ or
$x=\dfrac{-9\pm\sqrt{-3}}{2}$</td><td>$-3<0$ / which is not possible / complex roots o.e. / cannot square root a negative / no (real) roots</td></tr>
<tr><td>Via completing the square</td><td>$\left(x+\dfrac{9}{2}\right)^2+\dfrac{3}{4}$

or

$\left(x+\dfrac{9}{2}\right)^2+\dfrac{3}{4}=0\Rightarrow$
$\left(x+\dfrac{9}{2}\right)^2=-\dfrac{3}{4}$</td><td>which has a minimum value of $\dfrac{3}{4}$ / minimum (of the positive quadratic) is above the x-axis

$-\dfrac{3}{4}<0$ / cannot square root a negative / no (real) roots</td></tr>
<tr><td>Via calculus</td><td>$x=-\dfrac{9}{2}\Rightarrow y=\dfrac{3}{4}$</td><td>which has a minimum value of $\dfrac{3}{4}$ / minimum (of the positive quadratic) is above the x-axis</td></tr>
</table>

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 $\log\ldots=\log\ldots$ or $\log\ldots=\ldots$ 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)	$(x\pm 3)^2+(y\pm 7)^2 \pm ... = ...$	M1
	Centre = $(3,7)$	A1
		(2)
(b)	Attempts $(\pm 3)^2+(\pm 7)^2 \pm 32$	M1
	Radius = $3\sqrt{10}$	A1
		(2)
(c)	Uses radius < 3 $\Rightarrow 9+49-k<9$ or uses radius > 0 $\Rightarrow 9+49-k>0$	M1
	$k>49$ or $k<58$	A1
	Uses radius < 3 $\Rightarrow 9+49-k<9$ and uses radius > 0 $\Rightarrow 9+49-k>0$	dM1
	$49<k<58$ oe (see notes)	A1
		(4)
		(8 marks)

(a)

M1: Attempts to complete the square. Accept $(x\pm 3)^2+(y\pm 7)^2 \pm ... = ...$ as evidence.
Also score for $(\pm 3,\pm 7)$

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 $(\pm 3)^2+(\pm 7)^2 \pm 32$ or $\sqrt{(\pm 3)^2+(\pm 7)^2 \pm 32}$. Ignore labelling.
May be implied by sight of ± 90 or e.g. $\pm 58 \pm 32$

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** $49 < k \leqslant 58$ or $49 \leqslant k < 58$ or $49 \leqslant k \leqslant 58$ 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 $k > 49, k \leqslant 58$ 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
	$\Rightarrow 24\sin x = 5\left(1-\sin^2 x\right)$	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: $(2\theta =)\arctan\left(\dfrac{5}{7}\right)$. 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: $(\theta =)$ 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.

(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) $(x =)$ 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) at **Note that if no integration is seen then maximum score is M1dM0A0ftddM0A0. Attempts 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. $\left(y=(3x+6)^2\left(2-\frac{1}{2}x\right)=\right)3^2\left(x+2\right)^2\times\frac{1}{2}\left(4-x\right)=\frac{9}{2}\times\left(x+2\right)^2\left(4-x\right)$ 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. $r^4 = \frac{130}{22}$	M1
	$(r =)$ awrt 1.6	A1
	Max speed in second gear is $22 \times "1.559" = \text{awrt } 34.3\ (\text{kmh}^{-1})$	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. $S_{"261"} = \frac{"261"}{2}\left(2 \times 208 + (n-1) \times (-0.8)\right)$	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 $\sqrt[4]{\frac{130}{22}}$ or $\sqrt[4]{\frac{65}{11}}$ 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 $\frac{208}{0.8}$. Allow to show trial calculations of $u_{260} = 0.8$ or $u_{261} = 0$. May be implied by 260 or 261

Alternatively sets $S_n = \frac{n}{2}\left[2 \times 208 + (n-1) \times (-0.8)\right]$ and either

- differentiates and sets = 0 : $S_n = 208.4n - 0.4n^2 \Rightarrow 208.4 - 0.8n = 0 \Rightarrow n = ...$ look for $n^k \to n^{k-1}$ for at least one term, set the result equal to zero and finds n (condone slips in the rearrangement)
- uses roots: $S_n = 208.4n - 0.4n^2 = 0 \Rightarrow n\left(208.4 - 0.4n\right) = 0 \Rightarrow n = 0,\ n = ...$ 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 $4r\theta = \dfrac{30-2r^2}{r}$ oe or $\theta = \dfrac{30-2r^2}{4r^2}$ oe or $r\theta = \dfrac{30-2r^2}{4r}$ oe	A1
	Uses $P = 6r + 4r\theta$ with their θ or $...r\theta$ substituted	dM1
	$P = 6r + \dfrac{30-2r^2}{r} = 4r + \dfrac{30}{r}$ *	A1*
		(4)
(b)	Differentiates with $r^{-1} \to r^{-2}$	M1
	$\left(\dfrac{dP}{dr} =\right) 4 - \dfrac{30}{r^2}$	A1
	Solves $\dfrac{dP}{dr} = 0 \Rightarrow \left(r = \sqrt{\dfrac{15}{2}}\right)$ and substitutes to find P	dM1
	$\left(P = 4\sqrt{\dfrac{15}{2}} + \dfrac{30\sqrt{2}}{\sqrt{15}} = 2\sqrt{30} + 2\sqrt{30}\right) = 4\sqrt{30}$	A1
		(4)
(c)	e.g. finds $\left(\dfrac{d^2P}{dr^2} =\right) \dfrac{60}{r^3} = \dfrac{60}{\text{"}2.7\text{"}^3} = ...$	M1
	e.g. states that $\left(\dfrac{d^2P}{dr^2} =\right)$ 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 $4r\theta = \dfrac{30-2r^2}{r}$ or $\theta = \dfrac{30-2r^2}{4r^2}$ or $r\theta = \dfrac{30-2r^2}{4r}$ or other equivalences e.g.

$2r\theta = \dfrac{30}{2r} - r$

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 $\dfrac{dy}{dx}$ **and** $\dfrac{d^2y}{dx^2}$

(b)

M1: Differentiates $r^{-1} \to r^{-2}$

A1: $\left(\dfrac{dP}{dr} =\right) 4 - \dfrac{30}{r^2}$

dM1: Solves $M - \dfrac{N}{r^2} = 0 \Rightarrow r = ...\left(= \sqrt{\dfrac{15}{2}}\right) \Rightarrow P = ...$ (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 $4 + \dfrac{30}{r^2} = 0$)

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: $(P =)\ 4\sqrt{30}$ only

(c)

M1: **Any of the following possible approaches:**

- finds $\left(\dfrac{d^2P}{dr^2} =\right) \dfrac{k}{r^3}$ 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 $\dfrac{dP}{dr}$ either side of their $r = \sqrt{\dfrac{15}{2}}$
- finds *P* either side of their $r = \sqrt{\dfrac{15}{2}}$ provided a value for *P* at their $r = \sqrt{\dfrac{15}{2}}$ 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 $\left(\frac{\mathrm{d}^2P}{\mathrm{d}r^2}=\right)\text{awrt}\,3>0$ at $r=\text{awrt}\,2.7$ 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)