Pearson Edexcel

Mark Scheme (Results)

January 2022

Pearson Edexcel International A Level
In Pure Mathematics P1 (WMA11) Paper 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.

PEARSON EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Pearson 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 $\sqrt{}$ or ft 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
- $\ast$ The answer is printed on the paper or ag- answer given
- $\ulcorner$ 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.

8. Marks for each question are scored by clicking in the marking grids that appear below each student response on ePEN. The maximum mark allocation for each question/part question(item) is set out in the marking grid and you should allocate a score of '0' or '1' for each mark, or "trait", as shown:

	0	1
aM		●
aA	●	
bM1		●
bA1	●	
bB	●	
bM2		●
bA2		●

9. Be careful when scoring a response that is either all correct or all incorrect. It is very easy to click down the '0' column when it was meant to be '1' and all correct.

General Principles for Core Mathematics Marking

(But note that specific mark schemes may sometimes override these general principles).

<u>Method mark for solving 3 term quadratic:</u>

1. Factorisation

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

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

2. Formula

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

3. Completing the square

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

<u>Method marks for differentiation and integration:</u>

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. ($x^n \to x^{n+1}$)

<u>Use of a formula</u>

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:

<u>Method mark</u> for quoting a correct formula and attempting to use it, even if there are small errors in the substitution of values.

Where the formula is <u>not</u> quoted, the method mark can be gained by implication from <u>correct</u> working with values, but may be lost if there is any mistake in the working.

<u>Exact answers</u>

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.

Question Number	Scheme	Marks
1.	$$\int\left(\frac{8x^3}{5}-\frac{2}{3x^4}-1\right)\mathrm{d}x=\frac{1}{4}\times\frac{8x^4}{5}-\frac{2}{3}\times\frac{1}{-3}x^{-3}-x$$	M1 A1
	$$\frac{2}{5}x^4+\frac{2}{9}x^{-3}-x+c$$	A1 A1
		(4)
		Total 4

M1: For $x^3 \to x^4$ or $x^{-4} \to x^{-3}$ or $1 \to x$. Also allow eg $x^3 \to x^{3+1}$

A1: Any 2 correct unsimplified or simplified terms, which may appear on separate lines. The indices must be processed but fractions within fractions are acceptable. The + c does not count as a correct term here.

A1: For any 2 correct simplified terms of $\frac{2}{5}x^4+\frac{2}{9}x^{-3}-x$, which may appear on separate lines. The + c does not count as a correct term here.

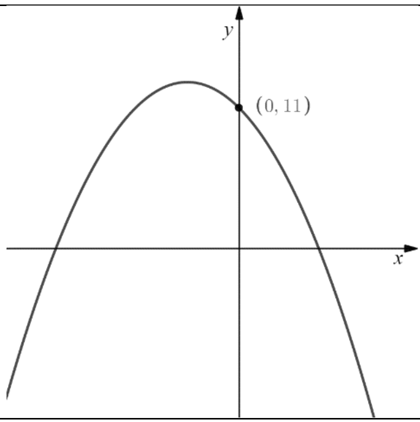
Accept exact decimals including eg. $0.\dot{2}$ for coefficients. Condone $-1x$ $-1x^1$, $-\frac{x}{1}$, $+-1x^1$ for this mark.

A1: $\frac{2}{5}x^4+\frac{2}{9}x^{-3}-x+c$ or simplified equivalent. All correct and on the same line (in any order) including a constant of integration. $\frac{2}{9x^3}$ is acceptable but not $\frac{2/9}{x^3}$.

Accept exact decimals including eg. $0.\dot{2}$ for coefficients. Condone $-1x$ only. Isw after a correct answer. Give the benefit of the doubt to terms such as $2/_{9x^3}$ where it is unclear whether the x^3 term is on the denominator or not provided no incorrect working is seen.

Award once a correct expression is seen and isw but if there is any additional/incorrect notation and no correct expression has been seen on its own, withhold the final mark.

Eg. $\int \frac{2}{5}x^4+\frac{2}{9}x^{-3}-x+c\ \mathrm{d}x$ $\qquad$ $\frac{2}{5}x^4+\frac{2}{9}x^{-3}-x+c=0$

Question Number	Scheme	Marks
2(a)	$\mathrm{f}(x)=11-4x-2x^2$ $\Rightarrow \ldots\underline{-2}\left(2x+x^2\right)\ldots$ or $\Rightarrow \ldots\underline{-2}\left(2x+x^2\ldots\right)$	B1
	$\ldots\left(2x+x^2\right)\Rightarrow \ldots.\left(\left(x+1\right)^2\pm\ldots\right)$	M1
	$\left(\mathrm{f}(x)=\right)\ 13-2\left(x+1\right)^2$	A1
		(3)
(b)		M1 A1
		(2)
(c)	$x=-1$	B1ft
		(1)
		Total 6
Alt(a)	$a+b(x^2+2cx+c^2)=11-4x-2x^2$ $b=-2$	B1
	$2bc=-4\Rightarrow c=\ldots\ (=1)$	M1
	$a+bc^2=-4\Rightarrow a=\ldots\ (=13)$ $\left(\mathrm{f}(x)=\right)\ 13-2\left(x+1\right)^2$	A1

(a)

B1: $b=-2$

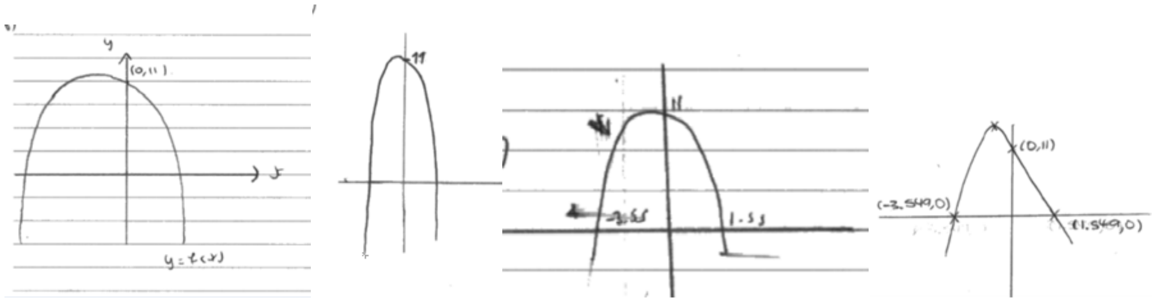
M1: Attempts to complete the square on $x^2\pm 2x$ so score for $(x\pm1)^2\pm\ldots$ or alternatively attempts to compare coefficients to find a value for c.
Condone $11-4x-2x^2\Rightarrow\ldots-2(2x-x^2)\ldots\Rightarrow -2(x\pm1)^2\pm\ldots$

A1: $13-2\left(x+1\right)^2$. If a, b and c are stated and there is a contradiction then mark their final expression. Condone $13+-2\left(x+1\right)^2$ or just the values of a, b and c being stated.

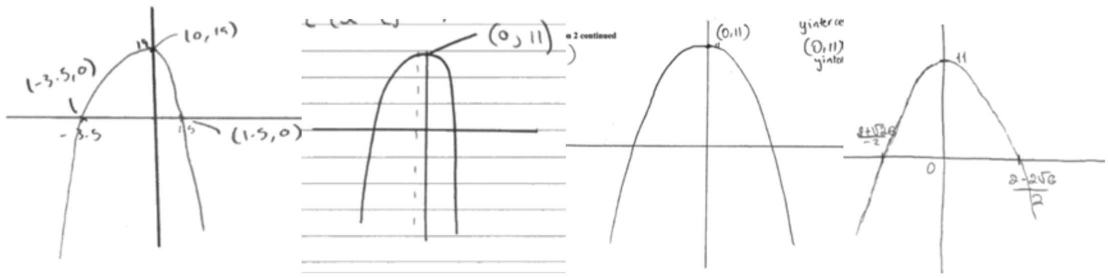
(b)

M1: $\cap$ shape anywhere on a set of axes Cannot be a part of other functions (eg a cubic). See examples below

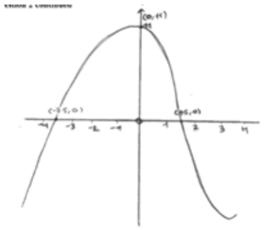
A1: Correct shape that cuts x-axis once either side of the origin, maximum in quadrant 2 and y intercept (0, 11) or 11 marked on y-axis. Condone $(11, 0)$ if the intercept is in the correct place. Do not be concerned with any labelled x-intercepts. Condone aspects of the graph which may appear linear (but not a ^ shape). Its line of symmetry must appear to the left of the origin and its curve should broadly appear symmetrical about this line. Ignore x-intercepts or the maximum stated.
The y-intercept may be stated underneath their graph instead, but if there is a contradiction between the graph and what is marked on the graph then the graph takes precedence.
Do not accept graphs which appear to be symmetrical about the y-axis.
Examples
M1A1



M1A0



M0A0



(c)

B1ft: Correct equation seen in part (c) (follow through their numeric c so allow $x = -$ "c").

Question Number	Scheme	Marks
3(i)	$\sqrt{8}=2\sqrt{2}$ seen anywhere in the solution (see notes)	B1
	$\left(x+\sqrt{2}\right)^2+\left(3x-5\sqrt{8}\right)^2$ $=x^2+2x\sqrt{2}+2+9x^2-30x\sqrt{8}+25\times 8$	M1
	$=10x^2-58x\sqrt{2}+202$	A1
		(3)
(ii)	$\sqrt{3}\left(4y-3\sqrt{3}\right)=5y+\sqrt{3}$ $\Rightarrow 4\sqrt{3}y-9=5y+\sqrt{3}$ $\Rightarrow 4\sqrt{3}y-5y=9+\sqrt{3}$	M1
	$\Rightarrow y=...$ or $\Rightarrow ky=...$ eg $y=\text{"}\dfrac{9+\sqrt{3}}{4\sqrt{3}-5}\text{"}$ or $\text{"}23\text{"}y=\text{"}9+\sqrt{3}\text{"}$	dM1
	$y=\dfrac{9+\sqrt{3}}{4\sqrt{3}-5}\times\dfrac{4\sqrt{3}+5}{4\sqrt{3}+5}\Rightarrow y=\dfrac{...}{\text{"}23\text{"}}$	ddM1
	$y=\dfrac{57}{23}+\dfrac{41}{23}\sqrt{3}$ (or $y=2\dfrac{11}{23}+1\dfrac{18}{23}\sqrt{3}$)	A1
		(4)
	(ii) Alternative 1:	
	$\sqrt{3}\left(4p+4q\sqrt{3}-3\sqrt{3}\right)=5\left(p+q\sqrt{3}\right)+\sqrt{3}$ $\Rightarrow 4p\sqrt{3}+12q-9=5p+5q\sqrt{3}+\sqrt{3}$ $\Rightarrow 4p=5q+1,\ 12q-9=5p$	M1 dM1
	$\Rightarrow 4p=5q+1,\ 12q-9=5p$ $\Rightarrow p=...,\ q=...$	ddM1
	$y=\dfrac{57}{23}+\dfrac{41}{23}\sqrt{3}$ (or $y=2\dfrac{11}{23}+1\dfrac{18}{23}\sqrt{3}$)	A1
		Total 7

Note solutions relying on calculator technology are not acceptable.
(i)

B1: May be stated in the margin or seen/implied anywhere in the solution.
It does not need to be explicitly stated.
Eg. sight of $30\sqrt{8}\to 60\sqrt{2}$ is fine as is $\left(3x-5\sqrt{8}\right)^2\to ...x^2-60\sqrt{2}+...$

M1: Expands both brackets so look for:
$x^2+ax\sqrt{2}+2+bx^2-cx\sqrt{8}+d$ or $x^2+ax\sqrt{2}+2+bx^2-cx\sqrt{2}+d$
where a, b, c and d are non-zero. **The x terms do not need to be collected to score this mark.**

A1: $10x^2-58x\sqrt{2}+202$ or equivalent isw after a correct answer. $58\sqrt{2}x$ is acceptable

Eg $x^2+2x\sqrt{2}+2+9x^2-30x\sqrt{8}+25\times 8 \Rightarrow 10x^2-58x\sqrt{2}+202$ scores B1M1A1
as $\sqrt{8}=2\sqrt{2}$ is correctly seen by the correct collection of the terms.
Eg $x^2+2x\sqrt{2}+2+9x^2-30x\sqrt{8}+25\times 8 \Rightarrow 10x^2-60x\sqrt{2}+202$ scores B0M1A0
as $\sqrt{8}=2\sqrt{2}$ is not correctly seen or implied as the coefficient of x is incorrect

(ii) On EPEN this is M1A1M1A1 we are marking this M1M1M1A1

M1: Attempts to multiply out and isolates the two y terms on one side of the equation.
Condone sign slips only in their rearrangement.

dM1: Attempts to make y or ky the subject (where k is an integer or fraction which would simplify to an integer). Score for $y=\mathrm{f}(x)$ or $ky=\mathrm{g}(x)$ where the function includes $\sqrt{3}$ but it cannot be scored for directly proceeding to $y=\frac{57}{23}+\frac{41}{23}\sqrt{3}$ or $y=\frac{57+41\sqrt{3}}{23}$.
It is dependent on the previous method mark.
Note $y\left(4\sqrt{3}-5\right)=9+\sqrt{3} \Rightarrow y=\frac{57}{23}+\frac{41}{23}\sqrt{3}$ is M1dM0ddM0A0

ddM1: Proceeds to $y=....$ with a rational denominator. The denominator does not need to be simplified. It is dependent on the previous method mark. They must have shown the step of either rationalising the denominator or showing how they achieve $ky=...$ and proceeds to $y=...$

A1: Correct answer in the correct form with all stages of working seen
- Collects y terms on one side of the equation
- Makes y the subject
- Rationalises and proceeds to the correct answer. Somewhere in their solution they will have had to have multiplied two brackets involving surds together and they must have shown this being multiplied out (calculators are not allowed)
  eg $\frac{9+\sqrt{3}}{4\sqrt{3}-5}\times\frac{4\sqrt{3}+5}{4\sqrt{3}+5}=\frac{36\sqrt{3}+45+12+5\sqrt{3}}{23}$

Condone solutions with invisible brackets to score full marks, provided the general method is sound and the answer has not just come from a calculator or incorrect working.

Do not accept $y=\frac{57+41\sqrt{3}}{23}$

Alt(ii)1 (main scheme alternative)

M1: Substitutes $y=p+q\sqrt{3}$ expands, collects terms. Condone sign slips.

dM1: Compares rational/irrational parts to form two equations. It is dependent on the previous method mark.

ddM1: Solves 2 linear equations in p and q using an acceptable method. They cannot just state the values. Condone slips in their working. It is dependent on the previous method mark.

A1: $y=\frac{57}{23}+\frac{41}{23}\sqrt{3}$ (or $y=2\frac{11}{23}+1\frac{18}{23}\sqrt{3}$) with full working shown.

Alt(ii)2 Squaring and completing the square

M1: Squares both sides and multiplies out brackets (condone slips)
eg. ($48y^2-72\sqrt{3}y+81=25y^2+3+10\sqrt{3}y$)

dM1: Rearranges to form a 3TQ = 0 ($23y^2-82\sqrt{3}y+78=0$). It is dependent on the previous method mark.

ddM1: Attempts to complete the square and proceeds to make y the subject. It is dependent on the previous method mark.

A1: $y = \frac{57}{23} + \frac{41}{23}\sqrt{3}$ (or $y = 2\frac{11}{23} + 1\frac{18}{23}\sqrt{3}$)

Alt(ii)3 Dividing by $\sqrt{3}$, then rationalising the denominator and collecting terms:

ii) $4y - 3\sqrt{3} = \frac{5y+\sqrt{3}}{\sqrt{3}}\frac{(\times\sqrt{3})}{(\sqrt{3})}$

$4y - 3\sqrt{3} = \frac{\sqrt{3}(5y+\sqrt{3})}{3}$

$4y - 3\sqrt{3} = \frac{5\sqrt{3}y+3}{3}$

$4y - 3\sqrt{3} = \frac{5\sqrt{3}}{3}y + 1$

$4y - \frac{5\sqrt{3}}{3}y = 1 + 3\sqrt{3}$ — M1 for isolating y terms on one side of the equation

$y\left(4 - \frac{5\sqrt{3}}{3}\right) = 1 + 3\sqrt{3}$

$y = \frac{1+3\sqrt{3}}{4-\frac{5}{3}\sqrt{3}}\frac{(\times 4+\frac{5}{3}\sqrt{3})}{(\times 4+\frac{5}{3}\sqrt{3})}$ — dM1 for making the y the subject

$y = \frac{4+12\sqrt{3}+\frac{5}{3}\sqrt{3}+15}{16-\frac{25}{3}}$ — ddM1 for proceeds to $y=\dots$ with a rational denominator

$\cancel{y = 4+12\sqrt{3}+\frac{5}{3}\sqrt{3}+15}$

$y = \frac{19+\frac{41}{3}\sqrt{3}}{\frac{23}{3}}$

$\boxed{y = \frac{57}{23} + \frac{41}{23}\sqrt{3}}$ — A1 Correct answer with full working shown

Question Number	Scheme	Marks
4(a)	$x+y=6,\ y=6x-2x^2+1$ $\Rightarrow 6-x=6x-2x^2+1$ $\Rightarrow 2x^2-7x+5=0$ oe	M1
	$2x^2-7x+5=0\Rightarrow(2x-5)(x-1)=0$ $\Rightarrow x=\frac{5}{2},\ 1$	M1
	$x="\frac{5}{2}"\Rightarrow y=\frac{7}{2}$ or $x="1"\Rightarrow y=5$	dM1
	$(1,\ 5)$ and $(2.5,\ 3.5)$	A1
		(4)
(b)	$y\geqslant 6x-2x^2+1$ oe	M1
	$x+y\leqslant 6$ oe $x\geqslant a$ where $1\leqslant a\leqslant 2.5$	A1
	$\left(\text{or } a\leqslant x\leqslant b \text{ where } 1\leqslant a\leqslant 2.5,\ b\geqslant 6\right)$ $y\geqslant 0$ (or $0\leqslant y\leqslant c$ where $c\geqslant 3.5$)	A1
	Allow strict or non-strict inequalities	
		(3)
		Total 7

Note solutions relying on calculator technology are not acceptable so a complete method must be shown

(a) **Answers only 0/4**

M1: Uses the line and the curve to obtain a 3TQ in x or y equal to zero (may be implied by solving their 3TQ). Condone slips in their rearrangement.

M1: Solves their 3TQ which must be different to $6x-2x^2+1=0$ by an acceptable method (factorising, formula or completing the square). They cannot state the roots without seeing a correct line of intermediate working. Allow recovery and condone lack of 3TQ $=0$
If they use the quadratic formula, the values must be embedded in the formula before proceeding to the roots.
If they factorise then do not accept $2x^2-7x+5=0\Rightarrow\left(x-\frac{5}{2}\right)(x-1)=0\Rightarrow x=...$
Condone $-2x^2+7x-5=0\Rightarrow(2x-5)(x-1)=0\Rightarrow x=...$

dM1: Solves for y for at least one of their values of x or alternatively solves for x for at least one of their values of y. It is dependent on the previous method mark.

A1: $(1,\ 5)$ and $(2.5,\ 3.5)$ which do not need to be paired. May be seen as $x=...,\ y=...$. But cannot be awarded if they are incorrectly paired in their final answer. Condone omission of brackets around the coordinates. Ignore if they have assigned coordinates as P and Q. Cannot be awarded if x and y are the wrong way round or if given as $(1,\ 3.5)$ and $(2.5,\ 5)$

(b) **Allow strict or non-strict inequalities and does not need to be consistent.**
Use of *R* instead of *x* or *y* will score 0 marks.
Note that $6x - 2x^2 + 1 \leqslant y \leqslant 6 - x$ counts as two inequalities.

M1: Any 2 of the inequalities.

A1: Any 3 of the inequalities. Ignore any reference to and/or or equivalent.

A1: All 4 correct. Withhold the final mark for use of "or" or $\cup$ is used between the different inequalities.

Question Number	Scheme	Marks
5(a)	$\angle BOD = \pi - 2\times 0.7 = 1.742\,*$	B1*
		(1)
(b)	Area of $BOD = \frac{1}{2}\times 3^2 \sin 1.742 \quad (= \text{awrt } 4.43)$	M1
	Area of R is: $\frac{1}{2}\times 3^2\times 1.742 - \frac{1}{2}\times 3^2 \sin 1.742$ or $\frac{1}{2}\times\pi\times 3^2 - \frac{1}{2}\times 3^2\sin 1.742 - 2\times\frac{1}{2}\times 3^2\times 0.7$	dM1
	= awrt 3.4 (m^2)	A1
		(3)
(c)	$BD = \sqrt{3^2+3^2-2\times 3\times 3\cos 1.742} \quad (= \text{awrt } 4.59)$ or $BD = 2\times 3\sin\left(\frac{1.742}{2}\right)$ or $BD = 2\times 3\cos 0.7$ or $BD = \frac{3\sin 1.742}{\sin\left(\frac{\pi - 1.742}{2}\right)}$ or arc $BCD = 3\times 1.742 \quad (= 5.226)$	M1
	Perimeter of R is: $3\times 1.742 + "BD"$	dM1
	= awrt 9.8 (m)	A1
		(3)
		Total 7

They may work in degrees which is acceptable

(a)

B1*: Correct working to achieve 1.742 (or better). Alternatively, they may use $\angle BOD$ and add this to 2×0.7 to achieve π. They must write a minimal conclusion that $\angle BOD = 1.742$

May work in degrees: $180 - 2\times\frac{0.7}{\pi}\times 180 = \text{awrt } 99.8° \Rightarrow \frac{\text{awrt } 99.8}{180}\times\pi = 1.742$

(b)

M1: Correct strategy for the area of triangle BOD using $\angle BOD = 1.742$. May be implied by awrt 4.43

May work in degrees (1.742 radians as awrt 99.8)

eg. $\frac{1}{2}\times 3^2 \sin 99.8$

dM1: Applies a correct method for the area of R. The values embedded is sufficient. May also work in degrees correctly. It is dependent on the previous method mark.

eg. $\pi \times 3^2 \times \frac{99.8}{360} - \frac{1}{2} \times 3^2 \sin 99.8$

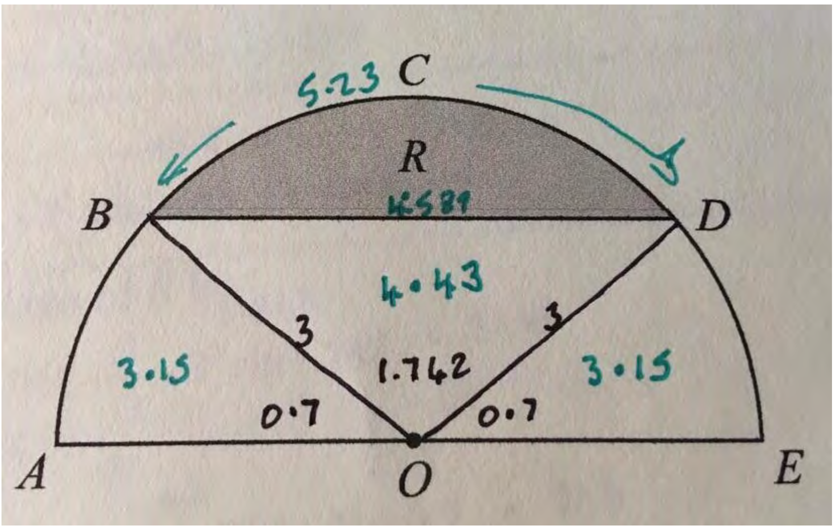
A1: awrt 3.4 (m^2) Do not isw if they add or subtract other areas.

(c)

M1: Correct method for the length of BD which may be implied by awrt 4.59
OR a correct method for the length of arc BCD (= 5.226)
May work in degrees (Take 1.742 in radians as awrt 99.8).

dM1: Applies a fully correct method to find the perimeter of R by adding the length of arc BCD to their BD. **The methods to find both of these must be correct**.
It is dependent on the previous method mark.

A1: awrt 9.8 (m) Do not isw.



Question Number	Scheme	Marks
6(a)(i)	$x=4 \Rightarrow \mathrm{f}'(4)=\dfrac{(4+3)^2}{4\sqrt{4}}=\dfrac{49}{8}$ (6.125)	B1
(ii)	$y-20=\text{"}\dfrac{49}{8}\text{"}(x-4)$	M1A1ft
	$49x-8y-36=0$	A1
		(4)
(b)	$\mathrm{f}'(x)=\dfrac{(x+3)^2}{x\sqrt{x}}=\dfrac{x^2+6x+9}{x\sqrt{x}}$ $=\dfrac{x^2}{x\sqrt{x}}+\dfrac{6x}{x\sqrt{x}}+\dfrac{9}{x\sqrt{x}}=...$	M1
	$=x^{\frac{1}{2}}+6x^{-\frac{1}{2}}+9x^{-\frac{3}{2}}$	A1
	$(\mathrm{f}(x)=)\ \dfrac{2}{3}x^{\frac{3}{2}}+12x^{\frac{1}{2}}-18x^{-\frac{1}{2}}+c$	dM1 A1A1
	$20=\dfrac{2}{3}(4)^{\frac{3}{2}}+12(4)^{\frac{1}{2}}-18(4)^{-\frac{1}{2}}+c \Rightarrow c=...$	M1
	$(\mathrm{f}(x)=)\ \dfrac{2}{3}x^{\frac{3}{2}}+12x^{\frac{1}{2}}-18x^{-\frac{1}{2}}-\dfrac{1}{3}$	A1
		(7)
		Total 11

(a)(i)

B1: Correct value

(ii)

M1: Correct straight line method using $y = 20$ and $x = 4$ with their f′(4) as $(y-20)=\text{"}\dfrac{49}{8}\text{"}(x-4)$ allowing a sign error in one of the brackets.
If they use $y=mx+c$ they must proceed as far as $c=...$
Using a perpendicular gradient is M0.

A1ft: Correct equation in any form following through on their f′(4)

A1: Correct equation in the required form where all terms are on one side of an equation (allow any integer multiple)

(b)

M1: Squares the numerator (condone if only x^2+9 terms are found) and attempts to split the fraction. If this is done in (a) it must be used in (b). Score for one correct index being achieved from correct working: $...x^{\frac{1}{2}}$ or $...x^{-\frac{1}{2}}$ or $...x^{-\frac{3}{2}}$

A1: $x^{\frac{1}{2}}+6x^{-\frac{1}{2}}+9x^{-\frac{3}{2}}$ These terms may appear on different lines.

dM1: $...x^{\frac{1}{2}} \to ...x^{\frac{3}{2}}$ or $...x^{-\frac{1}{2}} \to ...x^{\frac{1}{2}}$ or $...x^{-\frac{3}{2}} \to ...x^{-\frac{1}{2}}$
It is dependent on the previous method mark.

A1: Any 2 correct terms of $\frac{2}{3}x^{\frac{3}{2}}+12x^{\frac{1}{2}}-18x^{-\frac{1}{2}}$ which may be on different lines of their work (unsimplified or simplified)

A1: $(\mathrm{f}(x)=)\ \frac{2}{3}x^{\frac{3}{2}}+12x^{\frac{1}{2}}-18x^{-\frac{1}{2}}\ (+c)$ (unsimplified or simplified) which may appear on different lines of their work (condone lack of $+\,c$ for this mark). Condone spurious notation.

M1: Uses $y = 20$ and $x = 4$ in their integrated function to find a value for "c". (Not differentiated function or the original function)

A1: $\frac{2}{3}x^{\frac{3}{2}}+12x^{\frac{1}{2}}-18x^{-\frac{1}{2}}-\frac{1}{3}$ (accept equivalent simplified forms with exact coefficients and allow $y=$). Isw after a simplified correct answer, unless they attempt to multiply through by a value.
Condone spurious notation.

Question Number	Scheme	Marks
7(a)	$4\times -2\times -9=72$ $p="72"-50$	M1
	$(p=)\ 22$	A1
		(2)
(b)	$(q=)-4,\ 2,\ 4.5$	B1B1
		(2)
(c)	$\mathrm{f}(x)=(x+4)(x-2)(2x-9)$ $\mathrm{f}(x)=(x^2+2x-8)(2x-9)=...x^3\pm...x^2\pm...x\ (\pm...)$	M1
	$=2x^3-5x^2-34x\ \ (+72)$	A1
	$(\mathrm{f}'(x)=)\ 6x^2-10x-34$	M1A1
		(4)
(d)	$"6x^2-10x-34"=-18$ $"6x^2-10x-16"=0\Rightarrow x=...\left(-1,\ \frac{8}{3}\right)$	M1
	$-1<x<\frac{8}{3}$	dM1A1
		(3)
		Total 11

(a)

M1: Correct method for p. Condone sign slips in finding the product of $4\times -2\times -9$
Alternatively multiplies out to achieve a cubic (eg$..........\pm 72$) and subtracts 50 from their constant. $50-72\ (=-22)$ is M0.

A1: 22 cao (22 with no working is M1A1) In the alternative method they must identify p as 22.
Check for answer next to question. If there is a contradiction then the answer in the main body of working takes precedence.
Accept $y=\mathrm{f}(x)-22$ but do not accept contradictions such as $\mathrm{f}(x)-22\Rightarrow p=-22$ (M1A0)

(b) Check next to the question (ignore any references to x)

B1: Any 1 correct value of $-4,\ 2,\ 4.5$ in their final answer. If they proceed to changing the sign on the value then B0.

B1: $-4,\ 2,\ 4.5$ cao but if they exclude any of these then withhold this mark. If there is a contradiction, then the answer in the main body of working takes precedence and if they state the correct values followed by $4,\ -2,\ -4.5$ then withhold this mark.

(c) The expansion may be seen in (a) or (b) which is acceptable to score the first two marks.

M1: Correct method used to expand and achieve a cubic $ax^3 + bx^2 + cx\ (+d)$ where a, b, c are all non zero. Terms do not need to be collected.

A1: $2x^3 - 5x^2 - 34x$ (simplified or unsimplified). Do not be concerned with the value of d

M1: $x^n \to x^{n-1}$ on at least one term for their cubic.

A1: $6x^2 - 10x - 34$ following a correct expansion of the cubic (+72 may be omitted). If the constant term is incorrect (not just omitted) then A0
isw eg $6x^2 - 10x - 34 = 0$ can still score A1.

(d)

M1: Sets their f′(x) = ± 18, collects terms and attempts to solve their 3TQ by factorising, quadratic formula or completing the square. They may just write down their critical values which is acceptable, but you may need to check these on your calculator. Condone slips in their rearrangement.

dM1: Attempts "inside" region for their values. Do not be concerned as to whether the inequalities are $<$ or $\leqslant$ for this mark. It is dependent on the previous method mark.

A1: $-1 < x < \frac{8}{3}$ or other equivalent expressions such as $\left\{x \in \mathbb{R} : -1 < x < \frac{8}{3}\right\}$ $x > -1 \cap x < \frac{8}{3}$ or $x > -1$ and $x < \frac{8}{3}$, $\frac{8}{3} > x > -1$ or $x > -1,\ x < \frac{8}{3}$. Some minimal working must be seen.
Condone other attempts at set notation where there is the same intention.
Do not accept "$x > -1$ or $x < \frac{8}{3}$" or "$x > -1 \cup x < \frac{8}{3}$"

Question Number	Scheme	Marks
8(a)	$\frac{2}{5}$ or decimal equivalent	B1
		(1)
(b)	$m_N = -1 \div "\frac{2}{5}"$	M1
	$y+2 = "-\frac{5}{2}"(x-6)$	M1
	$y = -\frac{5}{2}x+13$	A1
		(3)
(c)	$"-\frac{5}{2}x+13" = "\frac{2}{5}x+\frac{7}{5}" \Rightarrow "\frac{29}{10}x" = "\frac{58}{5}" \Rightarrow x = \ldots(=4)$ or $"\frac{5}{2}y-\frac{7}{2}" = "-\frac{2}{5}y+\frac{26}{5}" \Rightarrow "\frac{29}{10}y" = "\frac{87}{10}" \Rightarrow y = \ldots(=3)$	M1
	$x = "4" \Rightarrow y = \ldots$ or $y = "3" \Rightarrow x = \ldots$	dM1
	$(4,3)$	A1
		(3)
(d)	$(2,8)$	B1B1
		(2)
		Total 9

(a)

B1: $\frac{2}{5}$ or decimal equivalent. It must be identified so do not just extract it from a rearranged equation into the form $y = \frac{2}{5}x + \ldots$ and do not allow $\frac{2}{5}x$. Must be seen in (a). Do not be concerned with the working to achieve $\frac{2}{5}$. Do not accept $\frac{-2}{-5}$

(b)

M1: Correct application of the perpendicular gradient rule

M1: Correct straight-line method with their "changed" gradient. Eg $(y+2) = "-\frac{5}{2}"(x-6)$. Allow one sign slip in the brackets. If they use $y = mx + c$ they must proceed as far as $c = \ldots$

A1: $y = -\frac{5}{2}x + 13$ oe

(c) Coordinates found with no algebraic working scores 0

M1: A correct method to solve for x or y for their l_1 and l_2. Do not be concerned by the mechanics of their rearrangement. Do not penalise if decimals appear in their working.

dM1: Finds the value of the other variable. It is dependent on the previous method mark.

A1: $(4,3)$ or $x=4,\ y=3$ Condone lack of brackets around the coordinates.

(d) Note on EPEN this is M1A1 we are marking this B1B1

B1: One of $x=2$ or $y=8$ May be seen within a pair of coordinates.

B1: $(2,8)$ or $x=2,\ y=8$ Condone lack of brackets around the coordinates.

Special Case: $(8,2)$ or $\begin{pmatrix}2\\8\end{pmatrix}$ score B1B0

Question Number	Scheme	Marks
9(a)	$(A=)-3$	B1
		(1)
(b)	$y=3$	B1
	eg $x=30+5\times180$ or $x=210+720$ or $x=180+2\times360+30$	M1
	$x=930$	A1
		(3)
		Total 4

Check for answers next to the questions and on the graph. If there are contradictions then the answers given in the main body of the work takes precedence

(a)

B1: $(A=)-3$

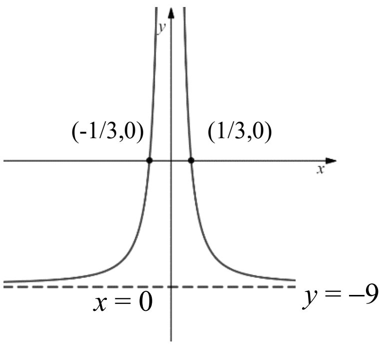
(b)

B1: Correct y coordinate only (others must be discarded)

M1: Correct strategy for the x coordinate. See scheme for examples.
Values embedded is sufficient for the mark.

A1: Correct x coordinate only (others must be discarded). Isw. Note $(930,\ 3)$ with no incorrect working and no other coordinates scores full marks.

Special case: If they give $(3,\ 930)$ or $\left(\frac{31}{6}\pi,\ 3\right)$ rather than $(930,\ 3)$ score B1M1A0

Question Number	Scheme	Marks
10(a)		B1B1B1B1
		(4)
(b)	$k < 0$	B1
	$\frac{1}{x^2} - 9 = kx^2 \Rightarrow 1 - 9x^2 = kx^4$	M1
	$1 - 9x^2 = kx^4 \Rightarrow kx^4 + 9x^2 - 1 = 0$ Require $b^2 - 4ac \Rightarrow 81 - 4 \times k \times -1$	M1
	Critical value $(k =) -\frac{81}{4}$	A1
	$-\frac{81}{4} < k < 0$	A1cso
		(5)
		Total 9

(a)

B1:  shape anywhere on a set of axes. Condone slips of the pen towards the asymptotes as long as they are not clear turning points.

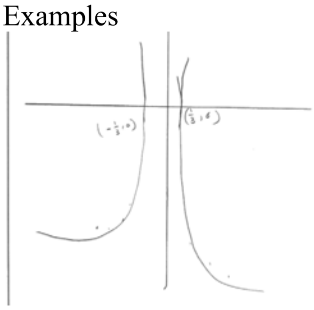
B1: x intercepts at $\left(-\frac{1}{3}, 0\right)$ and $\left(\frac{1}{3}, 0\right)$. May be marked as $-\frac{1}{3}$ and $\frac{1}{3}$. Do not allow $\left(0, -\frac{1}{3}\right)$ or $\left(0, \frac{1}{3}\right)$ but condone lack of brackets around the coordinates. Only accept $0.\dot{3}$ and $-0.\dot{3}$ or equivalent. May be stated underneath.
Cannot be scored without a corresponding sketch.

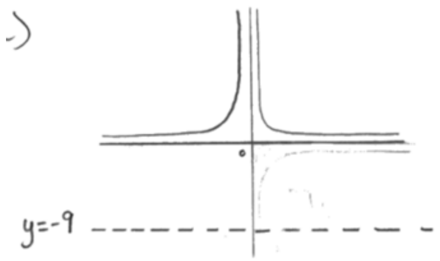
B1: States the asymptote $x = 0$ or $y = -9$ **as long as it is an asymptote for their sketch**

B1: States both asymptotes $x = 0$ and $y = -9$ **as long as they are asymptotes for their sketch**

For the coordinates or asymptotes if they are written on the sketch and then stated underneath then the sketch takes precedence.

Examples





(b)

B1: $k < 0$ (which may be part of their final answer).

M1: Sets $C = D$ and multiplies through by x^2 to achieve a quartic (does not need to be a 3TQ in x^2 for this mark). Terms do not need to be collected on one side of the equation.

M1: Considers the discriminant of their **3TQ** in x^2 to produce an expression in terms of k. Condone sign slips in their rearrangement before attempting the discriminant.

A1: Identifies $(k =)-\frac{81}{4}$ as a critical value from correct working which may be seen within their solution. Ignore use of equals or an inequality sign for this mark or x used instead of k.
Note $1-9x^2 = kx^4 \Rightarrow kx^4 - 9x^2 - 1 = 0 \Rightarrow -\frac{81}{4}$ is A0A0 (sign error when rearranging)

A1cso: $-\frac{81}{4} < k < 0$ or other equivalent expressions such as $k > -\frac{81}{4} \cap k < 0$ or $k > -\frac{81}{4}$ and $k < 0$
$0 > k > -\frac{81}{4}$. **Must be in terms of k**

Do not accept "$k > -\frac{81}{4}$ or $k < 0$" "$k > -\frac{81}{4}, k < 0$" "$k > -\frac{81}{4} \cup k < 0$"