Coimisiún na Scrúduithe Stáit

State Examinations Commission

Leaving Certificate Examination 2023

Mathematics

Higher Level

Paper 2

Marking scheme

300 marks

Marking Scheme – Paper 2, Section A and Section B

Structure of the marking scheme

Candidate responses are marked according to different scales, depending on the types of response anticipated. Scales labelled A divide candidate responses into two categories (correct and incorrect). Scales labelled B divide responses into three categories (correct, partially correct, and incorrect), and so on. The scales and the marks that they generate are summarised in this table:

Scale label	A	B	C	D
No of categories	2	3	4	5
5 mark scales		0, 2, 5	0, 2, 3, 5	0, 2, 3, 4, 5
10 mark scales		0, 5, 10	0, 4, 7, 10	0, 3, 5, 8, 10
15 mark scales				0, 4, 8, 12, 15
20 mark scales				0, 6, 12, 17, 20

A general descriptor of each point on each scale is given below. More specific directions in relation to interpreting the scales in the context of each question are given in the scheme, where necessary.

Marking scales – level descriptors

A-scales (two categories)
- incorrect response
- correct response

B-scales (three categories)
- response of no substantial merit
- partially correct response
- correct response

C-scales (four categories)
- response of no substantial merit
- response with some merit
- almost correct response
- correct response

D-scales (five categories)
- response of no substantial merit
- response with some merit
- response about half-right
- almost correct response
- correct response

Section A

Question 1	(30 marks)
(a)	10C
(b)	10D
(c)	10D

Question 2	(30 marks)
(a)	10C
(b)	10C
(c)	10D

Question 3	(30 marks)
(a)	15D
(b)(i)	5B
(b)(ii)	10D

Question 4	(30 marks)
(a)(i)	10C
(a)(ii)	15D
(b)	5D

Question 5	(30 marks)
(a)(i)(ii)(iii)	20D
(b)	10C

Question 6	(30 marks)
(a)	5B
(b)(i)	15D
(b)(ii)	10D

Section B

Question 7	(50 marks)
(a)	10C
(b)	10D
(c)(d)	10D
(e)(i)	5B
(e)(ii)	10C
(f)	5D

Question 8	(50 marks)
(a)	10D
(b)(i)	10C
(b)(ii)	5C
(c)	10D
(d)(i)	10D
(d)(ii)	5C

Question 9	(50 marks)
(a)(i)	5B
(a)(ii)	10C
(b)(i)	10C
(b)(ii)	10D
(c)(i)	5B
(c)(ii)	10C

Question 10	(50 marks)
(a)(i)	10C
(a)(ii)	15D
(a)(iii)	5D
(b)(i)	5B
(b)(ii)	5C
(b)(iii)	10C

Palette of annotations available to examiners

Symbol	Name	Meaning in the body of the work	Meaning when used in the right margin
✓	Tick	Work of relevance	The work presented in the body of the script merits full credit
✗	Cross	Incorrect work (distinct from an error)	The work presented in the body of the script merits 0 credit
*	Star	Rounding / Unit / Arithmetic error / Misreading	
	Horizontal wavy	Error	
P	P		The work presented in the body of the script merits *Partial Credit*
L	L		The work presented in the body of the script merits *Low Partial Credit*
M	M		The work presented in the body of the script merits *Mid Partial Credit*
H	H		The work presented in the body of the script merits *High Partial Credit*
F*	F star		The work presented in the body of the script merits *Full Credit – 1*
[	Left Bracket		Another version of this solution is presented elsewhere and it merits equal or higher credit
	Vertical wavy	No work on this page / portion of this page	
O	Oversimplify	The candidate has oversimplified the work	
WOM	Work of merit	The candidate has produced work of merit (in line with that defined in the scheme)	
S	Stops early	The candidate has stopped early in this part	

Note: Where work of substance is presented in the body of the script, the annotation on the right margin should reflect a combination of annotations in the work.

In a **C scale** that is **not** marked using steps, where * and and appear in the body of the work, then L should be placed in the right margin.

In the case of a **D scale** with the same annotations, M should be placed in the right margin.

Detailed marking notes

Model Solutions & Marking Notes

Note: The model solutions for each question are not intended to be exhaustive – there may be other correct solutions. Any Examiner unsure of the validity of the approach adopted by a particular candidate to a particular question should contact his / her Advising Examiner.

Q1	Model Solution –30 Marks	Marking Notes
(a)	$P(€6, €9, €6) = \left[\frac{5}{12} \times \frac{3}{12} \times \frac{5}{12}\right]$ $= \frac{75}{1728} = \frac{25}{576} = 0 \cdot 04340....$ $= 0 \cdot 0434$ [4 d.p.]	**Scale 10C (0, 4, 7, 10)** *Low Partial Credit:* • Any correct relevant probability stated *High Partial Credit:* • $P(€6) = \frac{5}{12}$ and $P(€9) = \frac{3}{12}$ and some multiplication indicated • $\frac{5}{12} \times \frac{3}{12} \times \frac{5}{12}$ • $\frac{5}{12} \times \frac{3}{11} \times \frac{5}{10}$ and continues *Full Credit -1* • Incorrect rounding or no rounding
(b)	Success = getting a 9 P(success)= $\frac{1}{4}$ Failure = not getting a 9 P(failure)= $\frac{3}{4}$ 2 successes in first 7 spins and then success $= \binom{7}{2}\left(\frac{1}{4}\right)^2\left(\frac{3}{4}\right)^5 \times \frac{1}{4}$ $= 0 \cdot 07786$ ... $= 0 \cdot 0779$ [4 d.p.]	**Scale 10D (0, 3, 5, 8, 10)** Consider the solution as being the product of four terms: $\binom{7}{2}$, $\left(\frac{1}{4}\right)^2$, $\left(\frac{3}{4}\right)^5$ and $\frac{1}{4}$ *Low Partial Credit:* • P(success)= $\frac{1}{4}$ • P(failure)= $\frac{3}{4}$ • $\binom{7}{2}$ • $\frac{1}{4}$ for the last day • $\binom{8}{3}$ *Mid Partial Credit:* • Product of two correct terms evaluated • Product of three correct terms *High Partial Credit:* • $\binom{7}{2}\left(\frac{1}{4}\right)^2\left(\frac{3}{4}\right)^5 \times \frac{1}{4}$ *Full Credit -1* • Incorrect rounding or no rounding

<table>
<tr><th>Q1</th><th>Model Solution –30 Marks</th><th>Marking Notes</th></tr>
<tr>
<td>(c)</td>
<td>
Will get less than €16 unless $9, 9$, so:
$1 - P(9,9) = 1 - \frac{1}{4} \times \frac{1}{4} = \frac{135}{144}$ or $\frac{15}{16}$
$= 0 \cdot 9375$
OR
<table>
<tr><td>$P(0,0)$</td><td>$\frac{4}{12} \times \frac{4}{12}$</td><td rowspan="3">$P(0 \text{ first})$</td><td rowspan="3">$\frac{4}{12}$</td></tr>
<tr><td>$P(0,6)$</td><td>$\frac{4}{12} \times \frac{5}{12}$</td></tr>
<tr><td>$P(0,9)$</td><td>$\frac{4}{12} \times \frac{3}{12}$</td></tr>
<tr><td>$P(6,0)$</td><td>$\frac{5}{12} \times \frac{4}{12}$</td><td rowspan="3">$P(6 \text{ first})$</td><td rowspan="3">$\frac{5}{12}$</td></tr>
<tr><td>$P(6,6)$</td><td>$\frac{5}{12} \times \frac{5}{12}$</td></tr>
<tr><td>$P(6,9)$</td><td>$\frac{5}{12} \times \frac{3}{12}$</td></tr>
<tr><td>$P(9,0)$</td><td>$\frac{3}{12} \times \frac{4}{12}$</td><td>$P(9,0)$</td><td>$\frac{1}{12}$</td></tr>
<tr><td>$P(9,6)$</td><td>$\frac{3}{12} \times \frac{5}{12}$</td><td>$P(9,6)$</td><td>$\frac{5}{48}$</td></tr>
<tr><td>TOTAL</td><td>$= \frac{15}{16}$</td><td></td><td>$= \frac{15}{16}$</td></tr>
</table>
$= 0 \cdot 9375$
</td>
<td>
Scale 10D (0, 3, 5, 8, 10)
Note:
Low Partial Credit:

Relevant probability
Relevant work on establishing the condition, for example, indicates $P(9,9)$, or lists three that are in line with the condition (e.g.,$(0,0)$, $(0,6)$, $(0,9)$)

Mid Partial Credit:

$\frac{1}{4} \times \frac{1}{4}$ indicated
Probability calculated correctly for three pairs on the table

High Partial Credit:

$\frac{1}{16}$ or equivalent
Probability calculated correctly for six pairs on the table

Full Credit -1

No rounding or incorrect rounding

</td>
</tr>
</table>

<table>
<tr><th>Q2</th><th>Model Solution – 30 Marks</th><th>Marking Notes</th></tr>
<tr><td>(a)</td><td colspan="2">$\cos(A-B) = \cos A\cos B + \sin A\sin B$

Replace A with $90-A$:
$\cos(90-A-B) = \cos(90-A)\cos B + \sin(90-A)\sin B$ ....as $\sin A = \cos(90-A)$
$\cos(90-(A+B)) = \sin A\cos B + \cos A\sin B$
$\sin(A+B) = \sin A\cos B + \cos A\sin B$

OR

$\sin A = \cos(90-A)$
$\sin(A+B) = \cos\big(90-(A+B)\big) = \cos\big((90-A)-B\big)$
$= \cos(90-A)\cos B + \sin(90-A)\sin B$ … by $\cos(A-B)$ formula
$= \sin A\cos B + \cos A\sin B$</td></tr>
<tr><td></td><td colspan="2">Scale 10C (0, 4, 7, 10)
Low Partial Credit:
• Work of merit, for example, $\cos(A-B)$ formula
• Verified with one or more values for A and B
• $\sin A = \cos(90-A)$ or $\cos A = \sin(90-A)$
High Partial Credit:
• $\cos(90-A-B) = \cos(90-A)\cos B + \sin(90-A)\sin B$</td></tr>
<tr><td>(b)</td><td>$\sin(30+45) = \sin 30\cos 45 + \cos 30\sin 45$
$\sin 75 = \frac{1}{2}\left(\frac{1}{\sqrt{2}}\right) + \frac{\sqrt{3}}{2}\left(\frac{1}{\sqrt{2}}\right)$
$\sin 75 = \frac{1}{2\sqrt{2}} + \frac{\sqrt{3}}{2\sqrt{2}} = \frac{1+\sqrt{3}}{2\sqrt{2}} = \frac{\sqrt{2}+\sqrt{6}}{4}$</td><td>Scale 10C (0, 4, 7, 10)
Note: Accept $\frac{1}{2}\left(\frac{1}{\sqrt{2}}\right) + \frac{\sqrt{3}}{2}\left(\frac{1}{\sqrt{2}}\right)$ for full credit.
Low Partial Credit:
• Work of merit, for example $30+45$, or some correct substitution into relevant formula
High Partial Credit:
• $\sin 30\cos 45 + \cos 30\sin 45$ or equivalent</td></tr>
</table>

(c)	**Method 1** $\sin t[1 - 2\cos t] = 0$ $\sin t = 0$ and $1 - 2\cos t = 0$ $\sin t = 0$ when $t = 0°, 180°$ and $360°$ $1 - 2\cos t = 0$ $\cos t = \frac{1}{2}$ $\cos t = \frac{1}{2}$ when $t = 60°$ and $t = 300°$ $t = 0°, 60°, 180°, 300°$ and $360°$ **OR** $sin2t - sint = 0$ $2cos\frac{3t}{2}sin\frac{t}{2} = 0$ $cos\frac{3t}{2} = 0$ $t = 60°, 180°\ and\ 300°$ $sin\frac{t}{2} = 0$ $t = 0°\ and\ 360°$ **OR** **Method 2** Trial & Improvement: $t = 0$ $\sin 0 = \sin(2(0))$ $0 = 0$ $t = 60$ $\sin 60 = \sin(2(60))$ $\frac{\sqrt{3}}{2} = \frac{\sqrt{3}}{2}$ $t = 180$ $\sin 180 = \sin(2(180))$ $0 = 0$ $t = 300$ $\sin \mathbf{300} = \sin(2(300))$ $\frac{\sqrt{3}}{2} = \frac{\sqrt{3}}{2}$ $t = 360$ $\sin 360 = \sin(2(360))$ $0 = 0$	**Scale 10D (0, 3, 5, 8, 10)** **Method 1** Consider as involving 4 steps: **1.** Replaces $sin\ 2t$ with $2\ sin\ t\ cos\ t$ **2.** $sin\ t[1 - 2\ cos\ t] = 0$ stated or implied **3.** Solves $sin\ t = 0$ **4.** Solves $1 - 2\ cos\ t = 0$ **OR** **1.** $sin2t - sint = 0$ **2.** $2cos\frac{3t}{2}sin\frac{t}{2} = 0$ **3.** Solves $cos\frac{3t}{2} = 0$ **4.** Solves $sin\frac{t}{2} = 0$ *Low Partial Credit:* • Work of merit, for example, effort to expand $sin\ 2t$ or some correct transposition *Mid Partial Credit:* • 2 steps correct *High Partial Credit:* • 3 steps correct *Full Credit –1:* • Apply a * for each solution omitted from Step 3 or Step 4 **Method 2** *Low Partial Credit:* • One correct solution *Mid Partial Credit:* • 3 correct values verified *High Partial Credit:* • 4 correct values verified • All values correct but no work shown

Q3	Model Solution – 30 Marks	Marking Notes
(a)	**Method 1** $(\mathbf{4}, \mathbf{6}), (-\mathbf{3}, -\mathbf{1}), (\mathbf{0}, \mathbf{11}).$ $-\mathbf{11}$ $(\mathbf{4}, -\mathbf{5}), (-\mathbf{3}, -\mathbf{12}), \ (\mathbf{0}, \mathbf{0})$ AREA $= \frac{1}{2}\lvert\mathbf{4}(-\mathbf{12}) - (-\mathbf{3})(-\mathbf{5})\rvert$ $= \frac{1}{2}\lvert-\mathbf{63}\rvert$ $= \mathbf{31} \cdot \mathbf{5}$ **OR** **Method 2** Uses any one of the following formulae: 1. Area $= \frac{1}{2}\boldsymbol{ab}\sin\boldsymbol{c}$ 2. Area $= \frac{1}{2} \times \textbf{base} \times \textbf{perpendicular height}$	**Scale 15D (0, 4, 8, 12, 15)** **Method1** *Low Partial Credit:* • Work of merit in translating one point to $(0,0)$ *Mid Partial Credit:* • Three points correctly translated • Two of the given points subbed in to the area formula and evaluated *High Partial Credit* • Correct substitution into Area formula • One error in translating points and finishes correctly **Method 2** *Low Partial Credit:* • Work of merit, for example, finds one relevant piece of data eg. length of one side *Mid Partial Credit:* • All information relevant to one formula calculated, for example, the lengths of 2 sides and the included angle; or the length of one side and the perpendicular height *High Partial Credit* • Correct substitution into Area formula

Q3	Model Solution – 30 Marks	Marking Notes
(b) (i)	Mid-point $= \left(\frac{-1+5}{2}, \frac{k+l}{2}\right)$ $= \left(2, \frac{k+l}{2}\right)$ **OR** -1 to 5 is 6 steps, then $x = -1 + 3 = 2$ k to l is $(l-k)$ steps, then $y = k + \frac{l-k}{2} = \frac{k+l}{2}$ Mid-point $= \left(2, \frac{k+l}{2}\right)$	**Scale 5B (0, 2, 5)** *Partial Credit:* • Work of merit, for example, some correct substitution into relevant formula

<table>
<tr><th>Q3</th><th>Model Solution – 30 Marks</th><th>Marking Notes</th></tr>
<tr><td>(b)(ii)</td><td>
Slope $AB = \frac{l-k}{5-(-1)} = \frac{l-k}{6}$
Perpendicular slope $= -\frac{6}{l-k}$
Slope of $3x + 2y - 14 = 0$ is $-\frac{3}{2}$
$-\frac{6}{l-k} = -\frac{3}{2}$ so $\boldsymbol{l - k = 4}$ … Eqn 1
or
Slope $AB = \frac{2}{3}$, then $(-1, k)$and $(5, l) \in$
$y = mx + c$, also gives $\boldsymbol{l - k = 4}$ … Eqn 1

$\left(2, \frac{k+l}{2}\right) \rightarrow 3(2) + 2\left(\frac{k+l}{2}\right) - 14 = 0$
$\boldsymbol{k + l = 8}$ … Eqn 2
$\begin{cases} l + k = 8 \\ l - k = 4 \end{cases}$
$2l = 12$ ….. $l = 6$, $k = 2$
OR
Slope $AB = \frac{l-k}{6}$ and perpendicular $= -\frac{6}{l-k}$
Eqn of perp bisector:
$y - \frac{k+l}{2} = -\frac{6}{l-k}(x - 2)$
$2y - k - l + \frac{12}{l-k}x - \frac{24}{l-k} = 0$ or
$\frac{12}{l-k}x + 2y - k - l - \frac{24}{l-k} = 0$
Equating coefficients:
x: $\frac{12}{l-k} = 3$ so $4 = l - k$ … Eqn 1
Const.: $-k - l - \frac{24}{l-k} = -14$
$-k - l - \frac{24}{4} = -14$
So $k + l = 8$ … Eqn 2
Solve for $l = 6$, $k = 2$
</td><td>
Scale 10D (0, 3, 5, 8, 10)
Low Partial Credit:
Work of merit, for example, relevant use of midpoint of $[A, B]$, or finds a relevant slope (of AB or of bisector)
Mid Partial Credit:
Equation 1 or 2 correct found
Finds equation of perpendicular bisector in terms of l and k
High Partial Credit:
Equation 1 and 2 correct found
</td></tr>
</table>

Q4	Model Solution – 30 Marks	Marking Notes
(a) (i)	Centre $= (h, -3)$ Radius $= \sqrt{12}\ or\ 2\sqrt{3}$	**Scale 10C (0, 4, 7, 10)** *Low Partial Credit:* • Work of merit towards finding x-ordinate **or** y-ordinate of the centre *High Partial Credit* • Centre or radius correct
(ii)	$\frac{\lvert h-4(-3)+7\rvert}{\sqrt{(1)^2+(-4)^2}} = 5$ $\lvert h+19\rvert = 5\sqrt{17}$ $h+19 = 5\sqrt{17}$ or $h+19 = -5\sqrt{17}$ $h = 5\sqrt{17}-19$ or $h = -5\sqrt{17}-19$ **OR** $(h+19)^2 = 425$ $h^2+38h-64 = 0$ $h = 5\sqrt{17}-19$ or $h = -5\sqrt{17}-19$	**Scale 15D (0, 4, 8, 12, 15)** **3 steps:** **1.** $\frac{\lvert \mathbf{h-4(-3)+7}\rvert}{\sqrt{\mathbf{(1)^2+(-4)^2}}}$ **2.** $\frac{\lvert h-4(-3)+7\rvert}{\sqrt{(1)^2+(-4)^2}} = 5$ **3.** Find values of h *Low Partial Credit:* • Work of merit, for example, some substitution into relevant formula, or draws diagram with relevant figures (5, centre marked, and line) *Mid Partial Credit:* • 1 step correct *High Partial Credit:* • 2 steps correct

Q4	Model Solution – 30 Marks	Marking Notes
(b)	Centre $= (h, k)$ $k = \dfrac{3-5}{2} = -1$ $(x-h)^2 + (y+1)^2 = \left(\sqrt{20}\right)^2$ $x^2 + y^2 - 2hx + h^2 + 2y + 1 = 20$ $(8,1)$ is on the circle… $(8)^2 + (1)^2 - 2h(8) + h^2 + 2(1) + 1$ $= 20$ $h^2 - 16h + 48 = 0$ $(h-4)(h-12) = 0$ $h = 4,\ \cancel{h = 12}$ $s\colon\ (x-4)^2 + (y+1)^2 = 20$ **OR** $(a, 3)$: $a^2 + 2ga + 6f + c = -9$ $(a, -5)$: $a^2 + 2ga - 10f + c = -25$ So: $f = 1$ $(8, 1)$: $16g + 2f + c = -65$ So: $16g + c = -67$ … **Eqn A** $\sqrt{g^2 + f^2 - c} = \sqrt{20}$ So: $g^2 - c = 19$ … **Eqn B** From **A** and **B**: $g^2 + 16g + 48 = 0$ so $g = -4$ So $c = -3$ And eqn is $x^2 + y^2 - 8x + 2y - 3 = 0$	**Scale 5D (0, 2, 3, 4, 5)** *Low Partial Credit:* • Some correct substitution of relevant point *Mid Partial Credit* • Finds $k = -1$ • Finds $f = 1$ • 4 independent equations in g, f, c and a *High Partial Credit:* • $k = -1$ and quadratic equation in h • Finds $f = 1$ and quadratic equation in g *Full Credit –1:* • Finds the relevant constants, but equation of circle not stated • Finds equation of circles for both values of *h* but does not select the correct one

<table>
<tr><th>Q5</th><th>Model Solution – 30 Marks</th><th>Marking Notes</th></tr>
<tr><td>(a)
(i)
(ii)
(iii)</td><td>(i)
Mean $\frac{0+3+2+2+4+5+1}{7} = \frac{17}{7} = 2 \cdot 42 \ldots$
= 2.4 [1 d.p.]

Standard deviation $= 1 \cdot 59.. = 1.6$ [1 d.p.]

(ii) $r = -0 \cdot 76204 \ldots$
$r = -0 \cdot 762$ [3 d.p.]

(iii) Any valid explanation, for example:
If the number of red cubes increases
then there will be less green cubes</td><td>Scale 20D (0, 6, 12, 17, 20)
Note: Accept correct answer without supporting work

Consider solution as requiring 4 items:
1. Mean
2. Standard deviation
3. r
4. Explanation
Low Partial Credit:
• Work of merit, for example, finds the total number of red cubes
Mid Partial Credit:
• 1 item correct and work of merit in any other item
High Partial Credit:
• 3 items correct

Full Credit -1
• One or more answers not to required number of decimal places</td></tr>
<tr><td>(b)</td><td><table><tr><td>3 faces:</td><td>8</td></tr><tr><td>2 faces:</td><td>24</td></tr><tr><td>1 face:</td><td>22</td></tr><tr><td>no faces:</td><td>6</td></tr></table></td><td>Scale 10C (0, 4, 7, 10)
Accept correct answer without work
Low Partial Credit:
• Work of merit, for example, relevant work on the diagram
• One correct value
• Reference to total of 60 cubes
High Partial Credit
• Two correct values</td></tr>
</table>

Q6	Model Solution – 30 Marks	Marking Notes
(a)	Answer: FALSE Justification: *Describes or draws any situation where two angles are equal in size without being vertically opposite. Eg. equilateral triangle, isosceles triangle, opposite angles in a parallelogram etc.*	**Scale 5B (0, 2, 5)** *Partial Credit:* • Correct answer with no justification • States True and justifies (ignores "and only if
(b) (i)	**1.** $\lvert\angle EHD\rvert = \lvert\angle DBC\rvert = \theta$ … alternate angles $\lvert\angle EFD\rvert = \lvert\angle EHD\rvert$ … both $= \theta$ **2.** $\lvert\angle FED\rvert = \lvert\angle HED\rvert$ …rectangle & straight angle $\lvert\angle FDE\rvert = \lvert\angle HDE\rvert$ … angles in tri. sum to 180** **3.** $\lvert ED\rvert = \lvert ED\rvert$ … common side **Conclusion:** So $FED \equiv HED$ … by ASA $\lvert FE\rvert = \lvert EH\rvert$ **OR** **1.** $\lvert\angle EHD\rvert = \lvert\angle DBC\rvert = \theta$ … alternate angles $\lvert\angle EFD\rvert = \lvert\angle EHD\rvert$ … both $= \theta$ $\lvert FD\rvert = \lvert DH\rvert$ … isosceles triangle **2.** $\lvert\angle FED\rvert = \lvert\angle HED\rvert = 90^\circ$ …rectangle & straight angle **3.** $\lvert ED\rvert = \lvert ED\rvert$ … common side **Conclusion:** So $FED \equiv HED$ … by RHS $\lvert FE\rvert = \lvert EH\rvert$ *Or similar*	**Scale 15D (0, 4, 8, 12, 15)** Consider the solution as having 4 elements: 3 steps and a conclusion: **Steps 1, 2 & 3:** 3 correct statements for congruency (with justifications) **and** Conclusion (with reason) Note: To prove by SAS, candidates will have to establish that $\lvert\angle FDE\rvert = \lvert\angle HDE$ *Low Partial Credit:* • Work of merit, for example, $\lvert\angle EHD\rvert = \lvert\angle DBC\rvert$ indicated *Mid Partial Credit:* • 2 correct steps (no justifications) *High Partial Credit:* • 3 correct steps (including one side) with at least one justification • All 3 steps correct and conclusion stated (no justifications) *Full Credit -1* • $\lvert FE\rvert = \lvert EH\rvert$ not stated

Q6	Model Solution – 30 Marks	Marking Notes
(b) (ii)	$\lvert FE\rvert = \frac{1}{2}\lvert AB\rvert = 10$ $\lvert FG\rvert = 40$ $\tan\theta = \frac{\lvert AG\rvert}{\lvert FG\rvert} = \frac{90}{40}$ $\theta = 66\cdot 037..^\circ$ $\theta = 66^\circ$ [nearest degree] **OR** $\lvert FE\rvert = \frac{1}{2}\lvert AB\rvert = 10$ Triangles FED and BCD are similar So $\lvert ED\rvert$ = 90/4 = 22.5 $\tan\theta = \frac{\lvert ED\rvert}{\lvert FE\rvert} = \frac{22.5}{10}$ $\theta = 66\cdot 037..^\circ$ $\theta = 66^\circ$ [nearest degree] **OR** $\lvert FE\rvert = \frac{1}{2}\lvert AB\rvert = 10$ Triangles FED and BCD are similar So $\lvert DC\rvert$ = 90 x $\frac{3}{4} = 67.5$ $\tan\theta = \frac{\lvert CD\rvert}{\lvert BC\rvert} = \frac{67.5}{30}$ $\theta = 66\cdot 037..^\circ$ $\theta = 66^\circ$ [nearest degree]	**Scale 10D (0, 3, 5 , 8, 10)** **4 steps:** **1.** $\lvert FE\rvert = \frac{1}{2}\lvert AB\rvert = 10$ **2.** Finds 2nd side in a relevant triangle **3.** Trignometric equation set up **4.** Finds θ *Low Partial Credit:* • Work of merit in finding any side of a relevant triangle *Mid Partial Credit* • 2 steps correct *High Partial Credit:* • 3 steps correct *Full Credit -1* • Incorrect rounding or no rounding

Q7	Model Solution – 50 Marks	Marking Notes
(a)	$\|AC\|^2 + 9^2 = 70^2$ $\|AC\|^2 = 70^2 - 9^2$ $\|AC\|^2 = 4819$ $\|AC\| = \sqrt{4819}$ Gradient $= \frac{9}{\sqrt{4819}} \times 100 = 12.96..$ =13% [nearest percent]	**Scale 10C (0, 4, 7, 10)** **3 steps:** **1.** Sets up Pythagoras **2.** Finds $\|\boldsymbol{AC}\|$ **3.** Finds the gradient *Low Partial Credit:* • Work of merit, for example, $70^2 = 4900$, gradient = $\frac{9}{70}$ *High Partial Credit* • 2 steps correct *Full Credit -1* • Incorrect rounding or no rounding
(b)	$\|< POR\| = 5°$ $\frac{\|RO\|}{\sin 87} = \frac{20}{\sin 5}$ $\|RO\| = \frac{20 \sin 87}{\sin 5}$ $\|RO\| = 229 \cdot 16$ m $\tan 17 = \frac{\|HO\|}{229 \cdot 16}$ $\|HO\| = 229 \cdot 16 \tan 17$ $\|HO\| = 70$ [m]	**Scale 10D (0, 3, 5, 8, 10)** **4 steps:** **1.** Substitution into 'sine rule' **2.** Finds $\|\boldsymbol{RO}\|$ **3.** Sets up trigonometric equation to solve $\|\boldsymbol{HO}\|$ **4.** Finds $\|\boldsymbol{HO}\|$ *Low Partial Credit:* • Work of merit, for example, finds $\|< POR\|$, some correct substitution into 'sine rule' *Mid Partial Credit:* • 2 steps correct *High Partial Credit* • 3 steps correct *Full Credit -1* • Calculator in incorrect mode • No rounding or incorrect rounding

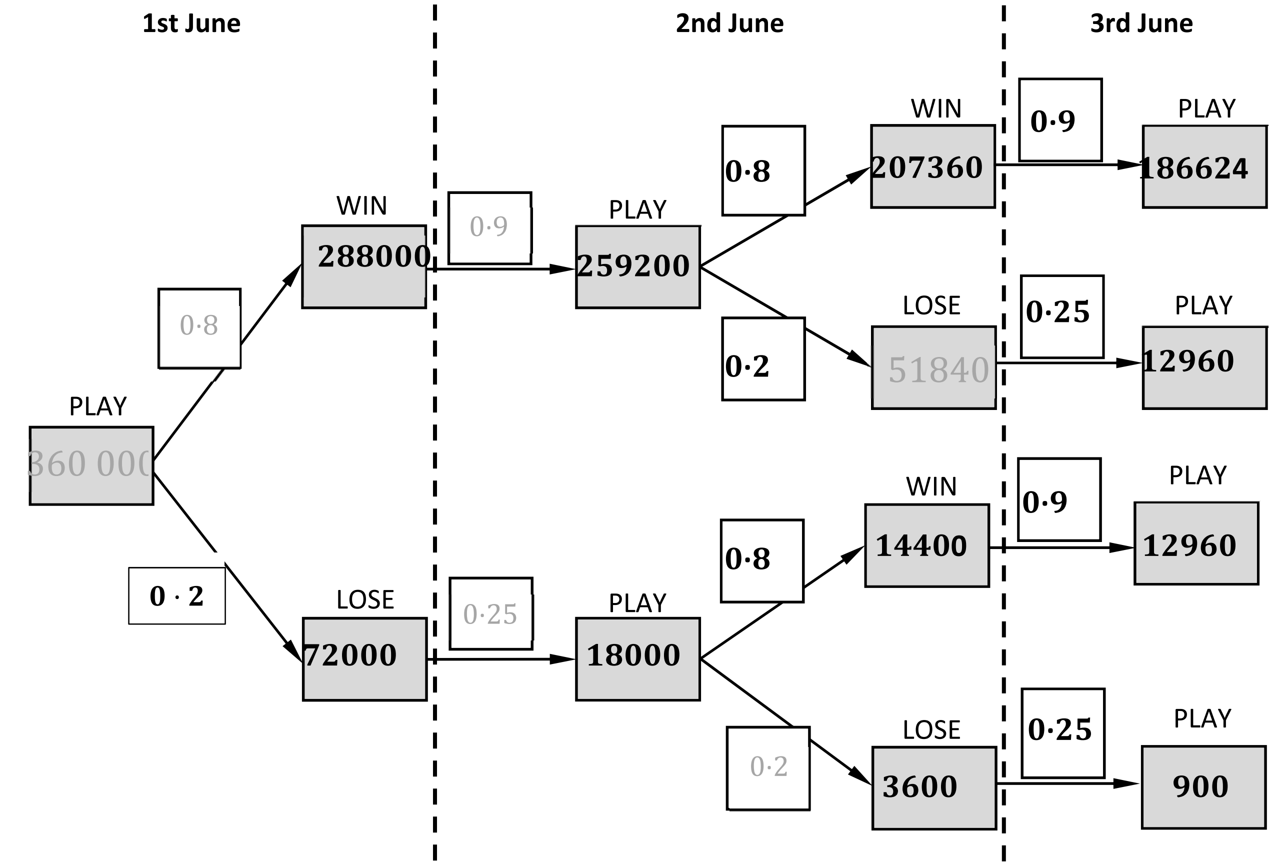
Q7	Model Solution – 50 Marks	Marking Notes
(c) **(d)**	**(c)** Range $= 2 \pm 0 \cdot 4$ $a = 1 \cdot 6 \quad b = 2 \cdot 4$ **OR** $V'(t) = -0 \cdot 4\left[(-\sin\frac{\pi}{2}t)\ \left(\frac{\pi}{2}\right)\right]$ =0 $\sin\frac{\pi}{2}t = 0$ $\frac{\pi}{2}t = 0$ or $\frac{\pi}{2}t = \pi$ $t = 0$ or $t = 2$ $V(0) = 1.6 \quad V(2) = 2.4$ $a = 1 \cdot 6 \quad b = 2 \cdot 4$ **(d)** If $V'(t) > 0$ then the volume of air is increasing so she is breathing in. If $V'(t) < 0$ then the volume of air is decreasing so she is breathing out.	**Scale 10D (0, 3, 5, 8, 10)** Note: in (d), accept correct explanation for breathing in or breathing out. *Low Partial Credit:* • Work of merit in finding either a or b • Work of merit in part **(d)**, for example, indicates that V' is the rate of change of volume of air *Mid Partial Credit:* • **(c)** or **(d)** correct • Work of merit in both **(c)** and **(d)** *High Partial Credit* • One part correct and work of merit in other part
(e) **(i)**	$V(0 \cdot 5) = 2 - 0 \cdot 4\cos\frac{\pi}{2}(0 \cdot 5)$ $= 1 \cdot 7171$ ... $= 1 \cdot 717$ litres [3 d.p.]	**Scale 5B (0, 2, 5)** *Partial Credit:* • Some relevant substitution *Full Credit -1* • Calculator in incorrect mode • No rounding or incorrect rounding • No units or incorrect units
(e) **(ii)**	$V'(t) = -0 \cdot 4\left[(-\sin\frac{\pi}{2}t)\ \left(\frac{\pi}{2}\right)\right]$ $V'(0 \cdot 5) = 0 \cdot 4\left(\frac{\pi}{2}\right)\left[\sin\frac{\pi}{2}(0 \cdot 5)\right]$ $= 0 \cdot 4442$.. $= 0 \cdot 444$ litres/sec [3 d.p.]	**Scale 10C (0, 4, 7, 10)** *Low Partial Credit:* • Work of merit in finding $V'(t)$ *High Partial Credit* • $V'(t)$ correct *Full Credit -1* • Calculator in incorrect mode • No rounding or incorrect rounding • No units or incorrect units

Q7	Model Solution – 50 Marks	Marking Notes
(f)	Form: $a + b\cos(ct)$ Maximum $= 3 \cdot 6$ Minimum $= 1 \cdot 3$ Range $= [3 \cdot 6,\ 1 \cdot 3]$ Mid-line $= \frac{1}{2}(3 \cdot 6 + 1 \cdot 3) = 2 \cdot 45 = a$ $b = \frac{1}{2}(3 \cdot 6 - 1 \cdot 3) = 1 \cdot 15$ Period $=$ 2 seconds $\frac{2\pi}{c} = 2$ $c = \pi$ $E(t) = 2 \cdot 45 - 1 \cdot 15\cos \pi\, t$	**Scale 5D (0, 2, 3, 4, 5)** *Low Partial Credit:* • Work of merit in finding any of a, b or c • Any work on graph towards finding $a, b,$ or c *Mid Partial Credit* • One of a, b or c correct *High Partial Credit* • Two of a, b or c correct *Full Credit -1* • $E(t) = 2 \cdot 45 + 1 \cdot 15\cos \pi\, t$

Q8	Model Solution – 50 Marks	Marking Notes
(a)	$z = \frac{x-\mu}{\sigma} = \frac{3\cdot5 - 3\cdot87}{0\cdot36} = -1\cdot03$ $P(x < 3\cdot5)$ $= P(z < -1\cdot03)$ $= 1 - P(z < 1\cdot03)$ $= 1 - 0\cdot8485$ $= 0\cdot1515$	**Scale 10D (0, 3, 5, 8, 10)** **1.** Find $\boldsymbol{z}$ -score **2.** Find $\mathbf{0\cdot8485}$ **3.** Find solution Note: Accept $\boldsymbol{z = 1.03}$ as correct $\boldsymbol{z}$ -score in Step 1, but must be handled correctly for Step 3 *Low Partial Credit:* • Work of merit, for example, some correct substitution into relevant formula, relevant diagram drawn, indicates μ or σ *Mid Partial Credit* • Correct z-score or $\frac{3\cdot5-3\cdot87}{0\cdot36}$ *High Partial Credit* • Finds z-score **and** further work, for example, finds 0.8485 or indicates $1 - P(z < 1\cdot03)$
(b) (i)	$\bar{x} \pm 1\cdot96\frac{\sigma}{\sqrt{n}}$ $3\cdot74 - 1\cdot96\left(\frac{0\cdot36}{\sqrt{64}}\right) = 3\cdot6518$ $3\cdot74 + 1\cdot96\left(\frac{0\cdot36}{\sqrt{64}}\right) = 3\cdot8282$ C.I. : $3\cdot6518 \le \mu \le 3\cdot8282$	**Scale 10C (0, 4, 7, 10)** Note: If $\sqrt{\mathbf{64}}$ is omitted, award Low Partial Credit at most *Low Partial Credit:* • Work of merit, for example, some correct substitution into relevant formula *High Partial Credit* • Confidence interval fully substituted • One side of interval only caculated

Q8	Model Solution – 50 Marks	Marking Notes
(ii)	$H_0: \mu = 3 \cdot 87$ $H_1: \mu \neq 3 \cdot 87$ We reject null hypothesis. Galway players do take a different average number of attempts. Confidence Interval: $3 \cdot 6518 \leq \mu \leq 3 \cdot 8282$ $3 \cdot 87$ is NOT within the confidence interval **OR** Test statistic: $z = \frac{3\cdot 74 - 3\cdot 87}{\frac{0\cdot 36}{\sqrt{64}}} = -2 \cdot 89$ $-2 \cdot 89 < -1 \cdot 96$ so test statistic is in the critical zone of rejection **OR** Test statistic: $z = \frac{3\cdot 74 - 3\cdot 87}{\frac{0\cdot 36}{\sqrt{64}}} = -2 \cdot 89$ $P(z \leq -2 \cdot 89) = 0 \cdot 9981$ p-value: $2 \times P(z < -2 \cdot 89) = 2(0.0019) = 0 \cdot 0038$ $0 \cdot 0038 < 0 \cdot 05$	**Scale 5C (0, 2, 3, 5)** Note: If $\boldsymbol{H_0}$ and $\boldsymbol{H_1}$ are reversed, treat as one error Note: treat solution as requiring the four parts laid out in answer grid *Low Partial Credit:* • Work of merit, for example, some correct calculation *High Partial Credit:* • Two parts correct

Q8	Model Solution – 50 Marks	Marking Notes
(c)	$\hat{p}+1\cdot 96\sqrt{\dfrac{\hat{p}(1-\hat{p})}{n}}=0\cdot 435$ $0{\cdot}35+1{\cdot}96\sqrt{\frac{0\cdot35(1-0\cdot35)}{n}}=0{\cdot}435$ $\sqrt{\dfrac{0\cdot 2275}{n}}=\dfrac{0\cdot 435-0\cdot 35}{1\cdot 96}$ $\dfrac{0\cdot 2275}{n}=\left(\dfrac{0\cdot 085}{1\cdot 96}\right)^2$ $\dfrac{0\cdot 2275}{\left(\frac{0\cdot 085}{1\cdot 96}\right)^2}=n$ $n=120.963.$ $n=121$	**Scale 10D (0, 3, 5, 8, 10)** **4 steps:** **1.** $\mathbf{1{\cdot}96}\sqrt{\frac{\mathbf{0\cdot35(1-0\cdot35)}}{\boldsymbol{n}}}$ **2.** Finds 0.085 or equivalent **3.** Sets up equation **4.** Solves Note: If margin of error is used ie.$\boldsymbol{E}=\frac{\mathbf{1}}{\sqrt{\boldsymbol{n}}}$ award Mid Partial Credit at most *Low Partial Credit:* • Some correct substitution into relevant formula *Mid Partial Credit* • 2 correct steps *High Partial Credit* • 3 correct steps *Full Credit -1* • Incorrect rounding

Q8	Model Solution – 50 Marks	Marking Notes
(d) (i)		

(d)(i) Scale 10D (0, 3, 5, 8, 10)

19 entries to check – note: candidates work will need to be followed from left to right as a single error may lead to subsequent answers differing from those shown in solution.

Low Partial Credit:

- At least one correct entry

Mid Partial Credit

- Eight correct entries

High Partial Credit

- 14 correct entries

Full Credit -1

- One incorrect entry

(d) (ii)	**Method 1** Total players $= 186624 + 12960 + 12960 + 900$ $= 213444$ Lost on 1st and/or 2nd $= 12960 + 12960 + 900$ $= 26820$ Probability $= \frac{26820}{213444} = \frac{745}{5929}$ **OR**	**Scale 5C (0, 2, 3, 5)** **Method 1** **3 steps:** **1.** Finds the total number of players who played on all three days **2.** Finds the number of players who lost **3.** Finds probability *Low Partial Credit:* • Work of merit in finding total players or number of players who lost *High Partial Credit:* • 2 steps correct
	Method 2 $P(win, win) = \frac{186624}{213444}$ $1 - P(win, win) = 1 - \frac{186624}{213444}$ $= \frac{26820}{213444} = \frac{745}{5929}$	**Method 2** *Low Partial Credit:* • Work of merit, for example, finds the total number of players who played on all three days *High Partial Credit:* • $1 - P(win, win) = 1 - \frac{186624}{213444}$
	Method 3 $P(\text{win, play, win, play}) = 0.8 \times 0.9 \times 0.8 \times 0.9 = \frac{324}{625}$ $P(\text{win, play, lose, play}) = 0.8 \times 0.9 \times 0.2 \times 0.25 = \frac{9}{250}$ $P(\text{lose, play, win, play}) = 0.2 \times 0.25 \times 0.8 \times 0.9 = \frac{9}{250}$ $P(\text{lose, play, lose, play}) = 0.2 \times 0.25 \times 0.2 \times 0.25 = \frac{1}{400}$ $P(lost\ on\ 1st\ and/or\ 2nd, given\ that\ they\ played\ 3\ days) =$ $\frac{\frac{9}{250}+\frac{9}{250}+\frac{1}{400}}{\frac{324}{625}+\frac{9}{250}+\frac{9}{250}+\frac{1}{400}} = \frac{745}{5929}$	**Method 3** *Low Partial Credit* • Work of merit, for example, $0.2 \times 0.25 \times 0.8 \times 0.9$ *High Partial Credit* • $\frac{9}{250} + \frac{9}{250} + \frac{1}{400}$ or equivalent • $\frac{324}{625} + \frac{9}{250} + \frac{9}{250} + \frac{1}{400}$ or equivalent

Q9	Model Solution – 50 Marks	Marking Notes
(a) (i)	Square: $l^2 = 140$ $l = \sqrt{140} = 11.83..$ $l = 11.8$ cm [1 d.p.]	**Scale 5B (0, 2, 5)** *Partial Credit:* • l^2 = 140 *Full Credit -1* • Incorrect rounding, or no rounding • No unit or incorrect unit

Q9	Model Solution – 50 Marks	Marking Notes
(a) (ii)	Hexagon: $\frac{140}{6}$ area of one triangle $\frac{1}{2}x^2 \sin 60 = \frac{140}{6}$ $x^2 = \dfrac{140}{3\sin 60}$ $x = \sqrt{\frac{140}{3\sin 60}} = \sqrt{\frac{280}{3\sqrt{3}}}$ $x = 7 \cdot 34 \ldots = 7.3$ [cm] [1 d.p.] **OR** Hexagon: $\frac{140}{6}$ area of one triangle Let $h =$ perpendicular height of one triangle $h^2 + \left(\frac{1}{2}x\right)^2 = x^2$ $h^2 = \frac{3}{4}x^2$ $h = \frac{\sqrt{3}}{2}x$ $\frac{1}{2} \times x \times \frac{\sqrt{3}}{2}x = \frac{140}{6}$ $x^2 = \dfrac{280}{3\sqrt{3}}$ $x = 7.34 \ldots. = 7.3$ [cm] [1 d.p.] **OR** Total Area = area of two identical trapeziums $140 = 2\left(\frac{x+2x}{2}\right)\frac{\sqrt{3}}{2}x$ …….. *h* calculated above $140 = \dfrac{3\sqrt{3}}{2}x^2$ $x^2 = \dfrac{280}{3\sqrt{3}}$ $x = 7.34 \ldots. = 7.3$ [cm] [1 d.p.]	**Scale 10C (0, 4, 7, 10)** Accept correct answer without units *Low Partial Credit:* • Work of merit, for example, finds area of one triangle; finds the area of one trapezium, work towards finding perpendicular height *High Partial Credit:* • Equation in $\boldsymbol{x}$ formed *Full Credit -1* • No rounding or incorrect rounding

Q9	Model Solution – 50 Marks	Marking Notes
(b) (i)	$4^2 = 6^2 + 8^2 - 2(6)(8)\cos\alpha$ $\cos\alpha = \dfrac{6^2 + 8^2 - 4^2}{2(6)(8)}$ $\cos\alpha = \dfrac{84}{96} = \dfrac{7}{8}$ $\alpha = \cos^{-1}\dfrac{7}{8}$	**Scale 10C (0, 4, 7, 10)** *Low Partial Credit:* • Correct formula with some substitution *High Partial Credit* • $\cos\alpha = \frac{6^2+8^2-4^2}{2(6)(8)}$ or equivalent • $16 = 100 - 96\cos\alpha$ • Uses the cosine rule to find either $\angle ADE$ or $\angle DEA$
(b) (ii)	$\cos\alpha = \frac{8}{\lvert AC\rvert} = \frac{7}{8}$ so $\lvert AC\rvert = \frac{64}{7}$ $\lvert CD\rvert = \sqrt{\left(\frac{64}{7}\right)^2 - 8^2} = \frac{8\sqrt{15}}{7}$ Area $= 2\left[\frac{1}{2}(8)\left(\frac{8\sqrt{15}}{7}\right)\right]$ $= \frac{64\sqrt{15}}{7}$ = 35.410… =35.41 cm^2 [2 d.p.] **OR** $\alpha = 28 \cdot 955°$ $\lvert AC\rvert = \dfrac{64}{7}$ Area $= 2\left[\frac{1}{2}(8)\left(\frac{64}{7}\right)\sin 28 \cdot 96\right] = 35 \cdot 410..$ $= 35.41\ cm^2$ [2 d.p.], **OR** $\alpha = 28 \cdot 955°$ $\tan 28.955 = \dfrac{\lvert CD\rvert}{8}$ $\lvert CD\rvert = 4.426$ Area $= 2[\frac{1}{2} \times 8 \times 4.426] = 35.410 \ldots$ $= 35.41\ cm^2$ [2 d.p.]	**Scale 10D (0, 3, 5, 8, 10)** *Low Partial Credit:* • Work of merit in finding a relevant side or angle *Mid Partial Credit:* • Correctly finds relevant sides and/or angles to allow for area to be found, for example, $\lvert CD\rvert$, or α and $\lvert AC\rvert$ *High Partial Credit* • Correctly filled formula for area of triangle ACD *Full Credit -1* • No rounding or incorrect rounding • No unit or incorrect unit

Q9	Model Solution – 50 Marks	Marking Notes
(c) (i)	*Verifies point, for example:* $Q = (\cos 135°, \sin 135°)$ [unit circle] $= \left(-\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}\right)$ **OR** Let co-ordinates of Q = (x, y) $\cos 45° = \frac{x}{1} = \frac{1}{\sqrt{2}} \Rightarrow x = -\frac{1}{\sqrt{2}}$ [2nd quadrant] $\sin 45° = \frac{y}{1} \Rightarrow y = \frac{1}{\sqrt{2}}$ **OR** Shows that $\lvert\angle QOP\rvert = 45°$ **and** that distance from Q to $(0, 0)$ is 1, or that Q lies on c **OR** $x^2 + y^2 = 1$ $y = -x$ $\therefore x^2 + x^2 = 1$ $2x^2 = 1$ $x = \pm\frac{1}{\sqrt{2}}$ But *x* in 2nd quadrant. $\therefore x = \frac{-1}{\sqrt{2}}$, and $y = \frac{1}{\sqrt{2}}$,	**Scale 5B (0, 2, 5)** Note: Check drawing for relevant work of merit *Partial Credit:* • Work of merit in finding x or y ordinate

(c) (ii)

Method 1

$P = (-1, 0)$ Tangent at P: $x = -1$

$Q = \left(-\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}\right)$ Slope of tangent at $Q = 1$

Tangent at Q: $y - \frac{1}{\sqrt{2}} = 1(x - -\frac{1}{\sqrt{2}})$

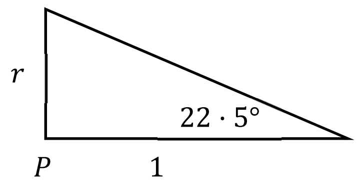
$$y = x + \sqrt{2}$$

At $x = -1$: $y = -1 + \sqrt{2}$

Centre $= (-1, -1 + \sqrt{2})$ Radius $= -1 + \sqrt{2}$

OR

Method 2



$r = \tan 22 \cdot 5°$

$$\tan 45° = \frac{2 \tan 22 \cdot 5°}{1 - \tan^2 22 \cdot 5°}$$

$$1 = \frac{2r}{1 - r^2}$$

$$r^2 + 2r - 1 = 0$$

$$r = \frac{-2 \pm \sqrt{2^2 - 4(1)(-1)}}{2(1)}$$

$$r = -1 + \sqrt{2}$$

Centre $= (-1, -1 + \sqrt{2})$ Radius $= -1 + \sqrt{2}$

OR

Method 3

Let $(-1, k)$ be centre of s

$(-1, 0)$ to $(-1, k) = \left(-\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}\right)$ to $(-1, k)$

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

$$k = \sqrt{\frac{3 - 2\sqrt{2}}{2} + \frac{2k^2 - 2\sqrt{2}k + 1}{2}}$$

$$2k^2 = 4 - 2\sqrt{2} - 2\sqrt{2}k + 2k^2$$

$$2\sqrt{2}k = 4 - 2\sqrt{2}$$

$$k = \frac{4 - 2\sqrt{2}}{2\sqrt{2}} = -1 + \sqrt{2}$$

Centre $= (-1, -1 + \sqrt{2})$ Radius $= -1 + \sqrt{2}$

Scale 10C (0, 4, 7, 10)

Consider the solution as having three steps:

1. Finds that the $\boldsymbol{x}$ co-ordinate of the centre $= \mathbf{-1}$

2. Indicates that the $\boldsymbol{y}$ co-ordinate of the centre $= \boldsymbol{r}$, the radius of circle $\boldsymbol{s}$

3. Finds $\boldsymbol{r}$

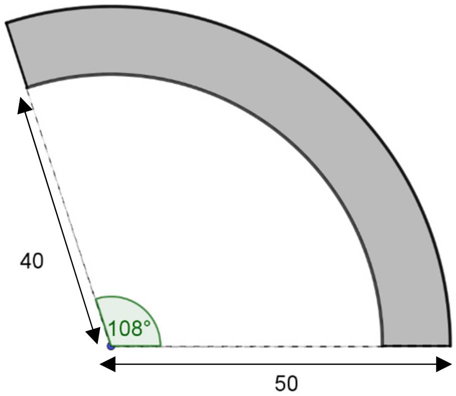
Low Partial Credit:

- Work of merit, for example, any relevant work on the diagram

High Partial Credit

- Two steps correct

Q10	Model Solution – 50 Marks	Marking Notes
(a)(i)	$\frac{x}{12} = \frac{x+10}{15}$ … or equivalent $15x = 12x + 120$ $3x = 120$ $x = 40$ [cm] **OR** $\frac{40}{12} = \frac{50}{15}$ … or equivalent $600 = 600$	**Scale 10C (0, 4, 7, 10)** *Low Partial Credit:* • Work of merit in establishing equation *High Partial Credit:* • Correct equation set up • $\frac{40}{12} = \frac{50}{15}$ or equivalent
(a)(ii)	Large cone: $R = 15$, $L = 50$ Small cone: $r = 12$, $l = 40$ Surface area $= \pi RL - \pi rl + \pi r^2$ $= \pi(15)(50) - \pi(12)(40) + \pi(12)^2$ $= 750\pi - 480\pi + 144\pi = 414\pi$ $1300 \cdot 61.. = 1300.6$ cm^2 [1d.p.]	**Scale 15D (0, 4, 8, 12, 15)** Note: Candidate may use $\boldsymbol{\pi(r+R)l}$, where $\boldsymbol{l = 10}$ to find the curved surface area *Low Partial Credit:* • Some correct substitution into πRL or πrl or πr^2 • $\pi RL - \pi rl + \pi r^2$ • $\pi RL - \pi rl$ *Mid Partial Credit* • One of πRL or πrl or πr^2 fully substituted and calculated • Fully correct substitution in to $\pi RL - \pi rl$ • $\pi RL - \pi rl + \pi r^2$ with some substitution *High Partial Credit* • $\pi RL - \pi rl + \pi r^2$ fully substituted • $\pi RL - \pi rl$ calculated *Full Credit -1* • No rounding or incorrect rounding • No unit or incorrect unit

Q10	Model Solution – 50 Marks	Marking Notes
(a)(iii)	Angle: $\frac{\theta}{360} 2\pi(40) = 2\pi(12)$ $\theta = 108°$ 	**Scale 5D (0, 2, 3, 4, 5)** Three measurements required: angle subtended at the centre and 2 relevant lengths of line segments *Low Partial Credit:* • Net of a cone drawn • Work of merit in calculating angle. • Correct structure but no measurements or incorrect measurements given *Mid Partial Credit* • Correct structure with one correct measurement given • Angle correctly calculated *High Partial Credit* • Correct structure with one incorrect measurement

(b)(i)	$9 \times 8 \times 7 \times 6 = 3024$ **OR** $9C_4 \times 4! = 3024$	**Scale 5B (0, 2, 5)** Note: Accept correct answer without work *Partial Credit:* • Work of merit, for example, lists some correct code *Full Credit-1* • $9 \times 9 \times 9 \times 9$ evaluated • $10 \times 9 \times 8 \times 7$ evaluated
(b)(ii)	$4(1 \times 8 \times 7 \times 6) = 1344$ **OR** No 2: $8 \times 7 \times 6 \times 5 = 1680$ $3024 - 1680 = 1344$ **OR** Of the 3024 codes: $\frac{1}{9}$ of them begin with a ‘2’, $\frac{1}{9}$ of them have a ‘2’ in the 2nd position… Therefore, number of codes that contain the digit 2 $= \frac{1}{9} \times 3024 \times 4$	**Scale 5C (0, 2, 3, 5)** Note: Accept correct answer without work *Low Partial Credit:* • Work of merit, for example, lists some correct codes, brings answer from b(i) down to b(ii) *High Partial Credit:* • $1 \times 8 \times 7 \times 6$ or $\frac{1}{9} \times 3024$ • 1680
(b)(iii)	$1 + 2 + 3 = 6$ $1 + 2 + 4 = 7$ $1 + 2 + 5 = 8$ $1 + 2 + 6 = 9$ $1 + 3 + 4 = 8$ $1 + 3 + 5 = 9$ $2 + 3 + 4 = 9$ 7 possible combinations with 6 possible arrangements of each So 7×6 *or* $7 \times 3! = 42$	**Scale10C (0, 4, 7, 10)** *Low Partial Credit:* • Work of merit in listing some codes *High Partial Credit:* • All 7 combinations listed • One correct combination and mentions 3! or 6 possible arrangements