Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2023

Marking Scheme

Mathematics

Ordinary Level

Note to teachers and students on the use of published marking schemes

Marking schemes published by the State Examinations Commission are not intended to be standalone documents. They are an essential resource for examiners who receive training in the correct interpretation and application of the scheme. This training involves, among other things, marking samples of student work and discussing the marks awarded, so as to clarify the correct application of the scheme. The work of examiners is subsequently monitored by Advising Examiners to ensure consistent and accurate application of the marking scheme. This process is overseen by the Chief Examiner, usually assisted by a Chief Advising Examiner. The Chief Examiner is the final authority regarding whether or not the marking scheme has been correctly applied to any piece of candidate work.

Marking schemes are working documents. While a draft marking scheme is prepared in advance of the examination, the scheme is not finalised until examiners have applied it to candidates' work and the feedback from all examiners has been collated and considered in light of the full range of responses of candidates, the overall level of difficulty of the examination and the need to maintain consistency in standards from year to year. This published document contains the finalised scheme, as it was applied to all candidates' work.

In the case of marking schemes that include model solutions or answers, it should be noted that these are not intended to be exhaustive. Variations and alternatives may also be acceptable. Examiners must consider all answers on their merits, and will have consulted with their Advising Examiners when in doubt.

Future Marking Schemes

Assumptions about future marking schemes on the basis of past schemes should be avoided. While the underlying assessment principles remain the same, the details of the marking of a particular type of question may change in the context of the contribution of that question to the overall examination in a given year. The Chief Examiner in any given year has the responsibility to determine how best to ensure the fair and accurate assessment of candidates' work and to ensure consistency in the standard of the assessment from year to year. Accordingly, aspects of the structure, detail and application of the marking scheme for a particular examination are subject to change from one year to the next without notice.

Leaving Certificate 2023

Mathematics

Marking Scheme

Ordinary Level

Paper 1

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	B	C	D
No of categories	3	4	5
5-mark scale	0, 3, 5	0, 3, 4, 5	0, 2, 3, 4, 5
10-mark scale	0, 7, 10	0, 4, 6, 10	0, 4, 6, 8, 10
15-mark scale		0, 6, 10, 15	
20-mark scale			0,7,10,15,20

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

B-scales (three categories)

- response of no substantial merit (no credit)
- partially correct response (partial credit)
- correct response (full credit)

C-scales (four categories)

- response of no substantial merit (no credit)
- response with some merit (low partial credit)
- almost correct response (high partial credit)
- correct response (full credit)

D-scales (five categories)

- response of no substantial merit (no credit)
- response with some merit (low partial credit)
- response about half-right (mid partial credit)
- almost correct response (high partial credit)
- correct response (full credit)

In certain cases, typically involving incorrect rounding, omission of units, a misreading that does not oversimplify the work, or an arithmetical error that does not oversimplify the work, a mark that is one mark below the full-credit mark may also be awarded. Such cases are denoted with a * and this level of credit is referred to as *Full Credit -1*. Thus, for example, in Scale 10C, *Full Credit -1* of 9 marks may be awarded.

The only marks that may be awarded for a question are those on the scale below, or *Full Credit -1*.

A rounding penalty is applied each time it occurs in the scheme. There is no penalty for omitted units if the question specifies the unit to be used in the answer, and there is generally no penalty for an omitted euro symbol in questions involving money.

In general, accept a candidate's work in one part of a question for use in subsequent parts of the question, unless this oversimplifies the work involved.

Unless otherwise specified, an answer without sufficient supporting work is generally awarded the lowest non-zero level of credit (typically *Partial Credit* or *Low Partial Credit*, as appropriate).

Summary of mark allocations and scales to be applied

<table>
<tr><th colspan="2">Section A (150)
Answer any five questions</th><th colspan="2">Section B (150)
Answer any three questions</th></tr>
<tr>
<td>Question 1 (30)
(a) 10C
(b) 10C
(c) 10C

Question 2 (30)
(a)(i)(ii) 10D
(a)(iii) 10C
(a)(iv) 5C
(b) 5B

Question 3 (30)
(a) 15C
(b)(i)(ii)(iii) 5D
(c) 10D</td>
<td>Question 4 (30)
(a)(i)(ii)(iii) 10D
(a)(iv) 5B
(b)(i) 10C
(b)(ii) 5C

Question 5 (30)
(a)(i) 10B
(a)(ii) 5C
(b)(i) 10B
(b)(ii) 5D

Question 6 (30)
(a)(i) 5B
(a)(ii) 5B
(b) 10C
(c) 10C</td>
<td>Question 7 (50)
(a)(i) 10B
(a)(ii) 5B
(a)(iii) 5C
(a)(iv) 10C
(b)(i) 10C
(b)(ii) 5B
(b)(iii) 5B

Question 8 (50)
(a) 10B
(b) 5C
(c) 5B
(d) 10C
(e) 10C
(f) 10C</td>
<td>Question 9 (50)
(a)(i) 10B
(a)(ii) 5B
(a)(iii) 5B
(a)(iv) 5C
(b)(i)(ii) 20D
(b)(iii) 5C

Question 10 (50)
(a)(i) 5B
(a)(ii) 5C
(b)(i)(ii) 10D
(b)(iii) 5C
(c)(i) 5C
(c)(ii) 10C
(c)(iii) 10D</td>
</tr>
</table>

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			The work presented in the body of the script merits partial credit
L			The work presented in the body of the script merits low partial credit
M			The work presented in the body of the script merits mid partial credit
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 the page)	
o	Oversimplify	The candidate has oversimplified the work	
WOM	Work of Merit	Nothing correct but **Work of Merit** within the body of work	

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** 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.

A ✔ in the body of the work may sometimes be used to indicate where a portion of the work presented has value and has merited one of the levels of credit described in the marking scheme. The level of credit is then indicated in the right margin.

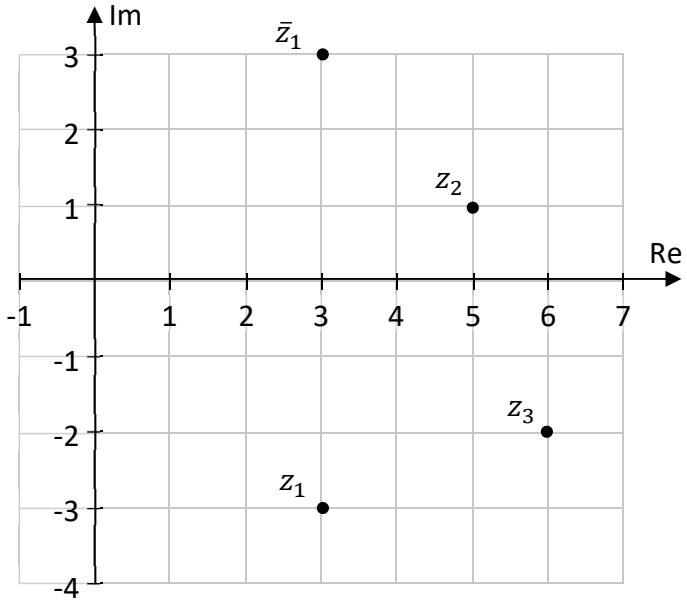
Detailed marking notes

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.

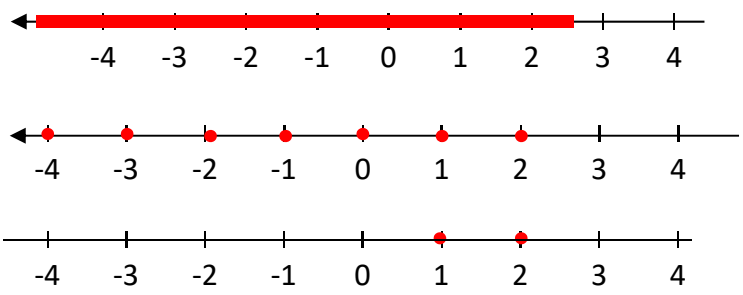
Q1	Model Solution – 30 Marks	Marking Notes
(a)	$240\,000 \times 1 \cdot 08 = [€]259\,200$ $259\,200 \times 1 \cdot 09 = [€]282\,528$	**Scale 10C (0, 4, 6, 10)** **Two steps Involved in solution** **1.** Finds $259\,200$ **2.** $1 \cdot 09$ applied correctly to answer for Step 1 *Low Partial Credit* • Work of merit, for example writes $1 \cdot 08$ or $1 \cdot 09$ or $\frac{8}{100}$ or $\frac{9}{100}$ *High Partial Credit* • One step correct **Note:** Accept **both** correct answers without supporting work **Note:** Full Credit -1 : correct answer without work €282 528
(b)	$\frac{472\,000 - 460\,000}{460\,000} \times 100$ $= \frac{12\,000}{460\,000} \times 100 = 2 \cdot 608 \ldots$ $= 2 \cdot 6\%$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit* • Writes 12000 • Writes $\frac{472\,000}{460\,000}$ *High Partial Credit* • $\frac{472\,000-460\,000}{460\,000} \times 100$ or 102.6 **Note:** Accept correct answer without supporting work for full credit **Note:** Full Credit -1 : $2 \cdot 608$ without work

Q1	Model Solution – 30 Marks	Marking Notes
(c)	$$F = P\left(1 + \frac{r}{100}\right)^t$$ $$370\,000 = 265\,000\left(1 + \frac{r}{100}\right)^4$$ $$1 + \frac{r}{100} = \sqrt[4]{\frac{370\,000}{265\,000}} = 1 \cdot 08702 \ldots$$ $$= 8 \cdot 7\%$$ [1 d.p]	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit* • Some correct substitution into $F = P\left(1 + \frac{r}{100}\right)^t$ *High Partial Credit* • Fully correct substitution **Note:** Apply F* for incorrect or no rounding

Q2	Model Solution – 30 Marks	Marking Notes
(a) **(i)** **(ii)**		**Scale 10D (0, 4, 6, 8, 10)** *Low Partial Credit* • Work of merit, for example shows knowledge of conjugate, **OR** plots one of z_2 **or** z_3 • Writes $\bar{z}_1$ only but nothing plotted *Mid Partial Credit* • Plots $\bar{z}_1$ • Writes $\bar{z}_1$ but doesn't plot **and** plots one of z_2 or z_3 • Plots z_2 **and** z_3 but doesn't deal with $\bar{z}_1$ *High Partial Credit* • Plots $\bar{z}_1$ **and** one of z_2 or z_3 **Note**: Award F* if plots all three points correctly but no or incorrect labels
		
(a) **(iii)**	$4(5+i)-5(6-2i)$ $20+4i-30+10i$ $=-10+14i$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit* • Work of merit, for example , correctly substitutes z_2 or z_3 or does distribution on one of z_2 or z_3 without showing the substitution *High Partial Credit* • Full substitution and distribution

Q2	Model Solution – 30 Marks	Marking Notes
(a) (iv)	$\sqrt{6^2+(-2)^2} = \sqrt{40}\ or\ 2\sqrt{10}$	**Scale 5C (0, 3, 4, 5)** *Low Partial Credit* • Writes 6^2 or $(-2)^2$ • Writes $\sqrt{a^2+b^2}$ *High Partial Credit* • $\sqrt{6^2+(-2)^2}$ **Note:** Accept correct answer without supporting work for full credit **Note**: Full Credit -1 : $6 \cdot 3$ without work
(b)	Ans: z_5 Reason: It is the furthest point from the origin	**Scale 5B (0, 3, 5)** *Partial Credit* • Correct box ticked • Shows knowledge of meaning of modulus • Joined to origin on diagram • Correctly explains the meaning of modulus but ticks the wrong box **Note**: Accept z_5 ticked and "furthest" for full credit

Q3	Model Solution – 30 Marks	Marking Notes
(a)	$6x + 12 - 5 = 3$ $x = \frac{-4}{6}$ or $\frac{-2}{3}$	**Scale 15C (0, 6, 10, 15)** **Steps** 1. Distribution of 3 2. Transposing done 3. Solves *Low Partial Credit* • Work of merit for example one correct operation *High Partial Credit* • Two steps correct
(b) **(i)** **(ii)** **(iii)**		**Scale 5D (0, 2, 3, 4, 5)** *Low Partial Credit* • Work of merit, for example, shows knowledge of $\mathbb{R}$, $\mathbb{Z}$, or $\mathbb{N}$. *Mid Partial Credit* • One of the three inequalities graphed correctly • Work of merit in 2 or 3 inequalities *High Partial Credit* • Two of the inequalities graphed correctly **Note**: Accept 0 in (iii) **Note:** Apply a * the first time $\geq$ is used instead of $\leq$; accept it thereafter



Q3	Model Solution – 30 Marks	Marking Notes
(c)	$$4x - 4y = -4$$ $$2x + 4y = 19$$ $$\Rightarrow\ 6x = 15 \quad \Rightarrow x = \frac{15}{6} = \frac{5}{2}$$ $$\frac{5}{2} + 1 = y$$ $$y = \frac{7}{2}$$	**Scale 10D (0, 4, 6, 8, 10)** **Four steps involved in solution.** **1.** Multiplies equation(s) so that 1 variable will cancel / express one variable in terms of the other **2.** Produce one equation in one variable **3.** Find value of one variable **4.** Find value of second variable **Note:** depending on method, step 3 may be automatically done when step 2 is completed. *Low Partial Credit* • Some work of merit, for example, relevant work in isolating one variable in one equation, or indicates multiplying one equation by a constant *Mid Partial Credit* • Two steps correct *High Partial Credit* • Three steps correct

Q4	Model Solution – 30 Marks	Marking Notes
(a) (i) (ii) (iii)	(i) $g(1 \cdot 5) = 2$ (ii) $x = -2 \cdot 8$ (iii) One root box ticked. Reason: Only cuts x-axis once.	**Scale 10D (0, 4, 6, 8, 10)** Four items: 1. (i) 2. (ii) 3. Correct box ticked 4. Reason *Low Partial Credit* • One item correct • Work of merit on the diagram *Mid Partial Credit* • Two items correct *High Partial Credit* • Three items correct **Note**: Apply F* if fully correct but no work on graph or incorrect work on graph **Note**: Tolerance in (ii) $-3 < x < -2 \cdot 5$
(a) (iv)	$Max\ (-1 \cdot 6, -1)$ $Min\ (0 \cdot 25, -3 \cdot 1)$	**Scale 5B (0, 3, 5)** *Partial Credit* • Work of merit, for example, indicated on diagram **Note**: Tolerance: **Max;** $-1 \cdot 9 \leq x \leq -1 \cdot 3$, $-1 \cdot 1 \leq y \leq -0 \cdot 9$ **Min;** $0 < x < 0 \cdot 5$, $-3 \cdot 5 \leq y < -3$

Q4	Model Solution – 30 Marks	Marking Notes
(b) (i)	$h'(x) = 3x^2 + 4x - 1$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit* • Work of merit, for example writes dy/dx • One term differentiated correctly *High Partial Credit* • Two terms differentiated correctly
(b) (ii)	$h'(2) = 12 + 8 - 1 = 19$ $y - 6 = 19(x - 2)$ or $19x - y - 32 = 0$	**Scale 5C (0, 3, 4, 5)** *Low Partial Credit* • Writes answer of part (i) in answer box of (ii) • Writes $y - y_1 = m(x - x_1)$ or $y = mx + c$ *High Partial Credit* • Evaluates slope using answer of part (i) and some work on equation of line formula

Q5	Model Solution – 30 Marks	Marking Notes
(a) (i)	$\frac{12\,000}{240} \times 320 = €16\,000$	**Scale 10B (0, 7, 10)** *Partial Credit* • Work of merit, for example 80 metres or 1/3 or 50, etc **Note:** Accept correct answer without supporting work for full credit
(a) (ii)	$6 \times 8 = 48$ $\frac{48}{4} = 12$ days	**Scale 5C (0, 3, 4, 5)** *Low Partial Credit* • Work of merit, for example $\frac{6+8}{4}$, 6×8, divides by 4 *High Partial Credit* • Finds 48 • $\frac{6+8}{4} = \frac{14}{4}$ days (or $\frac{6+8}{4} = 3\frac{1}{2}$ days) **Note:** Accept correct answer without supporting work for full credit
(b) (i)	$\frac{120}{180}$ *or* $\frac{2}{3}$ [of an hour]	**Scale 10B (0, 7, 10)** *Partial Credit* • $\text{Time} = \frac{\text{Distance}}{\text{Speed}}$ **Note**: Full Credit -1 : 40 minutes **OR** $0 \cdot 67$ **Note:** Accept correct answer without supporting work.

Q5	Model Solution – 30 Marks	Marking Notes
(b) (ii)	$T_1 = \frac{2}{3}$ $T_2 = \frac{120}{220} = \frac{6}{11}$ $\frac{2(120)}{{}^{2}/_{3} + {}^{6}/_{11}} = 198$	**Scale 5D (0, 2, 3, 4, 5)** **4 Steps in solution:** 1. T1 2. T2 3. Sets up equation 4. Finishes correctly *Low Partial Credit* • Work of merit, for example, $\text{Time} = \frac{\text{Distance}}{\text{Speed}}$, **OR** $2(120)$ **OR** writes answer from part (i) into answer box of (ii) *Mid Partial Credit* • Two parts correct *High Partial Credit* • Three parts correct

Q6	Model Solution – 30 Marks	Marking Notes
(a) (i)	$(-5)^2 + 8(-5) - 6 = 25 - 40 - 6$ $= -21$	**Scale 5B (0, 3, 5)** *Partial Credit* • Some correct substitution **Note:** Accept correct answer without supporting work for full credit
(a) (ii)	$2x + 8 = 0$ $x = -4$	**Scale 5B (0, 3, 5)** *Partial Credit* • Work of merit, for example writes dy/dx **Note:** Zero marks for solving $x^2 + 8x - 6 = 0$
(b)	$4x^2 - 8x - 8x + 16 - 6$ $4x^2 - 16x + 10$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit* • One term correct in expansion of $(2x - 4)^2$ • Writes $(2x - 4)\ (2x - 4)$ • Ignores twice the product and just writes $4x^2 \mp 16$ for the squaring *High Partial Credit* • Writes $4x^2 - 8x - 8x + 16$

Q6	Model Solution – 30 Marks	Marking Notes
(c)	$$x = \frac{-6 \mp \sqrt{6^2 - 4(9)(-5)}}{18}$$ $$x = 0 \cdot 483 \quad and \quad x = -1 \cdot 149$$ $$x = 0 \cdot 48 \quad and \quad x = -1 \cdot 15$$	**Scale 10C (0, 4, 6, 10)** **Three steps involved in solution:** **1.** Identifies **a, b,** and **c** **2.** Fully substituted formula **3.** Both **c**orrectly evaluated *Low Partial Credit* • Minus b formula written • Work of merit, for example identifies one of **a**, **b** or **c** *High Partial Credit* • Two steps correct • Formula fully correctly substituted • Second value not found **Note:** Apply F* if incorrect or no rounding, once only

Q7	Model Solution – 50 Marks	Marking Notes
(a) (i)	$$\frac{1000}{15+10}=40$$	**Scale 10B (0, 7, 10)** *Partial Credit* • Work of merit, for example substitutes in the 15 to the given formula or writes $15+10$ **Note:** Apply F* for $\frac{1000}{25}$ **Note:** Accept correct answer without supporting work for full credit
(a) (ii)	Answer: C decreases Reason: Because the denominator is getting bigger relative to the numerator.	**Scale 5B (0, 3, 5)** *Partial Credit* • Work of merit, for example answer correct (i.e. decreases) or indicates denominator gets bigger
(a) (iii)	$$C(S+10)=1000$$ $$CS+10C=1000$$ $$CS=1000-10C$$ $$S=\frac{1000-10C}{C}$$ Or $$S=\frac{1000}{C}-10$$	**Scale 5C (0, 3, 4, 5)** *Low Partial Credit* • One term correct when multiplying across by $(S+10)$ • Writes $C(S+10)$ *High Partial Credit* • $CS=1000-10C$ **Note:** $S=\frac{1000}{C+10}$ without work is zero marks

Q7	Model Solution – 50 Marks	Marking Notes
(a) (iv)	$S = \frac{1000 - 10(30)}{30} = 23 \cdot 33 \ldots$ $S = \frac{1000 - 10(100)}{30} = 0$ S goes from 0 to $23 \cdot 3$...	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit* • Carries answer from part (iii) down • Some correct substitution into $C = \frac{1000}{S + 10}$ *High Partial Credit* • Both formulas fully correctly substituted • One value correct **Note:** Award F* if both numbers are calculated correctly but no range indicated **Note:** Accept correct answers, 0 and 23 , without supporting work
(b) (i)	$P(0) = 0 \cdot 3$ $P(24) = 0 \cdot 3 + 0 \cdot 02(24) = 0 \cdot 78$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit* • Some correct substitution *High Partial Credit* • One value correct • Both formulas fully substituted **Note:** Accept correct answers without supporting work for full credit
(b) (ii)	$P'(t) = 0 \cdot 02$ This means that the probability that it is raining in Waterville is **increasing** at a rate of 2 % every hour.	**Scale 5B (0, 3, 5)** *Partial Credit* • Work of merit in either $P'(t)$ or in explaining the meaning • Writes dy/dx
(b) (iii)	$0 \cdot 35 + 0 \cdot 02 = 0 \cdot 37$ OR $0 \cdot 3 + 0 \cdot 02t = 0 \cdot 35$ $=> t = 2 \cdot 5$ 1 hour later $t = 3 \cdot 5$ $=> 0 \cdot 3 + 0 \cdot 02(3 \cdot 5) = 0 \cdot 37$	**Scale 5B (0, 3, 5)** *Partial Credit* • Work of merit, for example indicates the probability will be higher

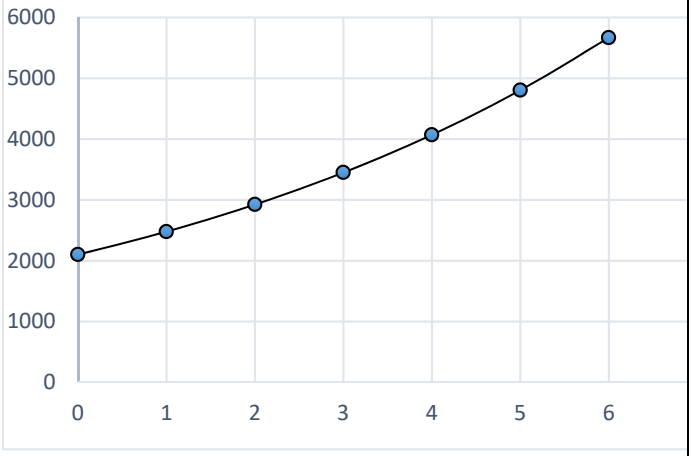
Q8	Model Solution – 50 Marks	Marking Notes
(a)	$50 \times 30 = 1500$ m²	**Scale 10B (0, 7, 10)** *Partial Credit* • Work of merit, for example writes area is length multiplied by breadth, or $50 \times$ something **Note:** Accept correct answer without supporting work for full credit **Note:** Apply F* if no units or incorrect units
(b)	$A = \frac{3}{2}[0 + 2 + 2(10 + 14 + 12 + 10 + 8)]$ $= 165$ m²	**Scale 5C (0, 3, 4, 5))** *Low Partial Credit* • Trapezoidal Rule written • Work of merit on the diagram *High Partial Credit* • Full correct substitution **Note:** Apply F* if no units or incorrect units
(c)	Make more divisions **Or** Measure more accurately	**Scale 5B (0, 3, 5)** *Partial Credit* • Work of merit, for example consistent extra vertical lines drawn on diagram
(d)	$1500 - 172 = 1328$ $1328 \times 2 \cdot 55 = 3386 \cdot 4$ $\approx €3390$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit* • $1500 - 172$ or 1328 written *High Partial Credit* • $1328 \times 2 \cdot 55$ **Note:** Apply F* if 165 used and finished out **Note:** Apply F* if incorrect or no rounding

Q8	Model Solution – 50 Marks	Marking Notes
(e)	$\frac{840}{116 \cdot 9} \times 100 = 718 \cdot 5628743$ $= £718 \cdot 56$ [nearest penny]	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit* • Writes $116 \cdot 9\%$ or $100 + 16 \cdot 9$ or $1 \cdot 169$ *High Partial Credit* • $\frac{840}{116 \cdot 9} \times 100$ or $\frac{840}{1 \cdot 169}$ **Note:** Apply F* if incorrect or no rounding
(f)	$\frac{840}{0 \cdot 8547} \times 1 \cdot 025 = 1007 \cdot 371007$ $€1007 \cdot 37$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit* • Work of merit in either the exchange rate calculation or the commission calculation • Writes 21 or 861 • Writes 982.80 with or without work • $\frac{840}{0 \cdot 8547}$ *High Partial Credit* • $\frac{840}{0 \cdot 8547} \times 1 \cdot 025$ **Note:** Apply F* if incorrect or no rounding

Q9	Model Solution – 50 Marks	Marking Notes
(a) (i)	1500	**Scale 10B (0, 7, 10)** *Partial Credit* • Work of merit, for example work on diagram **Note:** Tolerance: $1300 \leq x \leq 1700$
(a) (ii)	$\frac{500}{1500} \times 100 = 33 \cdot 33 \ldots$ $= 33\%$	**Scale 5B (0, 3, 5)** *Partial Credit* • Work of merit, for example answer from part (i) brought down **Note:** Apply F* if incorrect or no Rounding **Note:** Accept correct answer without supporting work
(a) (iii)	Day 15 is 1500 Day 20 is 3000	**Scale 5B (0,3,5)** *Partial Credit* • Work of merit, for example values of some days written
(a) (iv)	Day15 1500 Day 20 3000 Day 25 6000 Day 30 12000 Day 35 24000 Day 40 48 000 Day 45 96 000 Day 46 >100,000	**Scale 5C (0, 3, 4, 5)** *Low Partial Credit* • Some iteration of 5 days causing doubling • Any given day written with approx. value from graph, for example Day 5 = 400 *High Partial Credit* • Doubling the cases more than once or reaching Day 45 **Note:** Any day on the graph is a valid starting point **Note:** Where $D(k) < 100000$ and $D(k+5) > 100000$, accept any $k+1$ to $k+4$ as the solution

t	0	1	2	3	4	5	6
$C(t)$	**2100**	**2478**	2924	**3450**	**4071**	**4804**	5669

(b) (i) (ii)



Scale 20D (0, 7, 10, 15, 20)

Note: Solution requires 13 elements, 5 values in table, 7 plots and an appropriate curve

Low Partial Credit
- 1 to 4 elements correct

Mid Partial Credit
- 5 to 9 elements correct

High Partial Credit
- 10 or 11 elements correct

Note: Award F* if 12 elements correct from the required 13

(b) (iii)

$$21\,309 = a \times 0 \cdot 83^{14}$$

$$a = \frac{21\,309}{0 \cdot 83^{14}} = 289380 \cdot 8421$$

$$2 \cdot 89 \times 10^5$$

Scale 5C (0, 3, 4, 5)

Low Partial Credit
- Some correct substitution into $21\,309 = a \times 0 \cdot 83^{14}$

High Partial Credit
- $a = \frac{21\,309}{0 \cdot 83^{14}}$

Note: Early rounding of $0 \cdot 83^{14}$ to $0 \cdot 07$ or $0 \cdot 1$ is to be treated as an * (-1) and no further * applies if finishes to $3 \cdot 04$ or $2 \cdot 13$ in final step.

Note: Apply F* if incorrect or no rounding in final step

Q10	Model Solution – 50 Marks	Marking Notes
(a)(i)	$V = \pi \times 9^2 \times 5 = 1272 \cdot 345$ $= 1272$ [nearest mm^3]	**Scale 5B (0, 3, 5)** *Partial Credit* • Work of merit, for example cylinder formula or some correct substitution without formula • Writes r = 9 **Note:** Award F* for answer of $405\,\pi$ with or without work **Note:** Accept correct answer without supporting work **Note:** Apply F* if incorrect or no rounding
(a) (ii)	$\pi \times 9^2 \times 5 - \pi \times 7^2 \times 5$ $= 502 \cdot 6548246$ $= 503$ [nearest mm^3] OR $1272 - \pi \times 7^2 \times 5$ $= 502.30979 \ldots$ $= 502$ [nearest mm^3]	**Scale 5C (0, 3, 4, 5)** *Low Partial Credit* • Work of merit for example, Answer carried down from part (i) • Writes cylinder formula • Writes r = 7 or r = 9 or 245 or 245π *High Partial Credit* • $\pi \times 9^2 \times 5 - \pi \times 7^2 \times 5$ (or similar) **Note:** Apply F* if incorrect or no rounding or 160π with work
(b) (i) (ii)	$\frac{3}{8} \times 100 = 37 \cdot 5\ \%$ $\frac{15}{20} \times 25 = 18 \cdot 75$	**Scale 10D (0, 4, 6, 8, 10)** **Note:** Accept correct answers without supporting work *Low Partial Credit* • Work of merit in (i) **or** (ii) *Mid Partial Credit* • Work of merit in (i) **and** (ii) • One part correct *High Partial Credit* • One part correct and work of merit in the other

Q10	Model Solution – 50 Marks	Marking Notes
(b) (iii)	$7500: 2225: 275$ $300: 89: 11$	**Scale 5C (0, 3, 4, 5)** *Low Partial Credit* • Work of merit for example, ratios set up (even with the % symbols in) *High Partial Credit* • $7500: 2225: 275$ • Any 3 natural numbers in the correct ratio, but not simplified
(c) (i)	$1000 \times 0 \cdot 01 + (800 \times 0 \cdot 02)$ $= €26$	**Scale 5C (0, 3, 4, 5)** *Low Partial Credit* • Work of merit, for example writes €10 or €16 or $\cdot 01$ or $\cdot 02$ • Writes 800 *High Partial Credit* • $1000 \times 0 \cdot 01 + (800 \times 0 \cdot 02)$
(c) (ii)	$142 \cdot 8 - 10 = 132 \cdot 8$ $132 \cdot 8 = 2\%$ $100\% = 6640$ $6640 + 1000 = 7640$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit* • Work of merit, for example writes €10 or $132 \cdot 8$ or $\cdot 01$ or $\cdot 02$ *High Partial Credit* • Writes 6640
(c) (iii)	$1000\ at\ 1\% = €10$ next $9000\ at\ 2\% = €180$ $10 + 180 = €190$ $435 - 190 = €245$ the charge in excess of 10 000 $\frac{245}{7500} \times 100 = 3 \cdot 2666$ $3 \cdot 3\%$	**Scale 10D (0, 4, 6, 8, 10)** *Low Partial Credit* • Work of merit, for example, writes €10 or $€180$ or $\cdot 01$ or $\cdot 02$ • 7500 written *Mid Partial Credit* • Finds $€190$ (with work) *High Partial Credit* • Finds $€245$ **Note:** Apply F* if incorrect or no rounding

Leaving Certificate 2023

Mathematics

Marking Scheme

Ordinary Level

Paper 2

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 scale		0, 3, 5	0, 3, 4, 5	0, 2, 3, 4, 5
10-mark scale			0, 4, 6, 10	0, 4, 6, 8, 10
15-mark scale			0, 5, 10, 15	0, 5, 8, 12, 15

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

B-scales (three categories)

- response of no substantial merit (no credit)
- partially correct response (partial credit)
- correct response (full credit)

C-scales (four categories)

- response of no substantial merit (no credit)
- response with some merit (low partial credit)
- almost correct response (high partial credit)
- correct response (full credit)

D-scales (five categories)

- response of no substantial merit (no credit)
- response with some merit (low partial credit)
- response about half-right (mid partial credit)
- almost correct response (high partial credit)
- correct response (full credit)

In certain cases, typically involving incorrect rounding, omission of units, a misreading that does not oversimplify the work, or an arithmetical error that does not oversimplify the work, a mark that is one mark below the full-credit mark may also be awarded. Such cases are denoted with a * and this level of credit is referred to as *Full Credit -1*. Thus, for example, in Scale 10C, *Full Credit -1* of 9 marks may be awarded.

The only marks that may be awarded for a question are those on the scale above, or *Full Credit -1*.

A rounding penalty is applied each time it occurs in the scheme. There is no penalty for omitted units if the question specifies the unit to be used in the answer, and there is generally no penalty for an omitted euro symbol in questions involving money.

Throughout the scheme a correct relevant formula written is regarded as Work of merit, award the lowest non-zero level of credit (typically *Partial Credit* or *Low Partial Credit*, as appropriate).

In general, accept a candidate's work in one part of a question for use in subsequent parts of the question, unless this oversimplifies the work involved.

Unless otherwise specified, an answer without sufficient supporting work is generally awarded the lowest non-zero level of credit (typically *Partial Credit* or *Low Partial Credit*, as appropriate).

Summary of mark allocations and scales to be applied

<table>
<tr><th colspan="2">Section A (150)
Answer any five questions</th><th colspan="2">Section B (150)
Answer any three questions</th></tr>
<tr>
<td>
Question 1 (30)
(a)(i) 10C
(a)(ii) 10C
(b) 5C
(c)(i)(ii) 5D

Question 2 (30)
(a)(i)(ii) 10D
(a)(iii) 5C
(b) 15D

Question 3 (30)
(a)(i) 5C
(a)(ii) 10C
(a)(iii) 5B
(b)(i)(ii) 10D
</td>
<td>
Question 4 (30)
(a)(i) 5C
(a)(ii) 10C
(a)(iii) 5B
(b) 10C

Question 5 (30)
(a)(b) 10D
(c) 5C
(d) 5C
(e) 10C

Question 6 (30)
(a) 15D
(b) 5C
(c) 10C
</td>
<td>
Question 7 (50)
(a)(i) 10C
(a)(ii) 10C
(a)(iii) 10C
(a)(iv) 10C
(b) 5C
(c) 5C

Question 8 (50)
(a) 10C
(b)(i) 10C
(b)(ii) 10C
(c)(i) 5C
(c)(ii) 5C
(c)(iii) 10D
</td>
<td>
Question 9 (50)
(a)(i)(iii) 10C
(a)(ii) 5C
(a)(iv) 15C
(b)(i) 10C
(b)(ii) 5C
(b)(iii) 5D

Question 10 (50)
(a) 10C
(b) 10C
(c)(i) 10C
(c)(ii) 5C
(c)(iii) 5C
(d) 10C
</td>
</tr>
</table>

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			The work presented in the body of the script merits partial credit
L			The work presented in the body of the script merits low partial credit
M			The work presented in the body of the script merits mid partial credit
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 the page)	
o	Oversimplify	The candidate has oversimplified the work	
wom	Work of Merit	There is some value in the work	

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** 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.

A ✔ in the body of the work may sometimes be used to indicate where a portion of the work presented has value and has merited one of the levels of credit described in the marking scheme. The level of credit is then indicated in the right margin.

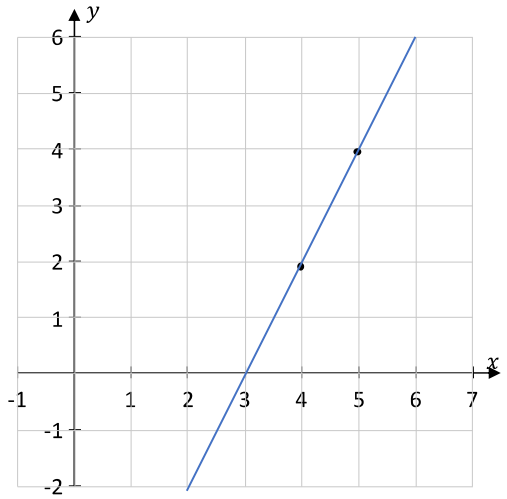
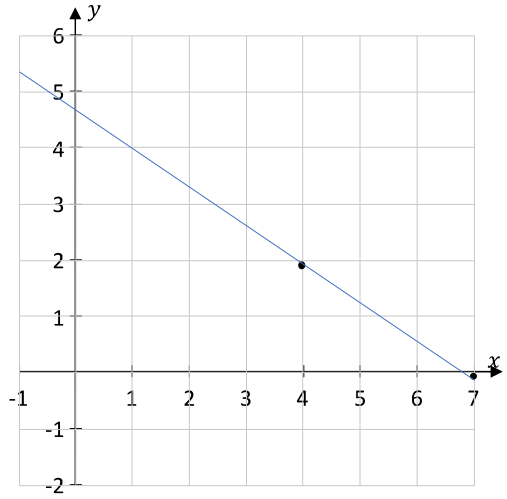
Detailed marking notes

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) (i)	Slope of A(4,2) to B(1,8) $= \frac{y_2 - y_1}{x_2 - x_1}$ $= \frac{8-2}{1-4}$ $= -2$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit:* • Work of merit *High Partial Credit:* • Correct formula fully substituted • Error(s) in substitution but finishes correctly *Full Credit:* • Correct answer without supporting work
(a) (ii)	Distance of (4,2) to (1,8) $= \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$ $= \sqrt{(1-4)^2 + (8-2)^2}$ $= \sqrt{(-3)^2 + (6)^2}$ $= \sqrt{9 + 36}$ $= \sqrt{45}$ or $3\sqrt{5}$ or $(6 \cdot 7\ldots)$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit:* • Work of merit *High Partial Credit:* • Correct formula fully substituted • Error(s) in substitution but finishes correctly *Full Credit:* • Correct answer without supporting work

Q1	Model Solution – 30 Marks	Marking Notes
(b)	$$y - y_1 = m(x - x_1)$$ $$y - 7 = \frac{1}{3}[x - (-2)]$$ $$3(y - 7) = 1(x + 2)$$ $$3y - 21 = x + 2$$ $$x - 3y + 23 = 0$$	**Scale 5C (0, 3, 4, 5)** *Low Partial Credit:* • Work of merit *High Partial Credit:* • Correct formula fully substituted • One error in substitution but finishes correctly • Answer not in required format *Full Credit (-1):* • $x - 3y + 23$

Q1	Model Solution – 30 Marks	Marking Notes
(c) (i) & (ii)	 	**Scale 5D (0, 2, 3, 4, 5)** *Low Partial Credit:* • Work of merit in (i) **or** (ii) • In(c)(i) line drawn with slope -2 **or** In(c)(ii) line drawn with slope $\frac{2}{3}$ *Mid Partial Credit:* • Work of merit in (i) **and** (ii) • One part correct *High Partial Credit:* • One part correct and work of merit in the other • In(c)(i) line drawn with slope -2 **and** In(c)(ii) line drawn with slope $\frac{2}{3}$ **Note**: Accept correct line segments outside the Range and Domain for Full Credit

Q2	Model Solution – 30 Marks	Marking Notes
(a) (i) **& (ii)**	**(i)** Centre $= (0\,, 0)$ Radius $= 5$ **(ii)** $(3)^2 + (-4)^2 = 25$ $9 + 16 = 25$ $\Longrightarrow$ On the circle **or** Distance from $(0,0)$ to $(3,-4)$ $\sqrt{(3-0)^2 + (-4-0)^2} = 5$ $=$ radius $\Longrightarrow$ on circle	**Scale 10D (0, 4, 6, 8, 10)** *Low Partial Credit:* • Work of merit in (i) **or** (ii) *Mid Partial Credit:* • Work of merit in (i) **and** (ii) • One part correct *High Partial Credit:* • One part correct and work of merit in the other *Full Credit (-1):* • No conclusion in (ii)
(a) (iii)	Any two points on the circle given e.g. $(3,4), (-3,4), (0,5), (5,0)$ etc.	**Scale 5C (0, 3, 4, 5)** *Low Partial Credit:* • Work of merit e.g. Some substitution into equation of *s* *High Partial Credit:* • One correct point given *Full Credit :* • Correct answer without supporting work *Full Credit(-1):* • Answers not given as a pair of coordinates

Q2	Model Solution – 30 Marks	Marking Notes
(b)	$y = 5x - 13$ $x^2 + (5x - 13)^2 = 13$ $x^2 + 25x^2 - 130x + 169 - 13 = 0$ $26x^2 - 130x + 156 = 0$ $x^2 - 5x + 6 = 0$ $(x - 2)(x - 3) = 0$ Thus $x = 2$ and $x = 3$ giving $y = -3$ and $y = 2$ [Hence Pts $(3, 2)$ and $(2, -3)$] **or** Trial and Error Method where both points are tested in both equations	**Scale 15D (0, 5, 8, 12, 15)** **Four steps involved in solution.** **1.** Express one variable in terms of the other **2.** Substitutes into the quadratic **3.** Find values of one variable **4.** Find values of second variable *Low Partial Credit:* • Some work of merit e.g. Work in isolating one variable e.g. One point tested in one equation *Mid Partial Credit:* • Two steps correct e.g. One point tested in both equations **or** e.g. Two points tested in one equation *High Partial Credit:* • Three steps correct e.g. One point tested in both equations **and** Other point tested in one equation only

3	Model Solution – 30 Marks	Marking Notes
(a) (i)	$7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1 = 5040$ ways **or** $7\,! = 5040$	**Scale 5C (0, 3, 4, 5)** *Low Partial Credit:* • Work of merit e.g. Some correct terms multiplied *High Partial Credit:* • All terms listed but not multiplied • One error in substitution but finishes correctly *Full Credit:* • Correct answer without supporting work
(a) (ii)	$1 \times 5 \times 4 \times 3 \times 2 \times 1 \times 4 = 480$ ways **or** $5! \times 4 = 480$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit:* • Work of merit e.g. Indicates $\times\, 4$ for vowels *High Partial Credit:* • Terms listed but not multiplied • One error in substitution but finishes correctly *Full Credit:* • Correct answer without supporting work
(a) (iii)	$\binom{7}{P}_{3} = 210$ **or** $(7)(6)(5) = 210$	**Scale 5B (0, 3, 5)** *Partial Credit:* • Work of merit e.g. 7 or 6 or 5 identified • Lists at least one 3 letter arrangement *Full Credit:* • Correct answer without supporting work

<table>
<tr><th>3</th><th>Model Solution – 30 Marks</th><th>Marking Notes</th></tr>
<tr><td></td><td>
<table>
<tr><td>Correlation coefficient</td><td>$0{\cdot}95$</td><td>$0{\cdot}6$</td><td>$-0{\cdot}95$</td></tr>
<tr><td>Scatterplot (A, B, or C)</td><td>B</td><td>C</td><td>A</td></tr>
</table>
</td><td></td></tr>
<tr><td>(b)
(i)
&
(ii)</td><td>(i) Table above

(ii) Strong positive linear correlation so as x goes up y goes up.

<u>or</u>

(ii) Points all lie close to a positive straight line</td><td>Scale 10D (0, 4, 6, 8, 10)

Low Partial Credit:
• Work of merit in (i) <u>or</u> (ii)
e.g. one correct correlation coefficient identified in (i)

Mid Partial Credit:
• Work of merit in (i) <u>and</u> (ii)
• One part correct

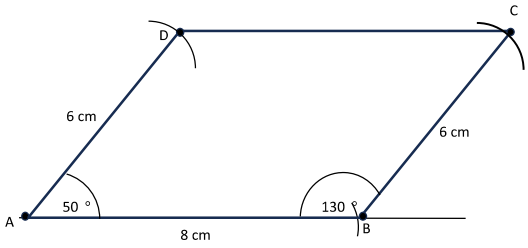
High Partial Credit:
• One part correct and work of merit in the other</td></tr>
</table>

4	Model Solution – 30 Marks	Marking Notes
(a) (i)	$S.S.S = (0\cdot 7)(0\cdot 7)(0\cdot 7)$ $= 0\cdot 343$ or $\frac{343}{1000}$ or $34\cdot 3\%$	**Scale 5C (0, 3, 4, 5)** *Low Partial Credit:* • Work of merit e.g. $0\cdot 7$ or $\frac{7}{10}$ written *High Partial Credit:* • Correct layout with full substitution e.g. $0\cdot 7^3$ or $\left(\frac{7}{10}\right)^3$ *Full Credit:* • Correct answers without supporting work *Zero Credit:* • Probability greater than 1
(a) (ii)	$S.S.F = (0\cdot 7)(0\cdot 7)(0\cdot 3)$ $= 0\cdot 147$ Three arrangements $0\cdot 147\times 3 = 0\cdot 441\left(\frac{441}{1000}\right)$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit:* • Work of merit e.g. indicates three arrangements *High Partial Credit:* • Correct layout with correct substitution • Answer as $0\cdot 147$ or $\frac{147}{1000}$ *Full Credit:* • Correct answers without supporting work *Zero Credit:* Probability greater than 1
(a) (iii)	Previous performance levels may affect future performance.	**Scale 5B (0, 3, 5)** *Partial Credit:* • Work of merit e.g. Partial explanation

4	Model Solution – 30 Marks	Marking Notes
(b)	$\mu = \frac{\sum fx}{\sum f}$ $= \frac{4(0)+5(6)+4(8)+2(10)+3(12)+1(16)}{4+5+4+2+3+1}$ $= \frac{0+30+32+20+36+16}{19}$ $= \frac{134}{19} = 7 \cdot 05263$ $= 7 \cdot 05$ points scored	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit:* • Work of merit e.g. Some addition of numerator or denominator terms • 134 and/or 19 without work *High Partial Credit:* • Correct formula fully substituted • One error and finishes correctly *Full Credit (-1):* • Incorrect rounding *Full Credit:* • Correct answer without supporting work

5	Model Solution – 30 Marks	Marking Notes
(a) & (b)	**(a)** 6 cm **(b)** $\text{Area} = \pi r^2$ $= \pi(6)^2$ $= 36\pi$ $= 113 \cdot 097$ $= 113 \cdot 10 \text{ cm}^2$	**Scale 10D (0, 4, 6, 8, 10)** *Low Partial Credit:* • Work of merit in either (a) **or** (b) e.g. work on diagram for (a) *Mid Partial Credit:* • One part correct *High Partial Credit:* • One part correct and work of merit in the other part *Full Credit (-1):* • Incorrect rounding • Incorrect or omitted units • Leaves answer in terms of π *Full Credit:* • Correct answers without supporting work
(c)	$\frac{\text{Area circle}}{\text{Area square}} = \frac{113 \cdot 10}{12 \times 12}$ $= 0 \cdot 7854 \times 100$ $= 78 \cdot 54[\%]$ $= 79[\%]$	**Scale 5C (0, 3, 4, 5)** *Low Partial Credit:* • Work of merit e.g. Finds Area of square *High Partial Credit:* • $\frac{113 \cdot 10}{12 \times 12} \times 100$ or $0 \cdot 7854$ *Full Credit (-1):* • Incorrect rounding *Full Credit :* • Correct answer without supporting work

5	Model Solution – 30 Marks	Marking Notes
(d)	$x^2 = 12^2 + 12^2$ $x^2 = 288$ $x = \sqrt{288}$ $x = 16.9705$ $\text{Radius} = \frac{16 \cdot 9705}{2}$ $= 8 \cdot 4853$ $= 8 \cdot 49$ **or** $x^2 = 6^2 + 6^2$ $x^2 = 72$ $x = \sqrt{72}$ $x = 8 \cdot 4853$ $x = 8 \cdot 49$	**Scale 5C (0, 3, 4, 5)** *Low Partial Credit:* • Work of merit e.g. Pythagoras Theorem formula written as $c^2 = a^2 + b^2$ *High Partial Credit:* • $x = \frac{\sqrt{288}}{2}$ or $\sqrt{72}$ with work *Full Credit (-1):* • Incorrect rounding *Zero Credit:* • No correct substitution and no formula
(e)	$\text{Circumference} = 2\pi r$ $= 2\pi(8 \cdot 49)$ $= 53 \cdot 344$ $= 53 \cdot 34 \text{ cm}$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit:* • Work of merit *High Partial Credit:* • Correct formula fully substituted *Full Credit (-1):* • Incorrect rounding • Incorrect or omitted units *Full Credit :* • Correct answer without supporting work *Zero Credit:* • $53 \cdot 3$ without work

6	Model Solution – 30 Marks	Marking Notes
(a)		**Scale 15D (0, 5, 8, 12, 15)** *Low Partial Credit:* • Work of merit e.g. ONE correct element • Work on diagram *Mid Partial Credit:* • Any TWO elements correct towards constructing a parallelogram *High Partial Credit:* • THREE or more elements correct *Full Credit (-1):* • If $[AD]$ is on the horizontal and the construction is correct
(b)	$2x - 30 = 100$ $2x = 130$ $x = 65$ $x + 3y = 80$ $65 + 3y = 80$ $3y = 80 - 65$ $3y = 15$ $y = 5$	**Scale 5C (0, 3, 4, 5)** *Low Partial Credit:* • Work of merit e.g. sets up equation, indicates knowledge of opposite angles in a parallelogram being equal or adjacent angles summing to $180°$ • Work on diagram *High Partial Credit:* • Value of x found *Full Credit (-1):* • Answer without supporting work that gives $y = 65, \quad x = 5$ *Full Credit :* • Correct answers without supporting work

6	Model Solution – 30 Marks	Marking Notes
(c)	Statement ….. True **Justification*:*** Opposite sides are parallel and equal in length. **<u>or</u>** Any other valid reason	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit:* • Work of merit e.g. Correct box (True) ticked but no work of merit in Justification • Incorrect box (False) ticked but some correct knowledge of the properties of a parallelogram or square indicated *High Partial Credit:* • Correct box ticked and work of merit in Justification

Section B		
Q7	**Model Solution – 50 Marks**	**Marking Notes**
(a) (i)	$$\text{Gradient} = \frac{24}{135} \times 100$$ $$= 17 \cdot 7\ \%$$ $$= 18[\%]$$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit:* • Work of merit e.g. formula with some substitution *High Partial Credit:* • Correct formula fully substituted *Full Credit (-1):* • Incorrect rounding *Full Credit :* • Correct answer without supporting work
(a) (ii)	$$\frac{12}{100} = \frac{16}{x}$$ $$12x = 1600$$ $$x = \frac{1600}{12} = 133.33\ \text{m}$$ $$\lvert AC \rvert = 133\ [\text{m}]$$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit:* • Work of merit e.g. Gradient formula with some substitution *High Partial Credit:* • Correct formula fully substituted • |AC| isolated correctly • One error in substitution and finishes correctly *Full Credit (-1):* • Incorrect rounding *Full Credit :* • Correct answer without supporting work

Section B		
Q7	**Model Solution – 50 Marks**	**Marking Notes**
(a) (iii)	$x^2 + 27^2 = 105^2$ $x^2 + 729 = 11025$ $x^2 = 11025 - 729 = 10296$ $x = \sqrt{10296}$ $x = 101 \cdot 469$ $x = 101\ \text{m}$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit:* • Work of merit e.g. Correct relevant formula • Formula with some substitution *High Partial Credit:* • Correct formula fully substituted • Correct answer without supporting work • $x^2 = 11025 - 729$ • One error in substitution but finishes correctly *Full Credit (-1):* • Incorrect rounding • Incorrect or omitted units
(a) (iv)	$TanA = \frac{9}{100}$ $A = tan^{-1}\frac{9}{100}$ $A = 5 \cdot 1427$ $A = 5[^\circ]$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit:* • Work of merit *High Partial Credit:* • $A = Tan^{-1}\left(\frac{9}{100}\right)$ • Correct answer without supporting work *Full Credit (-1):* • Incorrect rounding **Note:** Incorrect Calculator Mode (Apply once in paper) $\text{Rad: } = 0 \cdot 08975$ $\text{Grad} = 5 \cdot 714$

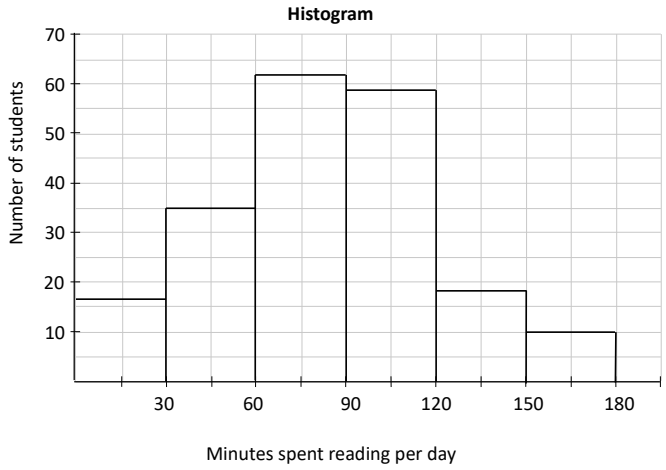
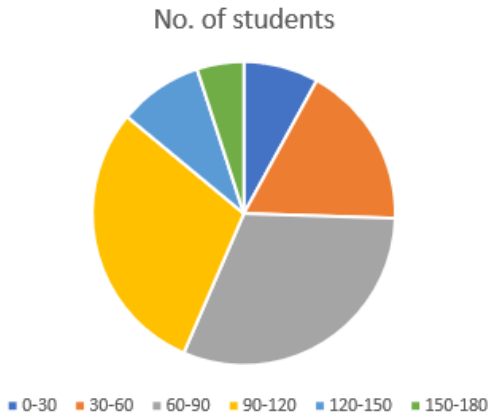
Section B		
Q7	**Model Solution – 50 Marks**	**Marking Notes**
(b)	$180 - [88 + 87] = 5$ $\frac{x}{\text{Sin } 87} = \frac{20}{\text{Sin } 5}$ $x = \frac{20 \text{ Sin } 87}{\text{Sin } 5}$ $x = 229 \cdot 15977 \text{ m}$ $\lvert OR \rvert = 229[\text{ m}]$	**Scale 5C (0, 3, 4, 5)** *Low Partial Credit:* • Work of merit e.g. Sine Rule written • Identifies 5^o *High Partial Credit:* • Correct formula fully substituted *Full Credit (-1):* • Incorrect rounding Rad: $= 17 \cdot 14$ Grad: $= 249 \cdot 61$
(c)	$550^2 = 700^2 + 800^2 - 2(700)(800)\text{Cos } X$ $\text{Cos } X = \frac{700^2 + 800^2 - 550^2}{2(700)(800)}$ $\text{Cos } X = \frac{490000 + 640000 - 302500}{2(700)(800)}$ $\cos X = \left(\frac{827500}{1120000}\right)$ $\angle X = \text{Cos}^{-1}\left(\frac{331}{448}\right)$ $\angle X = \text{Cos}^{-1} 0 \cdot 738839$ $\angle X = 42 \cdot 4^{[o]}$	**Scale 5C (0, 3, 4, 5)** *Low Partial Credit:* • Work of merit e.g. Some correct substitution into Cosine formula *High Partial Credit:* • Correct formula fully substituted *Full Credit (-1):* • Incorrect rounding Rad: $= 0 \cdot 73945$ Grad: $= 47 \cdot 07485$

Q8	Model Solution – 50 Marks	Marking Notes
(a)	$V = \pi r^2 h$ $V = \pi(1 \cdot 2)^2(0 \cdot 75)$ $= 3 \cdot 3929$ $= 3 \cdot 39[\mathrm{m}^3]$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit:* • Work of merit • Identifies *r* *High Partial Credit:* • Correct formula fully substituted • One error in substitution but finishes correctly *Full Credit (-1):* • Incorrect rounding • Leaves answer in terms of π
(b) **(i)**	$V = \mathrm{l} \times \mathrm{w} \times \mathrm{h}$ $= (0 \cdot 5)(0 \cdot 5)(0 \cdot 5)$ $= 0 \cdot 125 \times 3$ $= 0 \cdot 375\ [\mathrm{m}^3]$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit:* • Work of merit e.g. Length of One side of cube labelled correctly *High Partial Credit:* • Correct formula fully substituted
(b) **(ii)**	Volume of raised cylinder $= 0 \cdot 375$ $\pi r^2 h = 0 \cdot 375$ $\pi(1 \cdot 2)^2 h = 0 \cdot 375$ $h = \frac{0 \cdot 375}{\pi(1 \cdot 2)^2}$ $= 0 \cdot 0828$ $= 0 \cdot 08[\mathrm{m}]$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit:* • Work of merit e.g. Writes $0 \cdot 375$ • Identifies *r* *High Partial Credit:* • Correct formula fully substituted *Full Credit (-1):* • Incorrect rounding

Q8	Model Solution – 50 Marks	Marking Notes
(c) (i)	$l^2 = 0 \cdot 8^2 + 1 \cdot 3^2$ $l^2 = 2 \cdot 33$ $l = \sqrt{2 \cdot 33}$ $l = 1.5264 \ldots$ $l = 1.53\ [\mathrm{m}]$	**Scale 5C (0, 3, 4, 5)** *Low Partial Credit:* • Work of merit e.g. Identifies right angled triangle in diagram or correct relevant formula *High Partial Credit:* • Correct formula fully substituted • One error in substitution and finishes correctly *Full Credit (-1):* • Incorrect rounding
(c) (ii)	$C.S.A. = \pi rl$ $= \pi(1 \cdot 3)(1 \cdot 53)$ $= 6 \cdot 2486$ $= 6 \cdot 25\ \mathrm{m}^2$	**Scale 5C (0, 3, 4, 5)** *Low Partial Credit:* • Work of merit e.g. Identifies r *or* l *High Partial Credit:* • Correct formula fully substituted *Full Credit :* • Correct answer without supporting work *Full Credit (-1):* • Incorrect rounding • Incorrect or omitted units

Q8	Model Solution – 50 Marks	Marking Notes
(c) (iii)	$x = 1 \cdot 53$ m Area of Sector $=$ C.S.A. of Cone $\frac{\angle A}{360} \times \pi r^2 = 6 \cdot 25$ $\angle A = \frac{6 \cdot 25(360)}{\pi(1 \cdot 53)^2}$ $\angle A = 305 \cdot 949 \ldots$ $\angle A = 306^{[o]}$ **or** $x = 1 \cdot 53$ m Length of Sector $=$Length of Circular Base $\frac{\angle A}{360} \times 2\pi(1 \cdot 53) = 2\pi(1 \cdot 3)$ $\angle A = \frac{8 \cdot 168(360)}{2\pi(1 \cdot 53)}$ $\angle A = 305 \cdot 88.$ $\angle A = 306^{[o]}$ **or** $x = 1 \cdot 53$ m $\frac{2\pi r}{2\pi l} = \frac{\angle A}{360}$ $\frac{2\pi(1 \cdot 3)}{2\pi(1 \cdot 53)} = \frac{\angle A}{360}$ $\frac{1 \cdot 3}{1 \cdot 53} = \frac{\angle A}{360}$ $\angle A = \frac{1 \cdot 3(360)}{1 \cdot 53}$ $\angle A = 306^{[o]}$	**Scale 10D (0, 4, 6, 8, 10)** *Low Partial Credit:* • Work of merit e.g. Identifies *r* Use of Ans (c)(i) **or** (c)(ii) *Mid Partial Credit:* • Correct x value *High Partial Credit:* • Correct formula fully substituted • One error in substitution but finishes correctly *Full Credit (-1):* • Incorrect rounding

Q9	Model Solution – 50 Marks	Marking Notes
(a) (i) & (iii)	**(i)** Answer: $59 + 18 + 10 = 87$ **(iii)** Might be local students getting there first or students arriving together by school buses **or** Might not be representative **or** Leaves out students who arrive later to school	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit:* • Work of merit in either (i) **or** (iii) *High Partial Credit:* • Work of merit in (i) **and** (iii) • One part correct
(a) (ii)	Writes any value of median in the range $60 \leq \text{median} < 90$	**Scale 5C (0, 3, 4, 5)** *Low Partial Credit:* • Work of merit e.g. Gives answer as 90 *High Partial Credit* • $[60 - 90]$ interval indicated *Zero Credit* • $\text{Mean} = 83 \cdot 7$

Q9	Model Solution – 50 Marks	Marking Notes
(a) **(iv)**	 **or**  **or** Other acceptable graph / chart	**Scale 15C (0, 5, 10, 15)** *Low Partial Credit:* • Work of merit e.g. Partly drawn graph / chart • Identifies axes or sectors *High Partial Credit:* • Four intervals drawn correct *Full Credit (-1):* • No labels.(once only)
(b) **(i)**	$\hat{p} = \frac{61}{500}$ $= 0 \cdot 122 \times 100$ $= 12 \cdot 2\%$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit:* • Work of merit e.g. $\hat{p} = \frac{61}{500}$ or $\times 100$ *High Partial Credit:* • $\hat{p} = \frac{61}{500} \times 100$ or $0 \cdot 122$

Q9	Model Solution – 50 Marks	Marking Notes
(b) (ii)	$$\frac{1}{\sqrt{n}} = \frac{1}{\sqrt{500}}$$ $$= 0 \cdot 044721359$$ $$= 4 \cdot 5\%$$	**Scale 5C (0, 3, 4, 5)** *Low Partial Credit:* • Correct formula written e.g. $n = 500$ or $\sqrt{500}$ *High Partial Credit:* • Correct formula fully substituted e.g. $\frac{1}{\sqrt{500}}$
(b) (iii)	$$12 \cdot 2 - 4 \cdot 5 \leq \hat{p} \leq 12 \cdot 2 + 4 \cdot 5$$ $$7 \cdot 7 \leq \hat{p} \leq 16 \cdot 7$$ **Conclusion:** No difference between Cork and population proportion **Reason:** 10% is inside the range found. Within the CI.	**Scale 5D (0, 2, 3, 4, 5)** *Low Partial Credit:* • Work of merit e.g. Writes answer from (b)(i) or (b)(ii) in this part • $\hat{p} \pm \frac{1}{\sqrt{n}}$ • $\hat{p} \pm 1.96\sqrt{\frac{p(1-p)}{n}}$ *Mid Partial Credit:* • One boundary formed $12 \cdot 2 - 4 \cdot 5$ **or** $12 \cdot 2 + 4 \cdot 5$ *High Partial Credit:* • Both boundaries formed $12 \cdot 2 - 4 \cdot 5$ **and** $12 \cdot 2 + 4 \cdot 5$ but no conclusion **and** reason *Full Credit (-1):* Either conclusion **or** reason missing

Q10	Model Solution – 50 Marks	Marking Notes
(a)	$$\frac{180-72}{2}=54$$ $$\lvert\angle ABC\rvert = 54 \times 2 = 108[^o]$$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit:* • Work of merit e.g. Any correct geometrical interpretation worked or indicated diagram *High Partial Credit:* • Calculates 54^o and stops *Full Credit:* • Correct answer without supporting work
(b)	$$\text{Area } \Delta = \frac{1}{2}(6)(6)\text{Sin}72$$ $$= 17 \cdot 119$$ $$= 17 \cdot 1\ [\text{cm}^2]$$ Area of Pentagon $$17 \cdot 119 \times 5 = 85 \cdot 59 \ldots$$ $$= 85 \cdot 6\ [\text{cm}^2]$$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit:* • Work of merit e.g. Any correct work with area of triangle formula. • Correct formula for area of triangle fully substituted *High Partial Credit:* • Finds area of triangle Rad: Triangle $= 4 \cdot 56$, Pentagon $= 22 \cdot 84$ Grad: Triangle $= 16 \cdot 28$, Pentagon $= 81 \cdot 43$

<table>
<tr><th>Q10</th><th>Model Solution – 50 Marks</th><th>Marking Notes</th></tr>
<tr><td>(c)
(i)</td><td>
<table>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>1</td><td>(1,1)</td><td>(1,2)</td><td>(1,3)</td><td>(1,4)</td><td>(1,5)</td></tr>
<tr><td>2</td><td>(2,1)</td><td>(2,2)</td><td>(2,3)</td><td>(2,4)</td><td>(2,5)</td></tr>
<tr><td>3</td><td>(3,1)</td><td>(3,2)</td><td>(3,3)</td><td>(3,4)</td><td>(3,5)</td></tr>
<tr><td>4</td><td>(4,1)</td><td>(4,2)</td><td>(4,3)</td><td>(4,4)</td><td>(4,5)</td></tr>
<tr><td>5</td><td>(5,1)</td><td>(5,2)</td><td>(5,3)</td><td>(5,4)</td><td>(5,5)</td></tr>
</table>
<u>or</u>
Tree diagram
<u>or</u>
Some other acceptable list of outcomes
</td><td>Scale 10C (0, 4, 6, 10)

Low Partial Credit:
• Work of merit
e.g. one element correct in table <u>or</u>
effort at tree diagram

High Partial Credit:
• 15 elements correct in table
• Scores added in table</td></tr>
<tr><td>(c)
(ii)</td><td>Maximum $= 10$
Minimum $= 2$</td><td>Scale 5C (0, 3, 4, 5)

Low Partial Credit:
• Work of merit
e.g. Effort at finding totals

High Partial Credit:
• Calculates maximum or minimum

Full Credit (-1):
• Answer as
$\text{Maximum} = 2, \text{Minimum} = 10$

Full Credit:
• Correct answer without supporting work</td></tr>
</table>

Q10	Model Solution – 50 Marks	Marking Notes
(c) **(iii)**	Probability (4 or 5): $P(4 \text{ or } 5) = \frac{3}{25} + \frac{4}{25}$ $= \frac{7}{25}$ or $0 \cdot 28$ or 28%	**Scale 5C (0, 3, 4, 5)** *Low Partial Credit:* • Work of merit e.g. Indicates correct numerator **or** denominator • Some correct work in (c)(i) *High Partial Credit:* • Calculates: $P(4) = \frac{3}{25}$ **and** $P(5) = \frac{4}{25}$ *Full Credit:* • Correct answer without supporting work
(d)	**Working out** $E(x) = \sum x\,P(x)$ $\mathrm{E}(x) = 1(0{\cdot}3) + (0{\cdot}5)(0{\cdot}2) + 0(0{\cdot}4) + 5(0{\cdot}1)$ $\mathrm{E}(x) = €0 \cdot 90$ **Fair game?** Not a fair game as costs €1 to play **Why** Expected outcome $€0 \cdot 90$ is less than the amount paid to play **or** Expected value not equal to Zero	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit:* • Work of merit • One correct term **or** operation indicated e.g. $1(0 \cdot 3)$ • Indicates not a fair game with no justification *High Partial Credit:* • Two correct terms indicated • Expected value correct, but no conclusion **and** explanation *Full Credit (-1):* • Either conclusion **or** explanation missing.