Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2022

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 2022

Mathematics

Ordinary Level

Paper 1

Marking Scheme

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, 2, 5	0, 2, 3, 5	
10-mark scale		0, 3, 7, 10	0, 3, 5, 8, 10
15-mark scale			0, 4, 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 only once in each section (a), (b), (c) etc. A penalty for an omitted unit is applied only once in each section (a), (b), (c) etc. 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

Section A (120)		Section B (100)	
Answer any four questions		**Answer any two questions**	
Question 1 (30)	**Question 4 (30)**	**Question 7 (50)**	**Question 9 (50)**
(a), (b) 15D	(a)(i) 10C	(a)(i)(ii) 15D	(a)(i) 5B
(c) 10D	(a)(ii) 5B	(b) 5B	(a)(ii) 5C
(d) 5C	(a)(iii) 10C	(c) 10C	(b)(i) 5C
	(b)(i)(ii) 5C	(d) 5B	(b)(ii) 10C
Question 2 (30)		(e) 5B	(c)(i)(ii) 5B
(a) 10C	**Question 5 (30)**	(f) 10C	(d) 10D
(b) 5B	(a)(i)(ii) 10C		(e) 10C
(c) 15D	(b) 10D	**Question 8 (50)**	
	(c)(i)(ii) 10D	(a)(i) 5B	**Question 10 (50)**
Question 3 (30)		(a)(ii) 10C	(a)(i) 5B
(a) 10C	**Question 6 (30)**	(a)(iii) 5B	(a)(ii) 5B
(b) 10D	(a)(i) 5B	(a)(iv) 5C	(a)(iii) 10D
(c) 10C	(a)(ii) 5C	(b)(i) 5C	(a)(iv) 10C
	(b) 10C	(b)(ii) 10C	(b) 10D
	(c) 10C	(b)(iii) 10D	(c)(i) 5C
			(c)(ii) 5C

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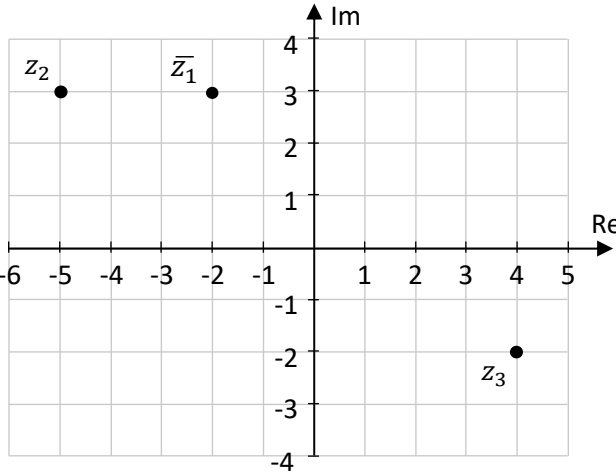
In the case of a **D scale** with the same annotations, **M** should be placed in the right margin.

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), (b)	$z_1 = -2 - 3i$ and $\bar{z_1} = -2 + 3i$ 	**Scale 15D (0,4, 8, 12, 15)** *Low Partial Credit* • Work of merit, for example, real or imaginary part of z_1 or $\bar{z_1}$ correct, or real or imaginary part of z_2 or z_3 plotted correctly • 1 part correct *Mid Partial Credit* • 2 parts correct *High Partial Credit* • 4 parts correct NOTE: Apply F* if labels omitted
(c)	$z_2 - z_3 = -5 + 3i - (4 - 2i) = -9 + 5i$ $\lvert -9 + 5i \rvert = \sqrt{81 + 25} = \sqrt{106}$	**Scale 10D (0,3,5,8,10)** **2 parts in the solution** **1.** Finds $z_2 - z_3$ in form $a + bi$ **2.** Finds $\lvert z_2 - z_3 \rvert$ *Low Partial Credit* • Work of merit in one part, for example, some correct work in substitution for $z_2 - z_3$, or formula for Modulus *Mid Partial Credit* • One part correct • Work of merit in both parts *High Partial Credit* • One part correct and work of merit in the other part
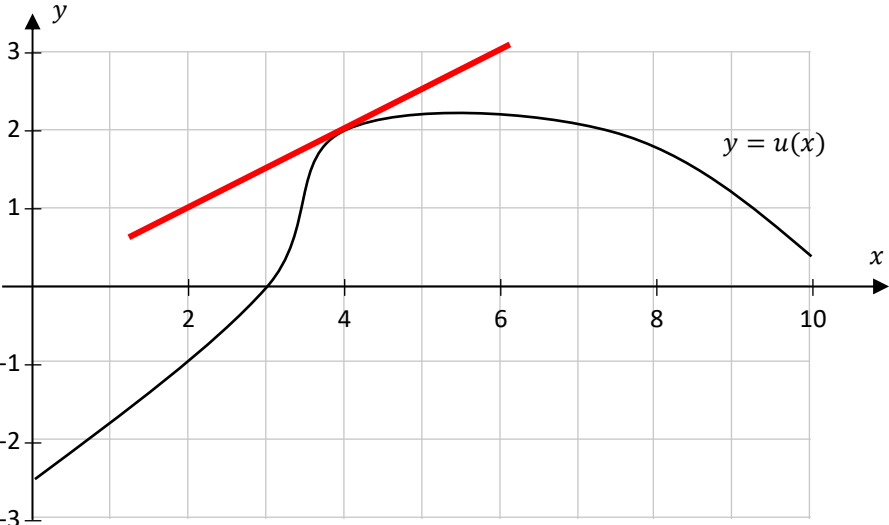
Q1	Model Solution – 30 Marks	Marking Notes
(d)	$(4 - 2i)^2 + 2i(4 - 2i) - 7i$ $= 16 - 16i - 4 + 8i + 4 - 7i$ $= 16 - 15i \neq 0$ Therefore z_3 is not a root. NOTE: accept without "$\neq 0$" stated, as long as conclusion is correct.	**Scale 5C (0,2,3,5)** *Low Partial Credit* • Work of merit, for example, substitutes in $4 - 2i$ for z, or makes attempt to solve given equation • - b formula without substitution or partially substituted *High Partial Credit* • Fully substituted $-b$ formula • Fully substitutes in $4 - 2i$ for z, and carries out some further correct work NOTE: Apply F* if finds $16 - 15i$, but fails to make a correct conclusion

Q2	Model Solution – 30 Marks	Marking Notes
(a)	$6x - 10 + 8 = 4x - 5$ $6x - 4x = -8 + 10 - 5$ $2x = -3$ $x = \frac{-3}{2}$ or equivalent	**Scale 10C (0,3, 7, 10)** *Low Partial Credit* • Carries out some relevant correct operation *High Partial Credit* • Correctly has x on one side and constants on other side • One error, for example, error in transposing but finishes correctly
(b)	$\dfrac{3^{20}}{3^6} = 3^{14}$	**Scale 5B (0,2,5)** NOTE: Accept correct answer without supporting work *Partial Credit* • Writes answer of 4,782,969 or 3486784401 • Shows relevant understanding of indices, for example, indicates that $3^6 = 3 \times 3 \times 3 \times 3 \times 3 \times 3$, or that power of 6 should be subtracted, or indicates $3^{4 \times 5}$ • 14 or 20 written
(c)	Eqn $1 \times (-5)$: $-15x - 10y = -5$ Eqn 2×2: $14x + 10y = -4$ So $-x = -9$, i.e. $x = 9$ and $3(9) + 2y = 1$ so $y = -13$ **OR** $y = \frac{1}{2}(1 - 3x)$ So $7x + 5\left(\frac{1}{2}(1 - 3x)\right) = -2$ So $14x + 5 - 15x = -4$, etc.	**Scale 15D (0,4,8,12,15)** **4 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* • 2 steps correct *High Partial Credit* • 3 steps correct

Q3	Model Solution – 30 Marks	Marking Notes
(a)	$(27500 \times 0 \cdot 2) = 5500$ Then $27500 - (5500 - 3300)$ $\qquad = 27500 - 2200 = 25\,300$	**Scale 10C (0,3,7,10)** **3 steps Involved in solution** **1.** Finds 5500 **2.** Correctly handles gross tax **and** tax credits **3.** Finishes correctly to get 25,300 *Low Partial Credit* • Some relevant operation, eg, 0·2, 0·8 • Finds 5500 *High Partial Credit* • Two steps correct (Using €35300 as the gross annual income is treated as work of merit in step **1** rather than a misreading) • Finds €22,000
(b)	Tax at 20%: $35300 \times 0 \cdot 2 = 7060$ Tax at 40%: $(43\,450 - 35\,300) \times 0 \cdot 4$ $\qquad\qquad = 3260$ Gross tax $= 7060 + 3260 = 10\,320$ Then $43\,450 - (10\,320 - 3300)$ $\qquad = 43\,450 - 7020$ $\qquad = 36\,430$	**Scale 10D (0,3,5,8,10)** **4 steps Involved in solution** **1.** Finds tax at 20% **2.** Finds tax at 40% **3.** Finds gross tax **4.** Finishes correctly *Low Partial Credit* • Some relevant operation, or 0.2 or 0.4 • 1 step correct *Mid Partial Credit* • 2 steps correct *High Partial Credit* • 3 steps correct

Q3	Model Solution – 30 Marks	Marking Notes
(c)	$80 \times 12 = €960$ total annual increase 60% of increase = €960 1% of increase $= \dfrac{960}{60} = 16$ 100% of increase $= 16 \times 100 = [€]1600$ **OR** Trial and improvement leading to solution **OR** Need to show solving using a variable?	**Scale 10C (0,3,7,10)** *Low Partial Credit* • Work of merit, for example, finds 960 • Indicates 60% • Shows use of trial and improvement *High Partial Credit* • Correct answer based on monthly increase • Finds total 960 **and** indicates 60% NOTE: **Full Credit** • Using trial and improvement leading to correct answer

Q4	Model Solution – 30 Marks	Marking Notes
(a) (i)	$5^3 - 7(5)^2 + 5 - 12 = -57$	**Scale 10C (0,3,7,10)** NOTE: Accept correct answer without supporting work *Low Partial Credit* • Work of merit, for example, some correct substitution *High Partial Credit* • Fully correct substitution
(a) (ii)	$g'(x) = 3x^2 - 14x + 1$	**Scale 5B (0,2,5)** *Partial Credit* • Some correct differentiation
(a) (iii)	$y - y_1 = m(x - x_1)$ $(x_1, y_1) = (5, -57)$, $m = 6$ $y + 57 = 6(x - 5)$ $y + 57 = 6x - 30$ $6x - y - 87 = 0$	**Scale 10C (0,3,7,10)** *Low Partial Credit* • Work of merit, for example, identifies m, or x_1, or y_1 • Equation of a line formula with some or no substitution *High Partial Credit* • Fully correct substitution NOTE: Full credit minus 1, fails to rearrange equation of the line
(b)	**(i)** *Accept any value of $x > 5$* **(ii)** Graph below [*accept any reasonable tangent that contains* $(4, 2)$] $u'(4) = \frac{2}{4}$ or $\frac{1}{2}$, approximately [*or value consistent with candidate's graph of tangent*]	**Scale 5C (0,2,3,5)** *Low Partial Credit* • 1 part correct • Indicates (4,2) on the diagram • Slope formula *High Partial Credit* • 1 part correct plus work of merit in the other

Q4	Model Solution – 30 Marks	Marking Notes
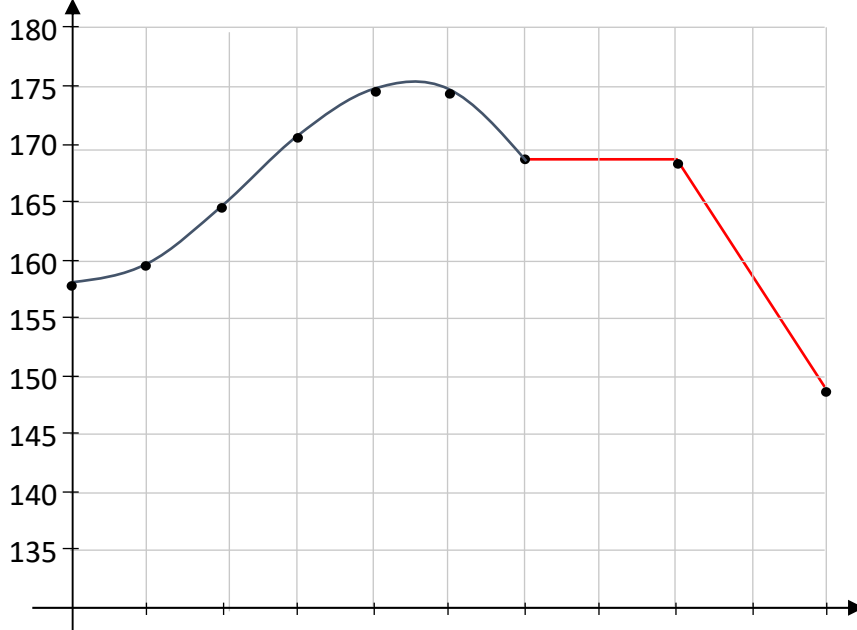
Q5	Model Solution – 30 Marks	Marking Notes
(a)	(i) $\quad 1{\cdot}2 \times 10^3$ (ii) $\quad 2{\cdot}7 \times 10^{-1}$	**Scale 10C (0,3,7,10)** *Low Partial Credit* • Work of merit, for example, a or n correct in one part, or one number correctly written in form $a \times 10^n$ but where $a < 1$ or $a > 10$ • 1000 or $\dfrac{1}{10}$ *High Partial Credit* • One part correct
(b)	120 miles in 1 hr $= 60 \times 60 = 3600$ secs $120 \times 1{\cdot}6$ km $= 192$ km in 3600 secs So 192 000 m in 3600 secs So 1 m in $\dfrac{3600}{192000} = 0{\cdot}01875$ secs So 100 m in $100 \times 0{\cdot}01875 = 1{\cdot}875$ secs $\qquad\qquad\qquad\qquad = 1{\cdot}9$	**Scale 10D (0,3,5,8,10)** **4 steps Involved in solution** **1.** Convert hours to seconds **2.** Convert miles to km or metres **3.** Time for **1** metre **4.** Time for **100** metres *Low Partial Credit* • Work of merit, for example, relevant use of 60 *Mid Partial Credit* • 2 steps correct *High Partial Credit* • 3 steps correct NOTE: Apply F* if fails to round off,

Q5	Model Solution – 30 Marks	Marking Notes
(c)	**(i)** $x = 1$ and $x = 4 \cdot 5$ [*Tolerance of* $\pm 0 \cdot 1$] **(ii)** $2 < x < 3 \cdot 5$ **OR** "Between 2 and 3·5"	**Scale 10D (0,3,5,8,10)** NOTE: 4 values are required, the 2 values in (i) and the 2 endpoints in (ii) *Low Partial Credit* • Work of merit, for example, one value correct in (i), or a value of x in (ii) for which $k(x) < m(x)$ • Point(s) marked on graph for one or both parts *Mid Partial Credit* • 2 values correct *High Partial Credit* • 3 values correct • 4 values correct but no range indicated *Full Credit –1* • 4 values correct, but includes endpoints in the range, ie $2 \leq x \leq 3 \cdot 5$ • "From 2 to 3·5"

Q6	Model Solution – 30 Marks	Marking Notes
(a) (i)	$T_1 = -254 + (1 - 1)(4) = -254$ **OR** $T_n = a + (n - 1)d$ So $T_1 = a = -254$	**Scale 5B (0,2,5)** NOTE: Accept correct answer without supporting work *Partial Credit* • Work of merit, for example, substitutes 1 for n, or indicates $n = 1$ • T_n formula written
(a) (ii)	$T_2 = -254 + (2 - 1)(4) = -250$ $-250 - (-254) = 4 = d$	**Scale 5C (0,2,3,5)** NOTE: Accept correct answer without supporting work *Low Partial Credit* • Work of merit, for example, substitutes 2 for n, or indicates $n = 2$ • Brings down answer from (a)(i) *High Partial Credit* • Finds T_2 • Error in finding T_2, but continues to find d correctly
(b)	$-254 + 4n - 4 > 0$ $n > 64 \cdot 5$ $n = 65$	**Scale 10C (0,3,7,10)** *Low Partial Credit* • One correct operation carried out • Trial and Improvement *High Partial Credit* • Correctly isolates n (i.e. $4n > 254 + 4$) • One error, and finishes correctly NOTE: Leaves answer as $64 \cdot 5$, apply F*

Q6	Model Solution – 30 Marks	Marking Notes
(c)	$\frac{n}{2}(-508 + 4n - 4) = 0$ $n \neq 0$, so $-512 + 4n = 0$ So $n = 128$	**Scale 10C (0,3,7,10)** *Low Partial Credit* • Work of merit, for example, sets second factor $= 0$, or some correct work in simplifying second factor • Any correct multiplication • Indicates $\frac{n}{2} = 0$ • Trial and Improvement *High Partial Credit* • One error, otherwise correct

$\frac{n}{2}(-508 + 4n - 4) = 0$

Q7	Model Solution – 50 Marks	Marking Notes
(a)	**(i)** *Table below* **(ii)** *Graph below*	**Scale 15D (0,4,8,12,15)** Solution requires 11 elements 4 values in table, and 6 integer-valued points to be plotted, joined by an appropriate curve (which must include the point **A**) *Low Partial Credit* • 1 element correct *Mid Partial Credit* • 4 elements correct *High Partial Credit* • 8 elements correct *Full Credit –1* • 9 elements correct, and an appropriate curve, including **A**

Time (minutes)	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Heart-rate (BPM)	**158**	160	**165**	171	**175**	**175**	169

(b)	"6 minutes after the start of the session, Joseph's heart rate is 169 BPM."	**Scale 5B (0,2,5)** *Partial Credit* • "6 minutes after start of session" **or** • "heart rate is 169 BPM"
(c)	*Graph below*	**Scale 10C (0,3,7,10)** *Low Partial Credit* • 1 correct point, written or plotted on graph *High Partial Credit* • Deals correctly with $6 \leq x \leq 8$, or with $8 \leq x \leq 10$ • Correct plots for $x = (7), 8, (9),$ and 10, but not joined appropriately

Q7	Model Solution – 50 Marks	Marking Notes

(d)	$c(6) = 0·1(169) - 7$ $= 9·9$ [calories per min]	**Scale 5B (0,2,5)** *Partial Credit* • Work of merit, for example, indicates $h(6)$, or mention of 169
(e)	From $2:55$ until $3:23$ is 28 minutes $(4 \times 28) + 1 = 113$ [times]	**Scale 5B (0,2,5)** NOTE: Accept correct answer of 113 without supporting work *Partial Credit* • Work of merit, for example, finds 4 or 28 or 1680 • 112 or 114 without work *Full Credit −1* • Answer of 112 *or* 114, with work

Q7	Model Solution – 50 Marks	Marking Notes
(f)	$$x = \frac{-5{\cdot}2 \pm \sqrt{5{\cdot}2^2 - 4(-1{\cdot}14)(-0{\cdot}13)}}{2(-1{\cdot}14)}$$ $$= \frac{-5{\cdot}2 \pm \sqrt{26{\cdot}4472}}{-2{\cdot}28}$$ $$= 4{\cdot}536 \; and \; 0.025 =$$ $$= 4{\cdot}54 \; [\text{mins}]$$	**Scale 10C (0,3,7,10)** **3 steps Involved in solution** **1.** Identifies a, b, and c **2.** Fully substituted formula **3.** Correctly evaluated *Low Partial Credit* • Work of merit, for example, identifies a, b, or c • - b formula without or partially substituted *High Partial Credit* • 2 steps correct • Formula fully substituted correctly *Full Credit –1* • Calculates both solutions to the equation, and fails to indicate which is the answer • Incorrect rounding

Q8	Model Solution – 50 Marks	Marking Notes
(a) (i)	$\dfrac{12}{100} \times 200 = 24$ [ml]	**Scale 5B (0,2,5)** NOTE: Accept correct answer without supporting work *Partial Credit* • Work of merit, for example, a correct operation (including $0{\cdot}12$ or $\dfrac{12}{100}$)
(a) (ii)	Volume of acid: $24 + (0{\cdot}05 \times 300)$ $= 24 + 15 = 39$ ml Concentration of acid: $\dfrac{39}{200+300} \times 100 = 7{\cdot}8$ [%]	**Scale 10C (0,3,7,10)** *Low Partial Credit* • Work of merit, for example, finds volume of acid from **B**, or finds total volume of mixture • Answer (a)(i) written *High Partial Credit* • One error, otherwise correct, for example, fails to multiply by 100 • Finds 39 **and** 500
(a) (iii)	*Any valid explanation, for example:* She can only make solutions between 5% and 12%, inclusive.	**Scale 5B (0,2,5)** *Partial Credit* • Work of merit, for example, indicates 5 or 12
(a) (iv)	$\dfrac{260-250}{250} \times 100 = \dfrac{10}{250} \times 100 = 4$ [%]	**Scale 5C (0,2,3,5)** *Low Partial Credit* • 1 correct operation • % error formula written • Correct answer without supporting work *High Partial Credit* • 2 correct operations, for example, $\dfrac{260-250}{250}$ or $\dfrac{260-250}{260} \times 100$ or 104

Q8	Model Solution – 50 Marks	Marking Notes
(b) **(i)**	$C = 8,\ F = 6$ $8 - 12 + 6 = 2$	**Scale 5C (0,2,3,5)** *Low Partial Credit* • Work of merit, for example, C or F correct, or at least one value filled into given identity *High Partial Credit* • C and F correct • C or F correct, and at least 2 values filled into given identity
(b) **(ii)**	$12 - 30 + F = 2$ So $F = 20$ Surface area $= 20 \times 5 = 100$ [cm²]	**Scale 10C (0,3,7,10)** *Low Partial Credit* • C and/or E filled into given identity • Indicates $5F$ *High Partial Credit* • Finds F • Finds F with an error, then finds $5F$
(b) **(iii)**	Multiply both sides by 6: $2(6h + 5p) - 3(6h + 5p) + 6h + 6p = 12$ $12h + 10p - 18h - 15p + 6h + 6p = 12$ $p = 12$ **OR** $2h + \frac{5}{3}p - 3h - \frac{5}{2}p + h + p = 2$ $\frac{1}{6}p = 2$ $p = 12$	**Scale 10D (0,3,5,8,10)** *Low Partial Credit* • Some mention of 6 *Mid Partial Credit* • Correctly multiplies across by 6 *High Partial Credit* • Multiplies out the equation correctly

Q9	Model Solution – 50 Marks	Marking Notes
(a) (i)	$V(0) = 30\,000 \quad V(1) = 24\,000$	**Scale 5B (0,2,5)** NOTE: Accept correct answer without work *Partial Credit* • Work of merit, for example, one value correct • Correct indication on graph
(a) (ii)	$\dfrac{30\,000 - 24\,000}{30\,000} \times 100$ $= \dfrac{6000}{30\,000} \times 100 = 20\%$	**Scale 5C (0,2,3,5)** *Low Partial Credit* • Work of merit, for example, finds 6000 or $\dfrac{6000}{30\,000}$ *High Partial Credit* • Finds $\dfrac{6000}{30\,000} \times 100$ but fails to finish
(b) (i)	$V = 30\,000(0{\cdot}8)^t$	**Scale 5C (0,2,3,5)** *Low Partial Credit* • Work of merit, for example, $0{\cdot}2$ or $30000 \times$ something • Correct depreciation formula written *High Partial Credit* • 2 elements of formula correct (30000, $0{\cdot}8$, or power of t)
(b) (ii)	$V = 30\,000(0{\cdot}8)^4 = [\text{€}]12\,288$ **Or** After 2 years: $0{\cdot}8 \times 24\,000 = 19\,200$ After 3 years: $0{\cdot}8 \times 19\,200 = 15\,360$ After 4 years: $0{\cdot}8 \times 15\,360 = [\text{€}]12\,288$	**Scale 10C (0,3,7,10)** *Low Partial Credit* • Work of merit, for example, writes *t = 4*, or works out 20% of $V(1)$ *High Partial Credit* • Finds $V(3)$ • Method 2, one consistent error in calculating $V(2)$, $V(3)$, and $V(4)$

Q9	Model Solution – 50 Marks	Marking Notes
(c)	**(i)** *Straight-line graph through* $(0, 30\,000)$, $(1, 24\,000)$, *and* $(5, 0)$. **(ii)** $T = 5$ years	**Scale 5B (0,2,5)** *Partial Credit* • One part correct or some work of merit NOTE: Allow a tolerance of +/- ·5
(d)	$19\,445(0{\cdot}3) + 36 \times (206{\cdot}97) + 7389$ $5833{\cdot}5 + 7450{\cdot}92 + 7389$ $= [€]20\,673{\cdot}42$	**Scale 10D (0,3,5,8,10)** **3 steps Involved in solution** **1.** Finds 30% **2.** Finds total cost of 36 repayments **3.** Finds overall total cost *Low Partial Credit* • Work of merit, for example, 1 correct operation, including 30/100 *Mid Partial Credit* • 1 step correct *High Partial Credit* • 2 steps correct
(e)	Usual time: $\frac{12}{60} = 0{\cdot}2$ hours or 12 minutes Time today: $\frac{12}{40} = 0{\cdot}3$ hours or 18 minutes % increase in time: $\frac{(0{\cdot}3 - 0{\cdot}2)}{0{\cdot}2} \times 100 = 50\%$ **OR** $\left(\frac{60}{40} - 1\right) \times 100 = 50\%$	**Scale 10C (0,3,7,10)** *Low Partial Credit* • One correct relevant fraction, or 12 or 18 *High Partial Credit* • Finds both times, ie ·2 and ·3, or 12 minutes and 18 minutes • Consistent error finding both times, but finishes correctly • Finds 1·5 or equivalent, from $\frac{60}{40}$ in 2nd method

Q10	Model Solution – 50 Marks	Marking Notes
(a) (i)	$h(0) = -2(0)^2 + 5(0) + 1\cdot2 = 1\cdot2$ [m]	**Scale 5B (0,2,5)** NOTE: Accept correct answer without supporting work *Partial Credit* • 0 substituted in for t
(a) (ii)	$h(2\cdot4) = -2(2\cdot4)^2 + 5(2\cdot4) + 1\cdot2$ $\quad\quad\quad = 1\cdot68$	**Scale 5B (0,2,5)** NOTE: Accept correct answer without supporting work *Partial Credit* • 2·4 substituted in for t
(a) (iii)	$-2t^2 + 5t + 1\cdot2 = 3\cdot2$ $2t^2 - 5t + 2 = 0$ $(2t - 1)(t - 2) = 0$ $t = \frac{1}{2}$ or $t = 2$ Answer: $t = 2$ [secs] [*as height was decreasing*]	**Scale 10D (0,3, 5,8,10)** **4 steps Involved in solution** 1. Sets $h = 3\cdot2$ 2. Rearranges (one side = 0) 3. Factorises / subs in -b formula 4. Solves *Low Partial Credit* • Work of merit, for example, one step correct? • -b formula *Mid Partial Credit* • 2 steps correct *High Partial Credit* • 3 steps correct, based on $h = 3\cdot2$ *Full Credit –1* • Finds both values of t, but does not indicate that $t = 2$ or discount $t = \frac{1}{2}$

Q10	Model Solution – 50 Marks	Marking Notes
(a) **(iv)**	$\frac{dh}{dt} = -4t + 5$ $-4t + 5 = 0$ at max So $t = 1{\cdot}25$ [secs]	**Scale 10C (0,3,7,10)** Note: there must be some correct differentiation in order to award any credit *Low Partial Credit* • Some correct differentiation • $\frac{dh}{dt} = 0$ *High Partial Credit* • $\frac{dh}{dt}$ correct, and sets $= 0$ • Work of merit in finding $\frac{dh}{dt}$, finishes correctly
(b)	*Points:* $(0, 1)$, $(2, 5)$, and $(4, 1)$ [*or any other valid points that must be on graph, if supported by working out*] *Graph below. Graph should pass through the three points above, and should cut the horizontal axis at $t > 4$.*	**Scale 10D (0,3,5,8,10)** Correct solution requires 7 elements: 3 co-ordinates written, these 3 points plotted on the answer grid, curve drawn between these points and extended to the x-axis *Low Partial Credit* • Work of merit, for example, 1 co-ordinate of 1 point correctly written; or 1 point correctly plotted *Mid Partial Credit* • 3 elements correct *High Partial Credit* • 4 elements correct, and an appropriate curve • 6 elements correct, but no curve or a curve that is not appropriate *Full Credit –1* • 6 elements correct, and an appropriate curve, but not extended to the x-axis

Q10	Model Solution – 50 Marks	Marking Notes

(c) **(i)**	$33 \times 0.85 = 28.05$	**Scale 5C (0,2,3,5)** NOTE: Accept correct answer without work *Low Partial Credit* • One correct operation, for example ·15 or ·85 or $\frac{15}{100}$ or $\frac{85}{100}$ *High Partial Credit* • Finds 15% (4·95)
(c) **(ii)**	123% is €49·50 1% is $\frac{49.50}{123} = 0.4024$ VAT is 23%, which is: $\frac{49.50}{123} \times 23$ $= 9.256 \ldots 9.26$ [nearest cent] **or** 926 cent	**Scale 5C (0,2,3,5)** *Low Partial Credit* • Indicates 123 *High Partial Credit* • Finds 1% or 100% (40·24) NOTE: Apply F* if fails to round off correctly

Leaving Certificate 2022

Mathematics

Ordinary Level

Paper 2

Marking Scheme

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, 5	0, 2, 5	0, 2, 3, 5	0, 2, 3, 4, 5
10-mark scale		0, 5, 10	0, 3, 7, 10	0, 3, 5, 8, 10
15-mark scale				0, 4, 8, 12, 15
20-mark scale				

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 only once in each section (a), (b), (c) etc. A penalty for an omitted unit is applied only once in each section (a), (b), (c) etc. 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

Section A (120)		Section B (100)	
Answer any four questions		**Answer any two questions**	

Question 1 (30)	**Question 4 (30)**	**Question 7 (50)**	**Question 9 (50)**
(a)(i) 5C	(a) 15D	(a)(i) 15D	(a) 5B
(a)(ii) 10C	(b)(i)(ii) 10C	(a)(ii) 5B	(b) 10D
(b)(i)(ii) 5C	(c) 5C	(a)(iii) 5B	(c) 10D
(b)(iii) 10C		(b) 10D	(d) 10C
		(c)(i)(ii) 5D	(e)(i) 10D
	Question 5 (30)	(d) 5B	(e)(ii) 5C
Question 2 (30)	(a)(i)(ii) 10C	(e) 5C	
(a)(i) 10C	(a)(iii) 10C		
(a)(ii) 5C	(b) 10D		**Question 10 (50)**
(b)(i) 5B		**Question 8 (50)**	(a) 5B
(b)(ii) 10C		(a)(i) 5C	(b)(i) 5C
	Question 6 (30)	(a)(ii) 10D	(b)(ii) 5B
	(a)(i) 5A	(b)(i) 5C	(b)(iii)(iv) 10D
Question 3 (30)	(a)(ii) 5C	(b)(ii) 5C	(c) 5C
(a)(i) 5C	(a)(iii) 10C	(c)(i) 5B	(d) 10C
(a)(ii) 5B	(b)(i)(ii) 10D	(c)(ii) 10B	(e) 10C
(a)(iii) 5C		(d) 10D	
(b)(i) 5B			
(b)(ii) 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			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.

Where steps are listed in the Marking Notes, unless otherwise specified, they are taken as being independent – that is, in a candidate's solution, step n can be considered correct even if previous step(s) have not been correctly presented, as long as the work done to arrive at step n from the previous step(s) has not been oversimplified.

Q1	Model Solution – 30 Marks	Marking Notes
(a) **(i)**	$m_{AC} = \dfrac{3-0}{0-(-2)} = \dfrac{3-0}{0+2} = \dfrac{3}{2}$	**Scale 5C (0, 2, 3, 5)** *Low Partial Credit:* • Work of merit e.g. slope formula written down *High Partial Credit:* • Correct formula, with fully correct substitution or gets slope of BC *Full Credit:* • Correct answer without supporting work
(a) **(ii)**	**Answer**: AC is **not** perpendicular to BC **Justification**: $m_{BC} = -\dfrac{3}{5}$ Slope of $AC_{\perp}$ would be $-\dfrac{2}{3}$ **OR** $m_{AC} \times m_{BC} = \dfrac{3}{2} \times \dfrac{-3}{5} \neq -1$	**Scale 10C (0, 3, 7, 10)** *Zero Credit:* • Mention of 90° *Low Partial Credit:* • Work of merit e.g Correct Box Ticked • Slope formula written • Shows an understanding of relationship between perpendicular lines and their slopes *High Partial Credit:* • Answer correct and significant slope-related work presented. • Brings down m_{AC} from (a)(i) and calculates m_{BC} in (a)(ii) *Full Credit (-1):* • Fully correct work but box not ticked **Note**: Watch out for consistent work here
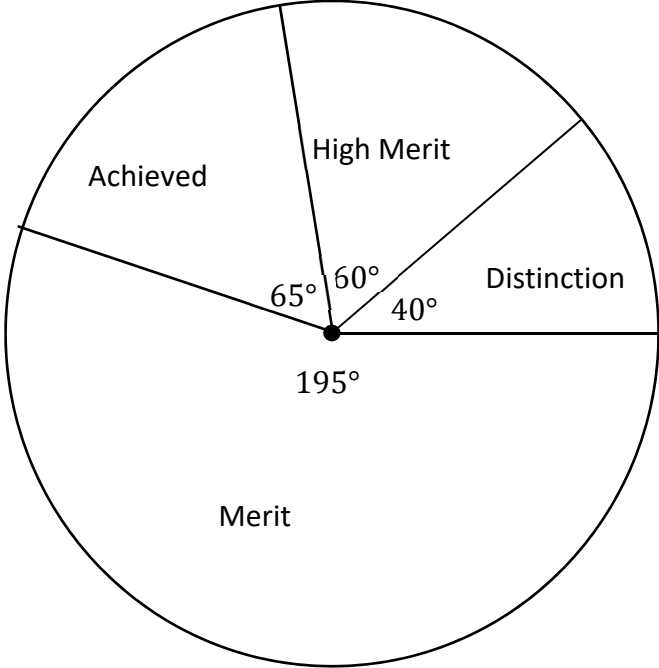
Q1	Model Solution – 30 Marks	Marking Notes
(b)		**Scale 5C (0, 2, 3, 5)**
	(i) $2 \times 9 = 18$	*Low Partial Credit:* • Work of merit in any one part • Correct relevant formula written
	(ii) $y = 1$ **OR** $y - 1 = 0(x - 9)$ So $[y - 1 = 0]$	*High Partial Credit:* • Part (i) or (ii) correct *Full Credit:* • Correct answers without supporting work
(b) **(iii)**	$x = 0 :$ $0 + 4y - 13 = 0$ $4y = 13$ $y = \dfrac{13}{4}$ $y = \dfrac{13}{4}$ $N = \left(0, \dfrac{13}{4}\right)$	**Scale 10C (0, 3, 7, 10)** *Low Partial Credit* • Work of merit e.g. indicates $x = 0$ • Finds a point on the given line other than the intercepts *High Partial Credit* • Substitutes $x = 0$ in equation, accompanied by further work of merit • Substitutes $y = 0$ and correctly finds x *Full Credit (–1):* • Answer not given as a pair of co-ordinates
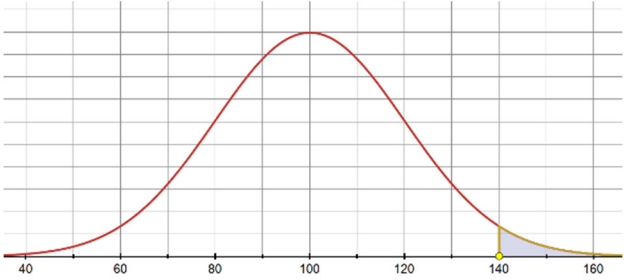
Q2	Model Solution – 30 Marks	Marking Notes

(a) **(i)**	Centre $= (4, -2)$
	
	 Radius $= \sqrt{169} = 13$
		Scale 10C (0, 3, 7, 10)
		
		 Low Partial Credit
		 • Work of merit
		  e.g. indicates h, k, or r^2, or
		  centre given as $(-4, 2)$
		
		 High Partial Credit
		 • Centre or radius correct
		
		 Full Credit (–1):
		 • Answer as $\sqrt{169}$
		
		 Full Credit:
		 • Correct answer without supporting work

(a) **(ii)**	Answer: **outside** k Distance of (4,-2) to (11,10) $\sqrt{(11-4)^2 + \big(10-(-2)\big)^2}$ $\sqrt{(7)^2 + (12)^2}$ $\sqrt{49 + 144}$ $\sqrt{193} >$ Radius Radius, therefore outside, and correct box ticked **OR** $(11-4)^2 + (10+2)^2 = 169$ $7^2 + 12^2 = 169$ $193 > 169$ therefore outside, and correct box ticked	**Scale 5C (0, 2, 3, 5)** *Low Partial Credit* • Work of merit • Correct answer with no supporting work • Correct relevant formula written *High Partial Credit* • Answer correct and significant work of merit in determining length of radius • Fully substituted equation of circle or formula for distance, but incorrect or omitted conclusion *Full Credit (–1):* • Fully correct work but box not ticked

Q2	Model Solution – 30 Marks	Marking Notes
(b) (i)	Any valid point: $(32,15)_{S_{(22,13)}}$, or, $(12,15)_{S_{(Y=13)}}$ or $(32,11)_{S_{(X=22)}}$ e.g. $(12,11) \xrightarrow{t(10,2)} (22,13) \xrightarrow{t(10,2)} (32,15)$	**Scale 5B (0, 2, 5)** *Partial Credit* • Work of merit e.g. indicates translation through the centre, or axial symmetry in horizontal or vertical line through the centre • One co-ordinate correct in the context of significant correct work *Full Credit:* • Correct answer without supporting work

(b) (ii)	$(22,13) \rightarrow (12,11) \Longrightarrow \xrightarrow{t(-10,-2)}$
	
	Half that, so: $\xrightarrow{t(-5,-1)}$ to give
	
	$(12,11) \xrightarrow{t(-5,-1)} (7,10)$
	
	OR
	
	$(12,11) \xrightarrow{t(10,2)} (22,13)$
	
	Endpoint of diameter of t is $\xrightarrow{t(-10,-2)}$ to give
	
	$(12,11) \xrightarrow{t(-10,-2)} (2,9)$
	
	So centre is midpoint
	[Line segment joining $(12,11)$ $(2,9)$]
	$i.e\left(\frac{2+12}{2},\frac{9+11}{2}\right) = (7,10)$
		Scale 10C (0, 3, 7, 10)
		
		Low Partial Credit
		• Work of merit
		  e.g Indicates required translation
		  (or double required translation)
		
		High Partial Credit
		• Finds endpoint of diameter
		• Fully specifies required translation (that is, necessary action to x and y co-ordinates)
		
		Full Credit:
		• Correct answer without supporting work

Q3	Model Solution – 30 Marks	Marking Notes
(a) (i)	$$\text{Mean} = \frac{17 + 8 + 9 + 8 + 14 + 11 + 28}{7}$$ $$= \frac{95}{7}\,(13 \cdot 5714)$$ $$= 13 \cdot 6$$	**Scale 5C (0, 2, 3, 5)** *Low Partial Credit:* • Work of merit e.g. Indicates some addition of the given numbers • Division by 7 *High Partial Credit:* • Correct addition ($Ans: = 95$) • Fully correct substitution into mean formula. *Full Credit (–1):* • Error in addition and finishes correctly *Full Credit:* • Correct answer without supporting work
(a) (ii)	4th number from: $8, 8, 9, 11, 14, 17, 28$ Median $= 11$	**Scale 5B (0, 2, 5)** *Partial Credit* • Work of merit e.g. Orders the given numbers, or indicates the middle number
(a) (iii)	One New number added suggest median is average of two centre numbers $$\text{Giving } \frac{10 + 11}{2} = 10 \cdot 5$$ $$\text{Answer} = 10$$	**Scale 5C (0, 2, 3, 5)** *Low Partial Credit:* • Indicates average of two numbers • Any use of 11 *High Partial Credit:* • Works to 21 *Full Credit:* • Correct answer without supporting work

Q3	Model Solution – 30 Marks	Marking Notes
(b) (i)	$$^3_1C \times {}^4_1C \times {}^5_1C = 3 \times 4 \times 5 = 60$$ **OR** Lists some or all choices, and derives or counts the choices	**Scale 5B (0, 2, 5)** *Partial Credit:* • Work of merit e.g. indicates the number choices in any one group • Lists TWO correct options • Treats as $3 + 4 + 5$ *Full Credit:* • Correct answer without supporting work
(b) (ii)	Answer: **Group A** Justification: Extra **A**: $4 \times 4 \times 5 = 80$ Extra **B**: $3 \times 5 \times 5 = 75$ Extra **C**: $3 \times 4 \times 6 = 72$ **OR** Biggest pair is 4×5 [**B** and **C**], so biggest increase by increasing **A**	**Scale 10C (0, 3, 7, 10)** *Low Partial Credit:* • Correct answer without justification • Work of merit in Justification e.g. One relevant calculation, or one listing of a relevant pair *High Partial Credit:* • **Group A** given as correct answer **and** work of merit in the justification • Justification that would fully support correct answer, but answer incorrect or not given
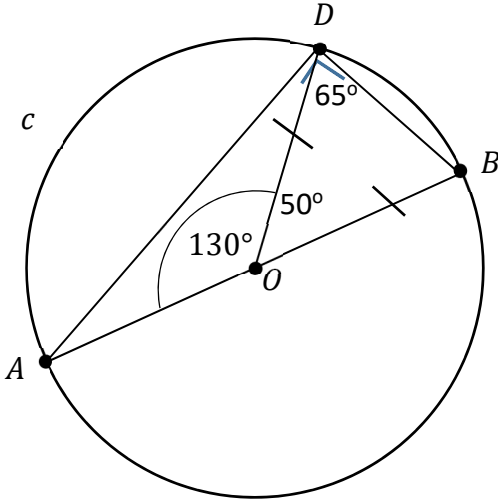
Q4	Model Solution – 30 Marks	Marking Notes
(a)	$8 + 12 + 39 + 13 = 72$ $\frac{360}{72} = 5°$ for every person **OR** $40 \div 8 = 5°$ per person $5 \times 12 = 60°$ High Merit $5 \times 39 = 195°$ Merit $[5 \times 13 = 65°$ Achieved$]$	**Scale 15D (0, 4, 8, 12, 15)** *Low Partial Credit:* • Work of merit e.g. total number of students (= 72) • 72 or 360° or indicates multiplication by 5 • One new angle identified *Mid Partial Credit:* • All angles identified • One correctly labelled sector added to the Pie Chart *High Partial Credit:* • Fully correct labelled Pie Chart without work *Full Credit (–1):* • One label missing

Q4	Model Solution – 30 Marks	Marking Notes

(b)	**(b)(i)**
	
	(i) 68 [%]
	
	(b)(ii)
	
	(ii) 100 + 2(20) = 140
	
		Scale 10C (0, 3, 7, 10)
		
		Low Partial Credit
		• Work of merit
		  e.g. Some relevant figures
		  indicated on the diagram
		• $\bar{x} = 100 \; or \; \sigma = 20$
		
		High Partial Credit
		• Part (i) **or** (ii) correct
		
		Full Credit:
		• Correct answer without
		  supporting work

Q4	Model Solution – 30 Marks	Marking Notes
(c)	Range $= 113 - 82 = 31$ S.D. $= 9 \cdot 758 \ldots = 9 \cdot 8$ **or** $$\text{Mean} = \frac{\sum x}{n}$$ $$= \frac{104 + 82 + 94 + 113 + 98 + 105}{6}$$ $$= \frac{596}{6} \, (99 \cdot \dot{3})$$ Standard Deviation (σ) by hand: $$= \sqrt{\frac{(104\text{-}99\cdot\dot{3})^2 + (82\text{-}99\cdot\dot{3})^2 + (105\text{-}99\cdot\dot{3})^2}{6}}$$ $$= 9 \cdot 758 \ldots$$ $$= 9 \cdot 8 \text{ to } 1 \, D.P$$ Standard Deviation from calculator: $\sigma = 9 \cdot 75818744 = 9 \cdot 8$ to 1 D.P.	**Scale 5C (0, 2, 3, 5,)** *Low Partial Credit:* • Work of merit • Attempt at finding mean • Maximum or minimum identified *High Partial Credit:* • Standard deviation or Range found correctly *Full Credit (–1):* • Standard deviation correct but Range given as Min and Max, instead of as a number • Incorrect rounding. *Full Credit:* • Correct answers without supporting work

Q5	Model Solution – 30 Marks	Marking Notes
(a)	**(i)** 60° **(ii)** Area $= \frac{1}{2} \times 8 \times 8 \times \sin 60 = 16\sqrt{3} \ [\text{cm}^2]$	**Scale 10C (0, 3, 7, 10)** *Low Partial Credit:* • Any correct property of an equilateral triangle identified • Work of merit in (ii) e.g. correct formula written *High Partial Credit:* • Part(i) **or** (ii) correct • Part(i) incorrect but value from (i) filled into (ii) and fully evaluated i.e. Consistent Work *Full Credit* • Accept (a)(i) without supporting work but work must be shown for (a)(ii) **Note:** Incorrect calculator mode (apply once in paper)
(a) (iii)	$8^2 = 4^2 + (h_\perp)^2$ $(h_\perp)^2 = 8^2 - 4^2$ $(h_\perp)^2 = 48$ $h_\perp = 4\sqrt{3} \ [\text{cm}]$ **OR** $\tan 60 = \frac{h}{4}$ $h = 4\tan 60 = 4\sqrt{3} \ [\text{cm}]$ **OR** Area $= \frac{1}{2} \times \text{base} \times \text{perpendicular height}$ $16\sqrt{3} = \frac{1}{2} \times 8 \times h$ $h = \frac{16\sqrt{3}}{4} = 4\sqrt{3} \ [\text{cm}]$	**Scale 10C (0, 3, 7, 10)** *Low Partial Credit* • Indicates shortest distance on diagram with right angle • Correct relevant formula written *High Partial Credit* • A fully correctly-substituted relevant formula • One incorrect substitution and finished correctly *Full Credit (–1):* • Correct value for h, but not in required form

Q5	Model Solution – 30 Marks	Marking Notes
(b)	$$\|GK\|^2 = \|GH\|^2 + \|HK\|^2$$ $$30^2 = 12^2 + \|HK\|^2$$ $$900 = 144 + \|HK\|^2$$ $$\|HK\|^2 = 756$$ $$\|HK\| = \sqrt{7}56 = [6\sqrt{21}]$$ $$\|HK\| = 27.5\text{cm}$$	**Scale 10D (0, 3, 5, 8, 10)** *Low Partial Credit:* • Pythagoras Theorem written *Mid Partial Credit:* • A fully correctly-substituted formula *High Partial Credit:* • $\|HK\| = \sqrt{7}56$ *Full Credit (−1):* • Correct answer, no unit or incorrect unit • Correct answer, incorrect rounding

Q6	Model Solution – 30 Marks	Marking Notes

Diagram:

(a) **(i)**	90°	**Scale 5A (0, 5)** • Hit or Miss

(a) **(ii)**	$2X = 130°$ so $X = 65°$ **OR** $\lvert \angle DOB \rvert = 180 - 130 = 50°$ $X = \dfrac{180 - 50}{2} = \dfrac{130}{2} = 65°$	**Scale 5C (0, 2, 3, 5)** *Low Partial Credit:* • Any correct geometrical property mentioned or illustrated e.g. finds 50°, or indicates that angle at B is also X *High Partial Credit:* • Geometrical property developed by correct substitution but X not calculated *Full credit:* • Accept correct answer without supporting work

Q6	Model Solution – 30 Marks	Marking Notes
(a) (iii)	**Minor arc**: $\frac{130}{360} \times 2\pi(18) = 13\pi$ [cm] **or** **Major arc**: $\frac{(360-130)}{360} \times 2\pi(18) = 23\pi$ [cm]	**Scale 10C (0, 3, 7, 10)** *Low Partial Credit:* • Work of merit • Correct relevant formula written • $\frac{130}{360}$ *High Partial Credit:* • Finds circumference • Fully correctly-substituted arc-length formula • Answer not in terms of π *Misreading(-1)* • If a different arc is correctly calculated e.g. $\frac{50}{360} \times 2\pi(18) = 5\pi$
(b)	**(i)** False *Reason*: Similar Triangles have the same shape but different measurements, thus a small and a large triangle could have angles the same but they are **not identical.** **(ii)** True *Reason*: Congruent Triangles are triangles where all the corresponding sides and interior angles are equal in measure (including area).This means all features **are identical** so angles must be the same	**Scale 10D (0, 3, 5, 8, 10)** *Low Partial Credit:* • Work of merit in either part e.g. True or False correct, or reason shows understanding of similarity or congruence *Mid Partial Credit:* • One part fully correct (answer and reason) • Work of merit in both parts *High Partial Credit:* • One part fully correct (answer and reason) **and** work of merit in the other part

Q7	Model Solution – 50 Marks	Marking Notes

(a) (i)

	Day X					Day Y		
		9	5	4	8			
7	5	3	3	5	4	5		
		9	7	6	0	1	3	
		4	3	7	0	6	9	
				8	1			

Marking Notes (a)(i):

Scale 15D (0, 4, 8, 12, 15)

Low Partial Credit:
• 5 correct values

Mid Partial Credit:
• 10 correct values

High Partial Credit:
• 15 correct values

Full Credit –1
• 19 correct values

Note:
Accept values that are not in order, but penalise "gaps" on rows (Once only)

(a) (ii)

Conclusion:

That the weight of the dogs has increased from Day X to Day Y

Marking Notes (a)(ii):

Scale 5B (0, 2, 5)

Partial Credit
• Work of merit

Note: Word "Increase" or similar must feature in conclusion.

(a) (iii)

Answer: 0·9

Reason:

There's a strong positive linear relationship

OR

The weight of the dogs is very likely to have increased by roughly the same amount after a few days

OR

If you graphed them, the points would all lie close to a straight line

OR

Any other valid reason

Marking Notes (a)(iii):

Scale 5B (0, 2, 5)

Partial Credit:
• Correct value of r without a reason or with an incorrect reason
• Reason shows an understanding of r but no r value identified
• Finds r on calculator r = 0.979… and stops

Full Credit (-1):
• Fully correct reason but box not ticked

Full Credit:
• Work given in the answer box identifies the value of r as $0 · 9$ accompanied with a valid reason

Q7	Model Solution – 50 Marks	Marking Notes

(b)

	Male	Female	Total
Cats	5	9	14
Dogs	11	15	**26**
Total	16	24	40

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

Low Partial Credit
- 1 correct value

Mid Partial Credit
- 2 correct values

High Partial Credit
- 3 correct values

Note:
Watch out for consistent work here

(c)

(i)

$$P(cat) = \frac{14}{40} \ or \ \frac{7}{20}$$

(ii)

$$P(3 \ male \ dogs) = \frac{11}{40} \times \frac{10}{39} \times \frac{9}{38}$$

$$= \frac{33}{1976} \ (0 \cdot 0167)$$

$$= 0 \cdot 017$$

Scale 5D (0, 2, 3, 4, 5)

Low Partial Credit
- Correct numerator or denominator in (i)
- One correct numerator or denominator in (ii)

Mid Partial Credit
- Part(i) correct
- 2 correct fractions in (ii)
- 3 numerators **or** 3 denominators correct in (ii)

High Partial Credit
- (i) correct **and** 2 correct fractions in (ii)
- 3 correct fractions in (ii)
- Incorrect operation used

Full Credit (-1):
- Incorrect rounding

(d)

$$9! = 362 \ 880$$

Scale 5B (0, 2, 5)

Partial Credit
- Work of merit
  e.g. indicates multiplication of two relevant numbers,
  or 9×8, or $9!$

Q7	Model Solution – 50 Marks	Marking Notes
(e)	$40 - 10 = 30$ animals at end of week $P(dog) = \frac{11}{15} \equiv \frac{22}{30}$ so 22 dogs remain. Thus $30 - 22 = 8$ cats remain at the end of week Therefore the number of cats left the shelter during the week is : $$14 - 8 = 6$$	**Scale 5C (0, 2, 3, 5)** **Steps involved in solution:** **1.** Finds total # animals at end of week **2.** Finds # dogs at end of week **3.** Finds # cats at end of week **4.** Finds answer *Low Partial Credit* • Finds total number of animals in shelter (30) • Finds equivalent fraction (22/30) • Finds $\frac{4}{15}$ *High Partial Credit* • Finds the number dogs or number of cats at the end of the week

| Q8	Model Solution – 50 Marks	Marking Notes
(a) (i)	$$V = \frac{2}{3}\pi(3^3) = 18\pi \ [\text{m}^3]$$	**Scale 5C (0, 2, 3, 5)** *Low Partial Credit* • Substitutes $r = 3$ into formula for volume of a sphere • Formula for volume of a hemisphere *High Partial Credit* • Formula correctly substituted • Answer not in terms of π • Correct answer without supporting work
(a) (ii)	$$V = \pi(3^2)h = 36\pi$$ $$\text{So } h = 4 \ \text{m}$$	**Scale 10D (0, 3, 5, 8,10)** *Low Partial Credit* • Formula for cylinder written with no substitution • Substitutes $r = 3$ into cylinder formula • Sets cylinder formula $= 36\pi$ *Mid Partial Credit* • Forms correct equation in h *High Partial Credit* • Correct equation in h **and** further significant work of merit in solving for h

Q8	Model Solution – 50 Marks	Marking Notes
(b) (i)	$$\tan A = \frac{47}{7 \cdot 5}$$ $$A = \tan^{-1}\left(\frac{47}{7 \cdot 5}\right)$$ $$A = 80 \cdot 93349°$$ $$A = 81°[\text{nearest degree}]$$	**Scale 5C (0, 2, 3, 5)** *Low Partial Credit:* • Correct trigonometric ratio • $a^2 = (7 \cdot 5)^2 + (47)^2$ *High Partial Credit:* • Fully substituted trigonometric ratio • Incorrect calculator mode but otherwise correct (only once in the paper) **Note:** Rad=1. Grad=90
(b) (ii)	$$\frac{3}{7 \cdot 5} = \frac{x}{47}$$ $$x = 18 \cdot 8$$ $$k = 47 - 18 \cdot 8 = 28 \cdot 2 \text{ m}$$ **OR** $$\frac{k}{47} = \frac{7 \cdot 5 - 3}{7 \cdot 5} = \frac{4 \cdot 5}{7 \cdot 5}$$ $$k = \frac{4 \cdot 5}{7 \cdot 5} \times 47 = 28 \cdot 2 \text{ m}$$ **OR** $$\tan 81° = \frac{x}{3}$$ $$x = 3(\tan 81)$$ $$x = 18 \cdot 94125$$ $$k = 47 - 18 \cdot 94125$$ $$k = 28 \cdot 058$$ $$k = 28 \cdot 06 \text{ m}$$	**Scale 5C (0, 2, 3, 5)** *Low Partial Credit* • One correct ratio of corresponding sides • Some correct substitution • Correct trigonometric ratio *High Partial Credit* • Correct equation in x • Error in setting up equation, but finishes correctly *Full Credit(–1)* • Correct value but no or incorrect unit **Note:** Rad $= 49 \cdot 433$ Grad$= 37 \cdot 248$

Q8	Model Solution – 30 Marks	Marking Notes
(c) **(i)**	Area $= \pi \, (50^2) = 7853 \cdot 98 \dots$ $= 7854 \text{ km}^2$ [nearest km^2]	**Scale 5B (0, 2, 5)** *Partial Credit* • Area of circle formula written *Full Credit(–1)* • Incorrect rounding *Full Credit:* • Correct answer without supporting work
(c) **(ii)**	$27 \; Nautical \; miles \; = 50 \text{ km}$ $1 \; Nautical \; mile \; = \dfrac{50}{27}$ $= 1 \cdot 8518 \dots$ $= 1 \cdot 852 \text{ [km]}$	**Scale 10B (0, 5, 10)** *Partial Credit* • $\dfrac{50}{27}$ • $\dfrac{27}{50}$, and finishes correctly *Full Credit (–1)* • Correct value, but incorrect rounding *Full Credit:* • Correct answer without supporting work
(d)	$\tan 1 \cdot 2° = \dfrac{49}{d}$ $d = \dfrac{49}{\tan 1 \cdot 2°}$ $d = 2339 \cdot 2 \; m$ $d = 2 \cdot 34 \text{ km}$	**Scale 10D (0, 3, 5, 8, 10)** *Low Partial Credit* • Tan formula written • Incorrect equation in d based on trig formula, but work of merit in solving equation • $\angle F = 88 \cdot 8°$ *Mid Partial Credit* • Correct equation in d • Incorrect equation in d based on trig formula, finishes correctly *High Partial Credit* Equation with d, as subject **Note:** Rad$= 0 \cdot 02$ Grad$= 2 \cdot 60$

Q9	Model Solution – 50 Marks	Marking Notes
(a)	Answer: 5 times Possible height: $\dfrac{8 \cdot 5}{5} = 1 \cdot 7$ m	**Scale 5B (0, 2, 5)** *Partial Credit:* • Correct box ticked • Incorrect box ticked but gives height consistent with answer
(b)	$V = (\text{Area of the face of the shed}) \times (\text{length})$ $V = \left((7 \times 12) + \dfrac{1}{2}(12 \times 1 \cdot 5) \right) 18$ $V = (84 + 9)18$ $V = (93)18$ $V = 1674\text{m}^3$ $V = (1674)1000$ $V = 1{,}674{,}000$ litres [>1,000,000]	**Scale 10D (0, 3, 5, 8, 10)** **1.** Finds area of face of shed **2.** Finds volume of shed, in m³, based on area of face **3.** Finds volume in litres, based on volume in m³ *Low Partial Credit* • Work of merit e.g. Finds area of rectangle or triangle, or step 2 or 3 correct based on own work in step 1 *Mid Partial Credit* • Step 1 correct • Error(s) in step 1, but other two steps correct based on this *High Partial Credit* • Step 1 correct, and one other step correct

Q9	Model Solution – 50 Marks	Marking Notes
(c)	$$d^2 = 6^2 + 1 \cdot 5^2$$ $$d^2 = 38 \cdot 25 \text{ or } \frac{153}{4}$$ $$d = \sqrt{38 \cdot 25}$$ $$d = 6 \cdot 18465$$ $$d = 6 \cdot 2 \text{ [m]}$$	**Scale 10D (0, 3, 5, 8, 10)** *Low Partial Credit* • Work of merit • Theorem of Pythagoras written *Mid Partial Credit* • Fully correctly-substituted Pythagoras Theorem • Error(s) in substituting into Pythagoras Theorem, but finishes correctly (must involve taking a square root) *High Partial Credit* • Writes or evaluates d^2 correctly

Q9	Model Solution – 50 Marks	Marking Notes

(d)
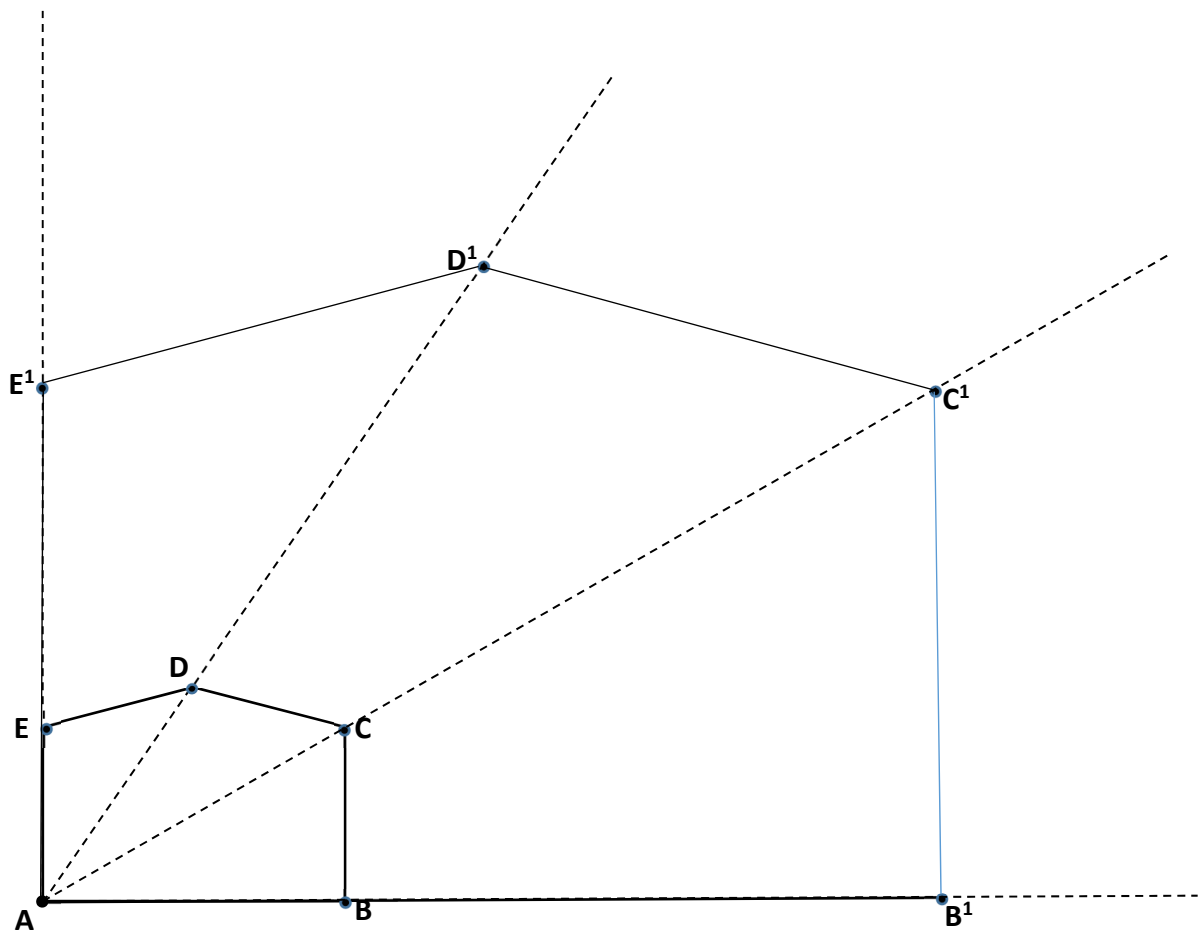
Note:

$|AB| \cong 4 \cdot 0$ cm

$|AC| \cong 4 \cdot 6$ cm

$|AD| \cong 3 \cdot 5$ cm

$|AE| \cong 2 \cdot 4$ cm

Scale 10C (0, 3, 7, 10)

Low Partial Credit:
- Work of merit
- Draws enlarged image correctly without construction line.
- Draws THREE or FOUR rays with at least one image point marked
- Marks off any of the image points to satisfy the Scale Factor (3) e.g. Draws = [AE^1]

High Partial Credit
- Draws ray AD^1 along with TWO other correct rays and at least ONE correct image point
- Constructs D^1 along with TWO other correct image points

Q9	Model Solution – 50 Marks	Marking Notes
(e) (i)	$$x^2 = 3^2 + 7^2 - 2(3)(7)\cos 30$$ $$x^2 = 9 + 49 - 42\cos 30°$$ $$x^2 = 21 \cdot 6269$$ $$x = 4 \cdot 65047$$ $$x = 4 \cdot 65$$	**Scale 10D (0, 3, 5, 8, 10)** *Zero Credit:* • Treats triangle as right angled triangle *Low Partial Credit* • Work of merit • Cosine Rule formula written *Mid Partial Credit* • Fully correctly-substituted Cosine Rule (with $|BC|$ as an unknown) • Error(s) in substituting Cosine Rule, but finds x to 2 D.P. *High Partial Credit* • Fully correctly-substituted Cosine Rule, **and** (finds x^2 correct) • Finds x correctly from incorrect x^2 **Note:** Incorrect calculator mode (apply once in paper)

Q9	Model Solution – 50 Marks	Marking Notes
(e) (ii)	$$\frac{\sin C}{3} = \frac{\sin 30°}{4 \cdot 65}$$ $$\sin C = \frac{3(\sin 30°)}{4 \cdot 65}$$ $$C = \sin^{-1}\left(\frac{10}{31}\right)$$ $$C = 18 \cdot 819063 \dots$$ $$C = 19°$$ **OR** $3^2 = 7^2 + 4\cdot65^2 - 2(7)(4\cdot65)\cos(\angle ACB)$ $9 = 49 + 21\cdot6225 - 65\cdot1 \cos(\angle ACB)$ $$\cos(\angle ACB) = \frac{61\cdot6225}{65\cdot1}$$ $|\angle ACB| = 18\cdot8119\dots$ $=19$	**Scale 5C (0, 2, 3, 5)** *Low Partial Credit* • Correct relevant formula written *High Partial Credit* • Fully correctly-substituted relevant formula • Error(s) in substituting Sine Rule or Cosine Rule but continues correctly **Note:** For Sine Rule: $\qquad$ Answer $= 19°$ $\quad$ Radian Answer $= -0 \cdot 69(-1)$ Gradian Answer $= 19$ For Cosine Rule: $\qquad$ Answer $= 19°$ $\quad$ Radian Answer $= 0 \cdot 33(0)$ Gradian Answer $= 21$

Q10	Model Solution – 50 Marks	Marking Notes
(a)	Advantage: any valid advantage, for example: cheaper or faster or more practical Disadvantage: any valid disadvantage, for example: not as accurate, sampling bias,	**Scale 5B(0, 2, 5)** *Partial Credit* • One advantage or one disadvantage
(b) **(i)**	$M.E. = \dfrac{1}{\sqrt{n}}$ $M.E. = \dfrac{1}{\sqrt{1500}}$ $\qquad = 0 \cdot 0258 \times 100$ $\qquad = 2 \cdot 58 \ \%$ $\qquad = 2 \cdot 6 \ \%$	**Scale 5C (0, 2, 3, 5)** *Low Partial Credit:* • $\dfrac{1}{\sqrt{n}}$ written and stops *High Partial Credit:* • Formula substituted correctly but not evaluated i.e. $\dfrac{1}{\sqrt{1500}}$ • Answer given as 0.0258 *Full Credit:* • Correct answer with supporting work
(b) **(ii)**	$1500 \times 0{\cdot}71 = 1065$ [people]	**Scale 5B (0, 2, 5)** *Partial Credit:* • Work of merit e.g. $\dfrac{71}{100}$ or $0{\cdot}71$ or $\dfrac{1500}{100}$ or 15×71 *Full Credit:* • Correct answer without supporting work

Q10	Model Solution – 50 Marks	Marking Notes
(b)	**(iii)** $71 - 2 \cdot 6 \leq p \leq 71 + 2 \cdot 6$ $68 \cdot 4 \leq p \leq 73 \cdot 6$ [C.I.] **(iv)** $[H_0 = 65\%\,]$ $[H_A \neq 65\%]$. **Conclusion:** Reject the Null hypothesis and conclude that the figure of 65% has changed in 2022 **Reason**: The figure 65% is outside the 95% C.I.	**Scale 10D (0, 3, 5, 8, 10)** *Low Partial Credit* • Work of merit • Interval written as $\left[\hat{p} - \frac{1}{\sqrt{n}}, \hat{p} + \frac{1}{\sqrt{n}}\right]$ in part (iii)and/or(iv). • Either lower **or** upper boundary as $68 \cdot 4$ **or** $73 \cdot 6$ in (iii) • Conclusion without reason correct in part (iv) • Reason without interpretation knowledge shown in part (iv) *Mid Partial Credit* • Either part (iii) **or** part (iv) correct • Significant work of merit in both parts (Correct substitution in both parts) *High Partial Credit* • Either part correct **and** significant work in the other part
(c)	Probability (Exactly one adult jogs): $= 3[(0 \cdot 8)(0 \cdot 8)(0 \cdot 2)]$ $= 0 \cdot 384$ or $\left(\dfrac{48}{125}\right)$	**Scale 5C (0, 2, 3, 5)** *Low Partial Credit* • Work of merit • Works with $80\%(0 \cdot 8)$ • Indicates any one possible arrangement *High Partial Credit* • Multiplies 3 relevant numbers
(d)	$E(x) = \sum x\,P(x)$ $= 0(0 \cdot 3)6 + 52(0 \cdot 6)6 + 104(0 \cdot 1)6$ $= €249 \cdot 60$	**Scale 10C (0, 3, 7, 10)** *Low Partial Credit* • Work of merit • One correct term or operation indicated e.g. 0 or 6×52 *High Partial Credit* • One correct term, (other than 0) • 6×52 **and** 6×104 • $0 \cdot 6 \times$ a relevant number, **and** $0 \cdot 1 \times$ a relevant number • Correct answer without supporting work

Q10	Model Solution – 50 Marks	Marking Notes
(e)	$\text{Gold} - \text{Silver} = €670 - €420 = €250$ $\dfrac{250}{6} = 41{\cdot}66$ classes So least number $= 42$ [classes] **OR** $420 + 6n > 670$ $6n > 250$ $n > 41{\cdot}66\ldots$ $n = 42$ [as $n \in \mathbb{N}$]	**Scale 10C (0, 3, 7, 10)** *Low Partial Credit* • One relevant operation e.g. $670 - 420$ or $\dfrac{670}{6}$ • $420 + 6n$ or similar *High Partial Credit* • $\dfrac{670-420}{6}$ • $420 + 6n > 670$ **and** further work: finds $6n > 250$ **or** mishandles 420 but divides by 6 to find n *Full Credit −1* • Finds n, but no or incorrect rounding