Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2025
Deferred Examinations

Marking Scheme

Mathematics

Higher Level

V2

Note to teachers and students on the marking schemes for the deferred examinations

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. However, it should be noted that the marking schemes for the deferred examinations may not necessarily be as detailed as the corresponding marking schemes for the main sitting of an examination, which serve to ensure consistency across a large team of examiners.

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 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 between the main sitting and the deferred sitting and from year to year. In the case of the deferred examinations, this means that the level of detail may vary by question, as the marking scheme will only have been finalised for the questions attempted by the candidates who sat these examinations.

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 a senior examiner when in doubt.

Future Marking Schemes

Assumptions about future marking schemes on the basis of past schemes (whether for the main examinations or the deferred examinations) 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 concerned. Accordingly, aspects of the structure, detail and application of the marking scheme for a particular examination will not necessarily be the same for the deferred sitting as for the main sitting or from one year to the next.

Coimisiún na Scrúduithe Stáit

State Examinations Commission

Leaving Certificate Examination 2025

Deferred Examination 2025

Mathematics

Higher Level

Paper 1

Marking scheme

300 marks

Structure of the marking scheme – Paper 1

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**
Number of categories	2	3	4	5
5-mark scales		0, 2, 5	0, 2, 3, 5	0, 2, 3, 4, 5
10-mark scales			0, 4, 6, 10	0, 2, 4, 6, 10
15-mark scale			0, 4, 8, 15	0, 4, 7, 10, 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.

Marking scales – level descriptors

A-scales (two categories)

- incorrect response
- correct response

B-scales (three categories)

- response of no substantial merit
- partially correct response
- correct response

C-scales (four categories)

- response of no substantial merit
- response with some merit
- almost correct response
- correct response

D-scales (five categories)

- response of no substantial merit
- response with some merit
- response about half-right
- almost correct response
- correct response

General notes on the marking – Paper 1

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.

In general, an answer without sufficient supporting work is awarded the lowest level of credit above *No 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.

Steps

Where steps are listed in the Marking Notes, unless otherwise specified, it is to be taken that they can be independently correct / incorrect – 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. It is specifically noted where this does not hold. Note also that these steps may not need to be presented in the order specified in the Marking Notes.

Errors

Where a question is **not** marked using steps, if a candidate has a single error, they are generally awarded one level of credit below that which they would otherwise have been awarded. Similarly, where they have two errors, they are generally awarded two levels of credit below that which they would otherwise have been awarded. (If they present sufficient work for *Low Partial Credit*, they will be awarded this at a minimum, regardless of the number of errors.) For example, on a C-scale:

- *High Partial Credit*: One error, otherwise fully correct (or fully correct with a *)
- *Low Partial Credit*: Two errors, otherwise fully correct (or fully correct with a *)

Where a question **is** marked using steps, this does not apply. Instead, an error in a step means that the step has not been completed correctly; this does not affect the completion of other steps (unless it oversimplifies the work). So if a candidate has multiple errors on a single step, they could still be awarded up to *High Partial Credit*, depending on the marking scheme.

Slips and *

Where a candidate has a single * on their solution, this is ignored in the awarding of credit unless they would otherwise have *Full Credit*. Where a candidate has multiple *s, this is generally treated as an error.

Multiple answers
Where the solution requires substantial work, mark all separate attempts and award the marks for the best one, regardless of crossing out.

Where a solution requires selection from the question:

- If a candidate has crossed out answer(s), ignore the crossed-out answers
- If a candidate has multiple answers that are **not** crossed out, award the lowest mark associated with these answers (generally, this will be considered incorrect)

Square brackets
Where something is contained in square brackets in the model solution, it is **not** required for *Full Credit*.

Work of merit
Where the scheme indicates "work of merit", examples are given that exemplify the standard of work required to be considered work of merit in that particular question.

Palette of annotations available to examiners – Paper 1

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	Partial Credit		The work presented in the body of the script merits *Partial Credit*
L	Low Partial Credit		The work presented in the body of the script merits *Low Partial Credit*
M	Mid Partial Credit		The work presented in the body of the script merits *Mid Partial Credit*
H	High Partial Credit		The work presented in the body of the script merits *High Partial Credit*
F*	F star		The work presented in the body of the script merits *Full Credit – 1*
[	Left Bracket		Another version of this solution is presented elsewhere and it merits equal or higher credit
	Vertical wavy	No work on this page / portion of this page	
o	Oversimplify	The candidate has oversimplified the work	
WOM	Work of merit	The candidate has produced work of merit (in line with that defined in the scheme)	
	Stops early	The candidate has stopped early in this part	

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

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

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

Model Solutions & Marking Notes – Paper 1

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)	$x = \frac{8 \pm \sqrt{64 - 4(2)(-11)}}{2(2)}$ $x = \frac{8 \pm \sqrt{64 + 88}}{4}$ $= \frac{8 \pm \sqrt{152}}{4}$ $x = 5.082..$ or $-1.082..$ $x = 5.08$ or -1.08 [2d.p]	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit* • Work of merit, for example, quadratic formula with some correct substitution; trials values *High* Partial *Credit* • Fully substituted quadratic formula *Full Credit -1:* • Apply a * for no rounding or incorrect rounding
(b)	$2p + 7 \geq 3$ $\quad$ $2p + 7 \leq -3$ $p \geq -2$ $\quad$ $p \leq -5$ $p \leq -5$ $\quad$ $p \geq -2$ **OR** $(2p + 7)^2 \geq 3^2$ $4p^2 + 28p + 49 \geq 9$ $4p^2 + 28p + 40 \geq 0$ $p^2 + 7p + 10 \geq 0$ $(p + 2)(p + 5) \geq 0$ $p \leq -5 \quad p \geq -2$	**Scale 10D (0, 2, 4, 6, 10)** *Low Partial Credit* • Work of merit, for example, $2p + 7 \geq 3$, indicates squaring *Mid Partial Credit* • One value of p found • Quadratic equation/inequality (0 on RHS) *High Partial Credit* • Both values of p found *Full Credit-1* • Apply a * once if strict inequality/inequalities are used

Q1	Model Solution – 30 Marks	Marking Notes
(c)	$\log_2(8-4n)-\log_2 n^2=2$ $\log_2\frac{8-4n}{n^2}=2$ $\frac{8-4n}{n^2}=2^2$ $4n^2+4n-8=0$ $n^2+n-2=0$ $x=1\ or\ x=-2$ $but\ x>0\Rightarrow x=1$	**Scale 10D (0, 2, 4, 6, 10)** *Low Partial Credit* • Work of merit, for example, any correct use of logs *Mid Partial Credit* • Simplifies to an equation in n with one log *High Partial Credit* • Equation written without logs *Full Credit -1:* • Apply a * for incorrect solution not eliminated

Q2	Model Solution – 30 Marks	Marking Notes
(a)	Test for n = 1 $P(1)$: $1 = \frac{1(1+1)}{2}$ =1 true Assume true for $n = k$ $P(k)$: $1 + 2 + \cdots .. + k = \frac{k(k+1)}{2}$ Prove true for $n = k + 1$ $P(k+1)$: $1 + 2 + \cdots + k + k + 1 = \frac{(k+1)(k+1+1)}{2}$ $\frac{k(k+1)}{2} + (k+1) = \frac{(k+1)(k+2)}{2}$ $\frac{k(k+1)+2(k+1)}{2} = \frac{(k+1)(k+2)}{2}$ $\frac{(k+1)(k+2)}{2} = \frac{(k+1)(k+2)}{2}$ $\therefore P(k+1)$ is true [So true for $n = k + 1$ if true for $n = k$.] Therefore, true for all $n \in \mathbb{N}$.	**Scale 15D (0, 4, 7, 10, 15)** **Step 1:** $P(1)$ verified **Step 2:** $P(k)$ stated **Step 3:** $P(k+1)$ stated and some valid work in using $P(k)$ to prove $P(k+1)$ **Step 4:** $P(k+1)$ proved *Low Partial Credit:* • Work of merit, for example, writes $P(1)$ *Mid Partial Credit:* • 2 steps correct *High Partial Credit:* • 3 steps correct *Full Credit –1:* • Omits part or all of conclusion but otherwise correct. Conclusion has three parts; these do not all have to come at the end of the proof: ○ $P(1)$ true ○ $P(k)$ true implies $P(k+1)$ true ○ $P(n)$ true for all $n \in \mathbb{N}$
(b) **(i)**	$\frac{1}{y} + 2y = 3$ $2y^2 - 3y + 1 = 0$ $(2y-1)(y-1) = 0$ $y = \frac{1}{2}$ *and* $y = 1$	**Scale 5D (0, 2, 3, 4, 5)** *Low Partial Credit* • Work of merit, for example, some correct transposition, trials values *Mid Partial Credit* • Sets up quadratic equation *High Partial Credit:* • Factors found • Correctly substituted quadratic formula

Q2	Model Solution – 30 Marks	Marking Notes
(b) (ii)	$y = 4^x$ $4^x = \frac{1}{2}$ | $4^x = 1$ $2^{2x} = 2^{-1}$ | $x = 0$ $x = -\frac{1}{2}$	**Scale 10D (0, 2, 4, 6, 10)** *Low Partial Credit:* • Work of merit, for example, some work in writing given equation in the form of that in (b)(i), lets $y = 4^x$, $4^{-x} = \frac{1}{4^x}$ *Mid Partial Credit* • Lets $4^x = 1$ **or** $4^x = \frac{1}{2}$ *High Partial Credit:* • Finds one correct value of x

Q3	Model Solution – 30 Marks	Marking Notes
(a)	<table><tr><th>Complex Number</th><th>Point on the Argand Diagram (**A**, **B**, or **C**)</th></tr><tr><td>$-z_1$</td><td>B</td></tr><tr><td>$\overline{z_1}$</td><td>C</td></tr><tr><td>$i\,z_1$</td><td>A</td></tr></table>	**Scale 5C (0, 2, 3, 5)** *Low Partial Credit:* • Work of merit, for example, shows understanding of conjugate; mentions anti-clockwise rotation, central symmetry *High Partial Credit:* • One point correctly identified
(b)	$r = 4 \qquad \theta = \frac{\pi}{2}$ $w^2 = 4\left(\cos\frac{\pi}{2} + i\sin\frac{\pi}{2}\right)$ $w = \left[4\left(\cos\left(\frac{\pi}{2} + 2n\pi\right) + i\sin\left(\frac{\pi}{2} + 2n\pi\right)\right)\right]^{\frac{1}{2}}$ $w = 2\left(\cos\left(\frac{\pi}{4} + n\pi\right) + i\sin\left(\frac{\pi}{4} + n\pi\right)\right)$ $n = 0$: $w = 2\left(\cos\left(\frac{\pi}{4}\right) + i\sin\left(\frac{\pi}{4}\right)\right) = \sqrt{2} + \sqrt{2}i$ $n = 1$: $w = 2\left(\cos\left(\frac{5\pi}{4}\right) + i\sin\left(\frac{5\pi}{4}\right)\right) = -\sqrt{2} - \sqrt{2}i$	**Scale 15D (0, 4, 7, 10, 15)** Consider the solution as having 4 steps: **Step 1:** Finds $\boldsymbol{\theta}$ **Step 2:** Finds $\boldsymbol{r}$ **Step 3:** 1 root evaluated using De Moivre's Theorem **Step 4:** Finds 2nd root *Low Partial Credit:* • Work of merit, for example, plots $4i$, or indicates $z = (4i)^{\frac{1}{2}}$ *Mid Partial Credit:* • 2 steps correct *High Partial Credit:* • 3 steps correct • Roots found correctly, but one or both in polar form

Q3	Model Solution – 30 Marks	Marking Notes
(c)	2nd root $= 3 + i$ Sum of the roots $= 6$ Product of the roots $= 10$ Quadratic factor: $z^2 - 6z + 10$ $\frac{z^3-2z^2-14z+40}{z^2-6z+10} = z + 4$ 3rd root $= -4$ **OR** $(-4)^3 - 2(-4)^2 - 14(-4) + 40 = 0$ 3rd root $= -4$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit:* • Work of merit, for example, trials value(s), writes conjugate of $3 - i$, linear factor $z - 3 + i$ *High Partial Credit:* • Finds quadratic factor • Verifies that $z = -4$ is a root

Q4	Model Solution – 30 Marks	Marking Notes
(a)	$3x^2 - 32x + 54 = 2x + 14$ $3x^2 - 34x + 40 = 0$ $(3x - 4)(x - 10) = 0$ $x = \frac{4}{3}$ *or* $x = 10$ $y = 2\left(\frac{4}{3}\right) + 14 \Rightarrow y = \frac{50}{3}$ $y = 2(10) + 14 \Rightarrow y = 34$ **OR** $2x = y - 14$ $x = \frac{y}{2} - 7$ $y = 3\left(\frac{y}{2} - 7\right)^2 - 32\left(\frac{y}{2} - 7\right) + 54$ $3y^2 - 152y + 1700 = 0$ $(3y - 50)(y - 34) = 0$ $y = \frac{50}{3}$ *or* $y = 34$ $x = \frac{4}{3}$ *or* $x = 10$	**Scale 10D (0, 2, 4, 6, 10)** *Low Partial Credit:* • Equation in one variable correctly established *Mid Partial Credit:* • Quadratic equation (=0) *High Partial Credit:* • x values found, but no y values • y values found, but no x values
(b)	No Any valid justification, for example, fails the Horizontal line test for all values of $y < 12$ Or similar	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit:* • Work of merit, for example shows some understanding of injectivity, sketches a graph showing max at (7,12) • Correct box ticked *High Partial Credit:* • Correct box ticked with work of merit in justification

Q4	Model Solution – 30 Marks	Marking Notes
(c)	$\int_2^8 \left(-\frac{1}{2}x^2 + 4x + 1 - (9-x)\right) dx$ $= \left\| -\frac{x^3}{6} + \frac{5x^2}{2} - 8x \right\|_2^8$ $= \left[-\frac{8^3}{6} + \frac{5(8)^2}{2} - 8(8)\right] - \left[-\frac{2^3}{6} + \frac{5(2)^2}{2} - 8(2)\right]$ $= 18$ units^2 **OR** $\int_2^8 \left(-\frac{1}{2}x^2 + 4x + 1\right) dx$ $= \left\| -\frac{x^3}{6} + 2x^2 + x \right\|_2^8$ $= \left[-\frac{8^3}{6} + 2(8^2) + 8\right] - \left[-\frac{2^3}{6} + 2(2^2) + 2\right]$ $= 42$ $\int_2^8 (9-x) dx$ $= \left\| 9x - \frac{x^2}{2} \right\|_2^8$ $= \left[9(8) - \frac{8^2}{2}\right] - \left[9(2) - \frac{2^2}{2}\right]$ $= 24$ Required Area $= 42 - 24 = 18$ units^2	**Scale 10D (0, 2, 4, 6, 10)** *Low Partial Credit:* • Integration indicated • Any correct integration • Finds $h(2)$ or $k(2)$ or $h(8)$ or $k(8)$ *Mid Partial Credit:* • Integration of both functions (or combined function) fully correct • One relevant area calculated *High Partial Credit:* • Fully correct substitution into integrated functions (or combined function)

Q5	Model Solution – 30 Marks	Marking Notes
(a)	$(x-1)(x^2-2x+1)$ $= x^3-2x^2+x-x^2+2x-1$ $= x^3-3x^2+3x-1$ **OR** $\binom{3}{0}(-1)^3+\binom{3}{1}(x)(-1)^2+\binom{3}{2}(x)^2(-1)+\binom{3}{3}(x)^3$ $= -1+3x-3x^2+x^3$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit:* • Work of merit, for example, some correct work in distributing the terms *High Partial Credit:* • 6 terms of the last 2 lines correct (Method 1) • Binomial expanded correctly (Method 2) • One error in binomial expansion, but otherwise correct
(b)	$3x^2-12x-15=0$ $x^2-4x-5=0$ $(x+1)(x-5)=0$ $x=-1 \ or \ x=5$ $h(-1)=18 \Rightarrow max=(-1,18)$ $h(5)=-90 \Rightarrow min=(5,-90)$	**Scale 10D (0, 2, 4, 6, 10)** *Low Partial Credit:* • Work of merit, for example, any correct differentiation; states $\frac{dy}{dx}=0$ *Mid Partial Credit:* • Differentiation fully correct *High Partial Credit:* • x values found *Full Credit -1* • Turning points found, but max/min not identified
(c)	$f(x)=2x+5+1(2x-1)^{-1}$ $f'(x)=2-1(2x-1)^{-2}(2)$ $\frac{2}{(2x-1)^2}=2$ $2(2x-1)^2=2 \Rightarrow 2(4x^2-4x+1)=2$ $8x^2-8x=0$ $8x(x-1)=0$ $x=0 \ or \ x=1$	**Scale 10D (0, 2, 4, 6, 10)** Note: Award Low Partial Credit at most, if chain or quotient rule is not used *Low Partial Credit:* • Work of merit, for example, any correct differentiation; $f(x)=2x+5+(2x-1)^2$ *Mid Partial Credit*: • Differentiation fully correct *High Partial Credit*: • Quadratic without fraction

Q6	Model Solution – 30 Marks	Marking Notes
(a)	$$6.7(1.1)^n > 20$$ $$n = \log_{1.1}\frac{20}{6.7}$$ $$n = 11.47\ldots$$ $$n = 12$$	**Scale 10D (0, 2, 4, 6, 10)** *Low Partial Credit:* • Work of merit, for example, 6.7×1.1 or finds 10% of 6.7 *Mid Partial Credit* • Equation / inequality set up *High Partial Credit:* • Log equation in n
(b)	$f'(x) = (\sin 3x)(-\sin x) + (3\cos x \cos 3x)$ $f'\left(\frac{\pi}{4}\right) = \left(\sin\frac{3\pi}{4}\right)\left(-\sin\frac{\pi}{4}\right) + 3\cos\frac{\pi}{4}\cos\frac{3\pi}{4}$ $= -\frac{1}{2} - \frac{3}{2}$ $= -2$	**Scale 10D (0, 2, 4, 6, 10)** Consider as 3 steps: **Step 1:** Finds $f'(x)$ **Step 2:** Substitutes $\frac{\pi}{4}$ for x in $f'(x)$ **Step 3:** Evaluates $f'\left(\frac{\pi}{4}\right)$ **Note:** Award LP credit at most if product rule is not used. *Low Partial Credit:* • Work of merit, for example, some correct differentiation *Mid Partial Credit:* • One step correct *High Partial Credit:* • Two steps correct
(c) **(i)** **(ii)**	**(i)** Any value of k , where $k > 12\ or\ k < -3$ **(ii)** $-3 < p < 7\ and\ 11 < p \leq 12$	**Scale 10C (0, 4, 6, 10)** **Note:** In c(ii) accept $\boldsymbol{p < 7\ and\ p > 11}$ *Low Partial Credit*: • Work of merit, for example, work on the diagram • Part (i) correct *High Partial Credit* • Part (i) correct and work of merit in part (ii) • Part (ii) correct

Q7	Model Solution – 50 Marks	Marking Notes
(a) **(b)**	**(a)** $$P(0) = Ae^{k(0)} = 101.3$$ $$A(1) = 101.3$$ **(b)** $$P(8849) = 101.3e^{\frac{\ln 0.88}{1000}(8849)}$$ $$p = 32.684\ldots$$ $$p = 32.68\ [1d.p.]$$	**Scale 10D (0, 2, 4, 6, 10)** *Low Partial Credit*: • Work of merit, for example, substitution of $h = 0$ in part(a) or correct substitution of k or h in part(b) *Mid Partial Credit* • One part correct *High Partial Credit*: • One part correct and work of merit in the 2nd part *Full credit-1* • Apply a * for incorrect rounding or no rounding in part (b)
(c)	$$101.3e^{\frac{\ln 0.88}{1000}(h)} = 80$$ $$e^{\frac{\ln 0.88}{1000}(h)} = \frac{80}{101.3}$$ $$\ln e^{\frac{\ln 0.88}{1000}(h)} = \ln\frac{80}{101.3}$$ $$h = \frac{\ln\frac{80}{101.3}}{\frac{\ln 0.88}{1000}} = 1846.62$$ $$= 1847 \text{ m [nearest m]}$$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit*: • Some correct substitution *High Partial Credit*: • Equation in h with no indices (logs handled correctly) *Full Credit -1* • Apply a * for incorrect rounding or no rounding
(d)	B Relevant reason given, for example, the graph of an exponential with a negative power will have a decreasing or decaying curve	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit:* • Correct box ticked • Some relevant calculations *High Partial Credit:* • Correct box ticked with relevant but incomplete calculations given

Q7	Model Solution – 50 Marks	Marking Notes
(e) (i)	$$p(8849)$$ $$= 101.325(1 - 2.2557 \times 10^{-5} \times 8849)^{5.2558}$$ $$= 31.441 \ldots$$ $$= 31.44\ units$$	**Scale 5B (0, 2, 5)** *Partial Credit*: • Correct substitution for h *Full Credit-1* • Apply a * for incorrect rounding or no rounding
(e) (ii)	$P(h) = 80$ $101.325(1 - 2.2557 \times 10^{-5} \times h)^{5.2558} = 80$ $(1 - 2.2557 \times 10^{-5} \times h)^{5.2558} = \frac{80}{101.325}$ $1 - 2.2557 \times 10^{-5} \times h = \left(\frac{80}{101.325}\right)^{\frac{1}{5.2558}}$ $2.2557 \times 10^{-5} \times h = 1 - \left(\frac{80}{101.325}\right)^{\frac{1}{5.2558}}$ $h = \frac{1 - \left(\frac{80}{101.325}\right)^{\frac{1}{5.2558}}}{2.2557 \times 10^{-5}}$ $h = 1949.07 \ldots$ $h = 1949$ m	**Scale 15C (0, 4, 8, 15)** *Low Partial Credit:* • Work of merit, for example, sets up an equation in h *High Partial Credit*: • Equation with h term to the power of 1 (3rd line of scheme) *Full Credit -1* • Apply a * for incorrect rounding or no rounding

Q8	Model Solution – 50 Marks	Marking Notes
(a) (i)	$285(1.0035)^{300} + 285(1.0035)^{299} +$ $\ldots 285(1.0035)^2 + 285(1.0035)$	**Scale 5C (0, 2, 3, 5)** *Low Partial Credit*: • Work of merit, for example, $F = P(1+i)^t$ with some correct substitution *High Partial Credit*: • 2 correct terms
(a) (ii)	$S_n = \frac{285(1.0035)(1-1.0035^{300})}{1-1.0035}$ $= [€]151\ 367.625..$ $= [€]151\ 367.63$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit*: • Some correct substitution into S_n formula *High Partial Credit*: • S_n formula with fully correct substitution *Full Credit-1* • Apply a * for no rounding or incorrect rounding
(b)	$A = 165646.2\left(\frac{0.0035(1.0035)^{240}}{1.0035^{240}-1}\right)$ $A = [€]1021.33$ **OR** $\frac{A}{1.0035} + \frac{A}{(1.0035)^2} + \cdots + \frac{A}{(1.0035)^{240}} = 165646.20$ $\left(\frac{\frac{1}{1.0035}\left(1-\frac{1}{1.0035^{240}}\right)}{1-\frac{1}{1.0035}}\right)A = 165\ 646.20$ $A = [€]1021.33$	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit*: • Work of merit, for example, states $n = 240$, some correct work in setting up the geometric sequence • Formula with some substitution *High Partial Credit*: • Fully substituted amortisation/S_n formula *Full Credit -1* • Apply a * for incorrect rounding or no rounding

Q8	Model Solution – 50 Marks	Marking Notes
(c) (i)	**Method 1** $0.4(x+y)=x$ $0.4y=0.6x$ $y=\frac{3x}{2}$ **Method 2** $40\%=x, 60\%=y$ $y=1.5x$	**Scale 5B (0, 2, 5)** Accept correct answer without work *Partial Credit*: • Work of merit, for example, mentions 60%
(c) (ii)	$x+1500=y+900$ $x+1500=\frac{3x}{2}+900$ $2x+3000=3x+1800$ $x=1200 \; and \; y=1800$ $Total=1200+1800+1500+900$ $=5400$	**Scale 10D (0, 2, 4, 6, 10)** *Low Partial Credit:* • Work of merit, for example, mentions $x+1500$ or $y+900$ *Mid Partial Credit:* • $x+1500=\mathrm{y}+900$ *High Partial Credit:* • Finds the value of x or y
(d)	$\frac{error}{Actual}\times 100=\%\, error$ $\frac{Actual-112}{Actual}=0.035$ $Actual=116.062\ldots$ $=116.1$ km/hour **OR** $96.5\%=112$ $100\%=\frac{112}{96.5}\times 100$ $=116.06$ $=116.1$ km/hour	**Scale 10C (0, 4, 6, 10)** *Low Partial Credit*: • Work of merit, for example, formula with some correct substitution, mentions 96.5% *High Partial Credit*: • Formula with full substitution • $96.5\%=112$ *Full Credit -1* • Apply a * for incorrect rounding or no rounding

Q9	Model Solution – 50 Marks	Marking Notes
(a) (i)	$20 = 4x + h$ $h = 20 - 4x$	**Scale 5B (0, 2, 5)** *Partial Credit:* • Work of merit, for example, diameter $= 4x$
(a) (ii)	$V(x) = \pi x^2(20 - 4x)$ $= 20\pi x^2 - 4\pi x^3$	**Scale 10C (0, 4, 6, 10)** **Note:** Accept candidates expression for $\boldsymbol{h}$ from part(i) *Low Partial Credit:* • Work of merit, for example, Volume of cylinder formula with some relevant substitution, brings expression from $\boldsymbol{h}$ down from part (i) *High Partial Credit:* • Volume of cylinder formula fully substituted in terms of x
(a) (iii)	$V(x) = 20\pi x^2 - 4\pi x^3$ $V'(x) = 40\pi x - 12\pi x^2 = 0$ $\pi x(40 - 12x) = 0$ $x = \frac{10}{3}$ $V\left(\frac{10}{3}\right) = 20\pi\left(\frac{10}{3}\right)^2 - 4\pi\left(\frac{10}{3}\right)^3$ $= 232.71\ldots$ $= 233$ cm³	**Scale 10D (0, 2, 4, 6, 10)** Consider solution as having 3 steps: **1.** Finds $\boldsymbol{V'(x)}$ **2.** Finds value of $\boldsymbol{x}$ for which $\boldsymbol{V'(x) = 0}$ **3.** Finds maximum volume *Low Partial Credit:* • Work of merit, for example, some correct differentiation *Mid Partial Credit:* • 1 step correct *High Partial Credit:* • 2 steps correct *Full Credit -1* • Apply a * for incorrect rounding or no rounding

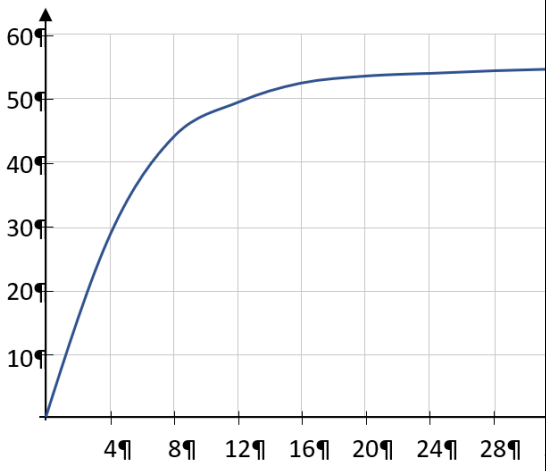
Q9	Model Solution – 50 Marks	Marking Notes
(a) (iv)	$V = 0 \Rightarrow 20\pi x^2 - 4\pi x^3 = 0$ $4\pi x^2(5 - x) = 0$ $x = 0 \; or \; x = 5$ $a = 0 \; and \; b = 5$	Accept correct answers without work **Scale 5C (0, 2, 3, 5)** *Low Partial Credit:* • Work of merit, for example, states $V = 0$ *High Partial Credit:* • One value of x given
(b) (i)	$(5h^2 + 4)^{\frac{3}{2}} - 6 = 203.285$ $(5h^2 + 4)^{\frac{3}{2}} = 209.285$ $5h^2 + 4 = (209.285)^{\frac{2}{3}}$ $h^2 = 6.24999$ $h = 2.4999$ $h = 2.5$ m	**Scale 5C (0, 2, 3, 5)** *Low Partial Credit:* • Equation set up *High Partial Credit:* • Equation with index removed (Line 3 of scheme) *Full Credit -1* • Apply a * for incorrect rounding or no rounding • Apply a * for incorrect units or no units
(b) (ii)	$\frac{dh}{dt} = 0.03$ $\frac{dV}{dh} = \frac{3}{2}(5h^2 + 4)^{\frac{1}{2}}(10h)$ $\frac{dV}{dt} = \frac{dv}{dh} \times \frac{dh}{dt}$ $= \frac{3}{2}(5h^2 + 4)^{\frac{1}{2}}(10h)(0.03)$ When $h = 1$ $\frac{dV}{dt} = \frac{3}{2}(5(1)^2 + 4)^{\frac{1}{2}}(10)(0.03)$ $= \frac{27}{20}$ $= 1.35$ [m³/hour]	**Scale 15D (0, 4, 7, 10, 15)** Consider the solution as consisting of 4 steps: **Step 1:** Finds $\frac{dV}{dh}$ **Step 2:** $\frac{dV}{dt} = \frac{dv}{dh} \times \frac{dh}{dt}$ **Step 3:** Fills in expressions for $\frac{dv}{dh}$ **and** $\frac{dh}{dt}$ **Step 4:** Evaluates $\frac{dV}{dt}$ at $h = 1$ Steps can happen in different orders. Step 2 does not need to be explicitly stated *Low Partial Credit* • States a relevant derivative, for example, $\frac{dh}{dt}$ *Mid Partial Credit:* • 2 steps correct *High Partial Credit* • 3 steps correct

10	Model Solution – 50 Marks	Marking Notes

t	0	4	8	12	16	20	24	28	32
$V(t)$	**0**	29·7	**43.1**	**49.1**	**51.8**	**53**	53·6	**53.8**	**53.9**

(a) (i)

Table + Graph



Scale 15D (0, 4, 7, 10, 15)
Consider solution as consisting of 17 parts
7 parts: 7 new table entries
9 parts: 9 points plotted from the values in the table
1 part: points joined appropriately

Low Partial Credit:

- 3 parts correct

Mid Partial credit:

- 8 parts correct

High Partial Credit:

- 14 parts correct

Full Credit-1

- Apply a * once for incorrect rounding
- 16 parts correct

(a) (ii)

$$V'(t) = 54(-e^{-0\cdot 2t}) \times (-0.2)$$
$$V'(1) = 54(-e^{-0\cdot 2}) \times (-0.2)$$
$$V'(1) = 8.8423$$
$$= 8.8 \text{ [m/s}^2\text{]}$$

Scale 10C (0, 4, 6, 10)

Low Partial Credit:

- Any correct differentiation

High Partial Credit:

- Differentiation fully correct

Full Credit -1

- Apply a * for incorrect rounding or no rounding

10	Model Solution – 50 Marks	Marking Notes
(a) (iii)	$\frac{1}{10-0}\int_0^{10} v(t)dt$ $\left\|\frac{1}{10}\left(54t-\frac{54e^{-0.2t}}{-0.2}\right)\right\|_0^{10}$ $\frac{1}{10}(540+36.54-270)$ $=\frac{1}{10}(306.54)=30.654$ $=31$ [m/s]	**Scale 10C (0, 4, 6, 10)** Indication of integration is required to be awarded any credit Accept correct answer without unit Consider solution as consisting of 4 steps: **Step 1:** $\frac{1}{10-0}\int_0^{10} v(t)dt$ **Step 2:** Integrates correctly **Step 3:** Substitutes in the limits **Step 4:** Evaluates correctly *Low Partial Credit:* • Work of merit, for example, Integral formulated correctly *Mid Partial Credit:* • 2 steps correct *High Partial Credit:* • 3 steps correct *Full Credit-1* • Apply a * for incorrect rounding
(a) (iv)	$\lim_{t\to\infty} 54(1-e^{-0.2t})$ $=54(1-0)$ $=54$ m/s	**Scale 10B (0, 5, 10)** Accept correct answer without work *Partial Credit:* • Work of merit, for example, substitutes 2 or more positive integers for t, • $\lim_{t\to\infty} 54(1-e^{-0.2t})$
(b)	Time for outward journey $=\frac{d}{x}$ Time for return journey $=\frac{d}{0.9x}$ $\frac{\frac{d}{0.9x}}{\frac{d}{x}}=\frac{1}{0.9}=1.111$ Percentage increase $=11.1\%$	**Scale 5B (0, 2, 5)** *Partial Credit:* • Work of merit, for example, return speed $=0.9x$

Coimisiún na Scrúduithe Stáit

State Examinations Commission

Leaving Certificate Examination 2025

Deferred Examination 2025

Mathematics

Higher Level

Paper 2

Marking scheme

300 marks

Structure of the marking scheme – Paper 2

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**
Number of categories	2	3	4	5
5-mark scales		0, 2, 5	0, 2, 3, 5	
10-mark scales		0, 5, 10	0, 4, 7, 10	0, 3, 5, 7, 10
15-mark scale			0, 5, 10, 15	0, 4, 7, 11, 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.

Marking scales – level descriptors

A-scales (two categories)

- incorrect response
- correct response

B-scales (three categories)

- response of no substantial merit
- partially correct response
- correct response

C-scales (four categories)

- response of no substantial merit
- response with some merit
- almost correct response
- correct response

D-scales (five categories)

- response of no substantial merit
- response with some merit
- response about half-right
- almost correct response
- correct response

General notes on the marking – Paper 2

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 scales above, or *Full Credit -1*.

Instructions regarding penalties for omitted or incorrect units are given in the scheme for each question to which they apply. A penalty for rounding is applied once per unit of marking (i.e., if parts (a) and (b) are marked as a single unit, a penalty for rounding is only applied once for (a) and (b) combined).

In general, an answer without sufficient supporting work is awarded the highest level of credit on the scale below *Full Credit* (typically *Partial Credit* or *High 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.

Steps
Where steps are listed in the Marking Notes, unless otherwise specified, it is to be taken that they can be independently correct / incorrect – 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. It is specifically noted where this does not hold. Note also that these steps may not need to be presented in the order specified in the Marking Notes.

Errors
Where a question is **not** marked using steps, if a candidate has a single error, they are generally awarded one level of credit below that which they would otherwise have been awarded. Similarly, where they have two errors, they are generally awarded two levels of credit below that which they would otherwise have been awarded. (If they present sufficient work for *Low Partial Credit*, they will be awarded this at a minimum, regardless of the number of errors.) For example, on a C-scale:

- *High Partial Credit*: One error, otherwise fully correct (or fully correct with a *)
- *Low Partial Credit*: Two errors, otherwise fully correct (or fully correct with a *)

Where a question **is** marked using steps, this does not apply. Instead, an error in a step means that the step has not been completed correctly; this does not affect the completion of other steps (unless it oversimplifies the work). So if a candidate has multiple errors on a single step, they could still be awarded up to *High Partial Credit*, depending on the marking scheme.

Slips and *
Where a candidate has a single * on their solution, this is ignored in the awarding of credit unless they would otherwise have *Full Credit*. Where a candidate has multiple *s, this is generally treated as an error.

Multiple answers
Where the solution requires substantial work, mark all separate attempts and award the marks for the best one, regardless of crossing out.

Where a solution requires selection from the question:

- If a candidate has crossed out answer(s), ignore the crossed-out answers
- If a candidate has multiple answers that are **not** crossed out, award the lowest mark associated with these answers (generally, this will be considered incorrect)

Square brackets
Where something is contained in square brackets in the model solution, it is **not** required for *Full Credit*.

Work of merit
Where the scheme indicates "work of merit", examples are given the exemplify the standard of work required to be considered work of merit in that particular question.

Palette of annotations available to examiners – Paper 2

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

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

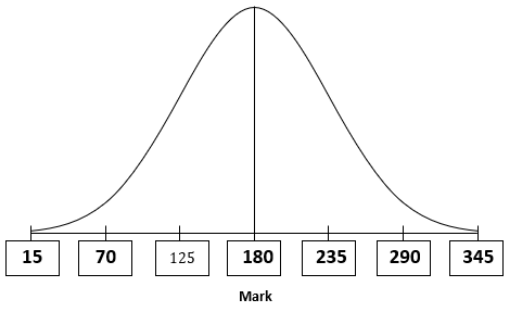
In a **C scale** that is **not** marked using steps, where * and  and  appear in the body of the work, then L should be placed in the right margin.

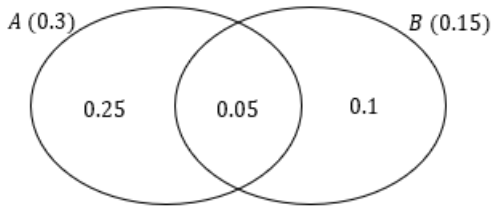
In the case of a **D scale** with the same annotations, M should be placed in the right margin.

Model Solutions & Marking Notes – Paper 1

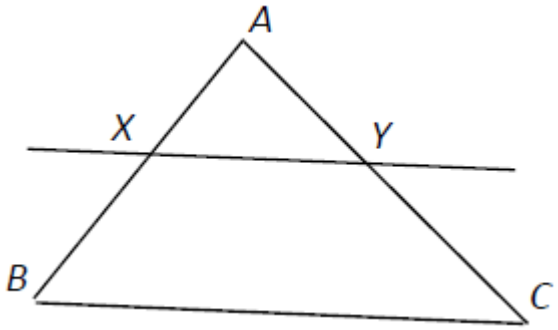
Note: The model solutions for each question are not intended to be exhaustive – there may be other correct solutions. Any Examiner unsure of the validity of the approach adopted by a particular candidate to a particular question should contact his / her Advising Examiner.

Q1	Model Solution – 30 Marks	Marking Notes
(a)(i)	$m_1 = \frac{1}{2}$ $m_2 = -1$	**Scale 10C (0, 4, 7, 10)** *Low Partial Credit* • Some effort at finding a slope *High Partial Credit* • One slope found
(a)(i)	$\tan\theta = \frac{\frac{1}{2} - (-1)}{1 + \frac{1}{2}(-1)} = 3$ $\tan^{-1} 3 = 71.56\ldots$ $= 71.6°$	**Scale 10C (0, 4, 7, 10)** *Low Partial Credit* • Some correct substitution into formula *High Partial Credit* • Fully correct substitution into formula *Full Credit -1* • Apply a * for no or incorrect rounding • Apply a * for no or incorrect units
(b)	$y = -x$ $\frac{\lvert x + y\rvert}{\sqrt{1^2 + 1^2}}$ $= \frac{\lvert 4 + 2\rvert}{\sqrt{2}}$ $= 3\sqrt{2}$	**Scale 10C (0, 4, 7, 10)** *Low Partial Credit* • Any correct substitution into formula • Finds the equation of the line AC *High Partial Credit* • Fully correct substitution into formula $\frac{\lvert 1(4)+1(2)\rvert}{\sqrt{1^2+1^2}}$ *Full Credit -1* • Apply a * for incorrect format

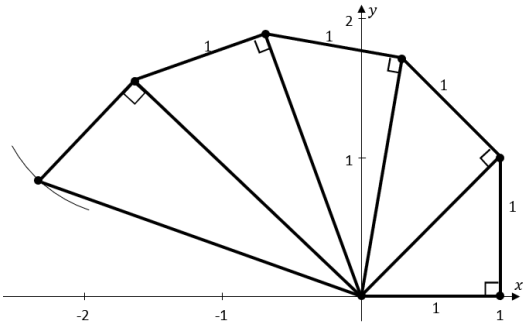
Q2	Model Solution – 30 Marks	Marking Notes
(a) **(i)** **(ii)**	**(i)**  **(ii)** $68 + 13.5 = 81.5\%$ $30\,000 \times 0.815 = 24\,450$	**Scale 15D (0, 4, 7, 11, 15)** *Low Partial Credit:* • Work of merit, for example, one correct entry in **(i)** • Work of merit, for example, a relevant percentage from the empirical rule in **(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 part
(b) **(i)**	$0\left(\frac{3}{5}\right) + 100\left(\frac{1}{20}\right) + 10\left(\frac{1}{4}\right) + 25\left(\frac{1}{10}\right)$ $= 10$ $10 + 0.5$ $= 10.50$	**Scale 10C (0, 4, 7, 10)** *Low Partial Credit:* • A correct term formulated *High Partial Credit:* • All terms formulated
(b) **(ii)**	$\frac{1}{4}$ The result of the previous spin doesn't influence the next spin	**Scale 5B (0, 2, 5)** *Partial Credit:* • Correct answer no justification

Q3	Model Solution – 30 Marks	Marking Notes
(a) **(i)** **(ii)**	**(i)**  $P(A\backslash B) = P(A) - P(A \cap B)$ $P(A\backslash B) = 0.25$ **(ii)** $P(A \cup B) = P(A) + P(B) - P(A \cap B)$ $0.3 + 0.15 - 0.05$ $= 0.4$ **OR** $0.3 + 0.1 = 0.4$	**Scale 10D (0, 3, 5, 7, 10)** *Low Partial Credit:* • Work of merit, for example, some relevant subtraction in **(i)** • Work of merit, for example, a relevant Venn diagram drawn 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 part
(b) **(i)** **(ii)**	**(i)** $x + 0.3$ **(ii)** 0	**Scale 10C (0, 4, 7, 10)** Accept correct answers without work *Low Partial Credit:* • Work of merit in **(i)** or **(ii)** *High Partial Credit:* • One part correct
(c)	$\frac{0.08}{x} = \frac{1}{3}$ $x = 0.24$	**Scale 10C (0, 4, 7, 10)** *Low Partial Credit:* • Relevant work on a Venn diagram *High Partial Credit:* • $\frac{0.08}{x}$

Q4	Model Solution – 30 Marks	Marking Notes
(a) **(b)**	**(a)** Reference angle = $45°$ or $\frac{\pi}{4}$ $360 - 45 = 315[°]$ $2\pi - \frac{\pi}{4} = \frac{7\pi}{4}$ **(b)** $\cos\left(-\frac{\pi}{6}\right) - \sin\left(-\frac{\pi}{6}\right)$ $\frac{1}{2} - \left(-\frac{\sqrt{3}}{2}\right)$ 1.3660	**Scale 10D (0, 3, 5, 7, 10)** *Low Partial Credit:* • Work of merit, for example, reference angle found in **(i)** • Work of merit, for example, some correct substitution in **(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 part *Full Credit -1* • Apply a * for incorrect format
(c)	$\sin 2x = \frac{\sqrt{3}}{2}$ $2x = 60$ $x = 30[°]$ $2x = 120$ $x = 60[°]$	**Scale 10C (0, 4, 7, 10)** *Low Partial Credit:* • Work of merit, for example, isolating $\sin 2x$ *High Partial Credit:* • One correct value for x
(d)	$A = 30$ $B = 250$ $C = \frac{2\pi}{3}$	**Scale 10C (0, 4, 7, 10)** *Low Partial Credit:* • Work of merit, for example, some understanding of the period or range • One value correct *High Partial Credit:* • Two values correct

Q5	Model Solution – 30 Marks	Marking Notes
(a)	*Diagram*:  Given: A triangle *ABC* and a line *XY* parallel to *BC* which cuts *AB* in the ratio $s : t$ where $s, t \in \mathbb{N}$. *To Prove*: $[AY] : [YC] = s : t$ *Construction*: Divide [*AB*] into *s* +*t* equal parts, *s* of them lying along [*AX*] and *t* of them lying along [*XB*]. Through each point of division draw a line parallel to [*BC*] *Proof*: By a previous theorem the parallel lines cut off segments of equal length along [*AC*]. Therefore [*AC*] is divided into $s + t$ equal parts with *s* of them forming [*AY*] and t of them forming [*YC*]. Let *k* be the length of one segment on [*AC*]. $$[AY] : [YC] = ks : kt = s : t$$	**Scale 15D (0, 4, 7, 11, 15)** *Low Partial Credit:* • Relevant diagram drawn *Mid Partial Credit:* • Construction clearly indicated *High Partial Credit:* • Proof missing 1 relevant step
(b)	Let $a = 8$ $$\frac{4}{7} = \frac{8}{8+d}$$ $$8 + d = 14$$ $$d = 6$$ Or similar	**Scale 15C (0, 5, 10, 15)** *Low Partial Credit:* • Work of merit, for example, a relevant ratio found *High Partial Credit:* • One variable written in terms of the other

Q6	Model Solution – 30 Marks	Marking Notes
(a) (i)	$$\text{Centre} = (2, -1)$$ $$r = \sqrt{2^2 + -1^2 + 20} = 5$$	**Scale 5C (0, 2, 3, 5)** *Low Partial Credit:* • Work towards finding the centre or radius *High Partial Credit:* • Centre or radius correct
(a) (ii)	$\text{Centre} = (-14, 11)$, $\text{radius} = 15$ $$\lvert c_1c_2 \rvert = \sqrt{(-14-2)^2 + (11-(-1))^2}$$ $$\lvert c_1c_2 \rvert = 20$$ $$r_1 + r_2 = 5 + 15 = 20$$ $$\lvert c_1c_2 \rvert = r_1 + r_2$$	**Scale 10D (0, 3, 5, 7, 10)** *Low Partial Credit:* • Radius and/or centre of circle t found • Some correct substitution into distance formula • Some understanding of circles touching externally *Mid Partial Credit:* • $r_1 + r_2$ found *High Partial Credit:* • $\lvert c_1c_2 \rvert$ found *Full Credit -1:* • Incorrect or no conclusion
(b) (i)	$$h^2 + h^2 = 2^2$$ $$h = \sqrt{2}$$ **OR** $$\sin 45 = \frac{h}{2}$$ $$h = \frac{2}{\sqrt{2}} = \sqrt{2}$$	**Scale 5B (0, 2, 5)** *Partial Credit:* • Work of merit, for example, some relevant work towards finding the value of h or relevant work on the diagram *Full Credit -1* • Apply a * for incorrect format
(b) (ii)	$$l = 2 + \sqrt{2}$$ $$l^2 = \left(2 + \sqrt{2}\right)^2$$ $$l^2 = 6 + 4\sqrt{2}$$	**Scale 10C (0, 4, 7, 10)** *Low Partial Credit:* • Some relevant use of their value of h or some use of area of a square *High Partial Credit:* • Length of the side of the square found

Q7	Model Solution – 50 Marks	Marking Notes
(a)		**Scale 10C (0, 4, 7, 10)** *Low Partial Credit:* • 90° angle correct or 1 unit correct *High Partial Credit:* • 90° angle correct and 1 unit correct
(b) (i)	$\tan A = 1 \Rightarrow A = 45°$ $\tan B = \frac{1}{\sqrt{2}} \Rightarrow B = 35.26$ $A + B = 80.26[°]$	**Scale 10C (0, 4, 7, 10)** *Low Partial Credit:* • 1 correct angle *High Partial Credit:* • 2 correct angles
(b) (ii)	$\sqrt{3}\sin 80.26$ $= 1.707 \ldots$ $= 1.71$	**Scale 5C (0, 2, 3, 5)** *Low Partial Credit:* • Work of merit, for example, use of trigonometry in co-ordinates or relevant work on the diagram *High Partial Credit:* • Finds the x co-ordinate
(c)	No The first triangle has two sides equal to one, the hypotenuse is always increasing while one side always equals one	**Scale 5B (0, 2, 5)** *Partial Credit:* • Correct answer (No) given
(d)	$\sqrt{1025}$ $1025 - 1 = 1024$	**Scale 5B (0, 2, 5)** *Partial Credit:* • $\sqrt{1025}$ found

Q7	Model Solution – 50 Marks	Marking Notes
(e)	$\sin(X+Y) = \sin X \cos Y + \cos X \sin Y$ $\sin X = \frac{1}{\sqrt{26}}$ $\quad$ $\cos X = \frac{5}{\sqrt{26}}$ $\sin Y = \frac{1}{\sqrt{27}}$ $\quad$ $\cos Y = \frac{\sqrt{26}}{\sqrt{27}}$ $\sin(X+Y) = \frac{1}{\sqrt{26}}.\frac{\sqrt{26}}{\sqrt{27}} + \frac{5}{\sqrt{26}}\frac{1}{\sqrt{27}}$ $= \frac{5+\sqrt{26}}{\sqrt{702}}$	**Scale 15D (0, 4, 7, 11, 15)** **There are four steps involved in the solution:** **Step 1**. Finds $sin\, X$ and $cos\, X$ **Step 2**. Finds $sin\, Y$ and $cos\, Y$ **Step 3.** Substitutes into the correct trigonometric formula **Step 4**. Finishes in correct form *Low Partial Credit:* • Work of merit, for example, $\sqrt{25}$ found or some relevant work with trigonometric ratios *Mid Partial Credit:* • Finds two of $\frac{1}{\sqrt{26}}, \frac{5}{\sqrt{26}}, \frac{1}{\sqrt{27}}, \frac{\sqrt{26}}{\sqrt{27}}$ • 1 step correct *High Partial Credit:* • 3 steps correct *Full Credit -1:* • Apply a * for incorrect format

Q8	Model Solution – 50 Marks	Marking Notes
(a) (i)	$$\frac{x}{\sin 36} = \frac{73}{\sin 81}$$ $$x = 43.443\ldots$$ $$x = 43.4 \text{ m}$$	**Scale 10C (0, 4, 7, 10)** *Low Partial Credit:* • Work of merit, for example, some correct substitution into the sine rule formula *High Partial Credit:* • Fully substituted sine rule formula
(a) (ii)	$$73^2 = 58^2 + 41^2 - 2(58)(41)\cos\theta$$ $$4756\cos\theta = -284$$ $$\theta = \cos^{-1}\left(-\frac{284}{4756}\right)$$ $$\theta = 93.423\ldots$$ $$\theta = 93.4°$$	**Scale 10C (0, 4, 7, 10)** *Low Partial Credit:* • Work of merit, for example, some correct substitution into the cosine rule formula *High Partial Credit:* • Fully substituted cosine rule formula *Full Credit -1* • Apply a * for no or incorrect units
(a) (iii)	$$Area\ \Delta ABC = \frac{1}{2}(73)(43.4)\sin 63$$ $$= 1411.44\ldots$$ $$Area\ \Delta ACD = \frac{1}{2}(58)(41)\sin 93.4$$ $$= 1186.907\ldots$$ $$Total\ area\ ABCD = 2598.35\ldots$$ $$2598.35\ldots \times 0.2$$ $$= 519.67\ldots$$ $$= 520\ [\text{m}^3]$$	**Scale 10D (0, 3, 5, 7, 10)** **There are four steps involved in the solution:** **Step 1**. Finds the area of ΔABC **Step 2**. Finds the area of ΔACD **Step 3.** Finds total area **Step 4**. Finds the volume *Low Partial Credit:* • Work of merit, for example, uses their answers from (i) or (ii) *Mid Partial Credit:* • 2 steps correct *High Partial Credit:* • 3 steps correct
(b) (i)	$$20\left(\frac{3\sqrt{3}}{2}L^2\right) + 12\left(\frac{L^2}{4}\sqrt{5\left(5+2\sqrt{5}\right)}\right)$$	**Scale 5B (0, 2, 5)** *Partial Credit:* • Total area of hexagons or pentagons found in terms of L

Q8	Model Solution – 50 Marks	Marking Notes
(b) (ii)	S.A. of sphere $4\pi(11)^2$ $= 484\pi$ $L^2\left(30\sqrt{3} + 3\sqrt{25 + 10\sqrt{5}}\right) = 484\pi$ $L^2 = 20.941\ldots$ $L = 4.576\ldots$ $L = 4.6$ cm	**Scale 10D (0, 3, 5, 7, 10)** **There are three steps involved in the solution:** **Step 1**. Finds the surface area of the sphere **Step 2**. Equates surface area of sphere to answer from (i) **Step 3.** Finishes *Low Partial Credit:* • Work of merit, for example, radius found or some substitution into surface area of a sphere formula or uses their answer from (i) *Mid Partial Credit:* • 1 step correct *High Partial Credit:* • 2 steps correct
(c)	$l^2 = n\,x^2$ $n = \frac{l^2}{x^2}$ $\frac{l}{x} = \sqrt{n}$ $l^3 = k\,x^3$ $k = \frac{l^3}{x^3}$ $\frac{l}{x} = \sqrt[3]{k}$ $\sqrt[3]{k} = \sqrt{n}$ $k = n^{\frac{3}{2}}$	**Scale 5D (0, 2, 3, 4, 5)** **There are three steps involved in the solution:** **Step 1**. Surface area equation **Step 2**. Volume equation **Step 3.** Finishes *Low Partial Credit:* • Work of merit, for example, some substitution into surface area or volume of a cube *Mid Partial Credit:* • 1 step correct *High Partial Credit:* • 2 steps correct

Q9	Model Solution – 50 Marks	Marking Notes
(a) (i)	<table><tr><th></th><th>Voted Alayah</th><th>Voted David</th><th>Total</th></tr><tr><td>Rural Voter</td><td>10%</td><td>8</td><td>18%</td></tr><tr><td>Urban Voter</td><td>51.8</td><td>30.2</td><td>82</td></tr><tr><td>Total</td><td>61·8%</td><td>38.2</td><td>100%</td></tr></table>	**Scale 10C (0, 4, 7, 10)** *Low Partial Credit:* • 1 correct new entry *High Partial Credit:* • 3 correct new entries
(a) (ii)	$P(D) + P(A) - P(D \cap A)$ $= 38.2 + 82 - 30.2$ $= 90\%$	**Scale 5B (0, 2, 5)** *Low Partial Credit:* • $P(D)$ or $P(A)$
(a) (iii)	$P(Urban/Alayah)$ $= \frac{51.8}{61.8}$ $= 0.8382$	**Scale 5C (0, 2, 3, 5)** *Low Partial Credit:* • 51.8 or 61.8 *High Partial Credit* • $\frac{51.8}{61.8}$
(a) (iv)	$P(P \cap Q) = P(P).P(Q)$ $(P \cap Q) = 0.518$ $P(P).P(Q) = (0.618)(0.82)$ $= 0.50676$ $0.518 \neq 0.50676$ $\Longrightarrow Not\ independent$	**Scale 5D (0, 2, 3, 4, 5)** *Low Partial Credit:* • Effort at independent formula *Mid Partial Credit:* • $P(P \cap Q) = 0.518$ • $P(P).P(Q) = 0.50676$ *High Partial Credit:* • $P(P \cap Q) = 0.518$ and $P(P).P(Q) = 0.50676$

Q9	Model Solution – 50 Marks	Marking Notes
(b) **(i)** **(ii)**	**(i)** $9!$ $= 362\,880$ **(ii)** $7! \times 3!$ $30\,240$	**Scale 10D (0, 3, 5, 7, 10)** *Low Partial Credit:* • Work of merit, for example, some relevant multiplication in **(i)** • Work of merit, for example, some understanding of arrangements in **(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 part
(c) **(i)**	0.65^6 0.0754	**Scale 10B (0, 5, 10)** *Partial Credit:* • Work of merit, 0.65 written
(c) **(ii)**	$P(6) = 0.35^6 = 0.001838\ldots$ $P(5) = \binom{6}{5}(0.35^5)(0.65) = 0.02048\ldots$ $P(4) = \binom{6}{4}(0.35^4)(0.65^2) = 0.0951\ldots$ $P(6) + P(5) + P(4) = 0.1174$ $\therefore n = 4$	**Scale 5D (0, 2, 3, 4, 5)** *Low Partial Credit:* • Work of merit, for example, effort at calculating the probability of one possible result *Mid Partial Credit:* • Probability of two results set up *High Partial Credit:* • Probability of three results set up

10	Model Solution – 50 Marks	Marking Notes
(a) (i)	$$\frac{82-78}{6}=0.67$$ $$74.86\%$$	**Scale 10C (0, 4, 7, 10)** *Low Partial Credit:* • Some correct substitution into formula *High Partial Credit:* • 3 correct new entries
(a) (ii)	$$\frac{70-78}{6}=-1.33$$ $$P(Z>-1.33)=0.9082$$ $$0.9082-0.5=0.4082$$ $$P(Z>x)=1-0.4082$$ $$0.5918$$ $$x=0.23$$ $$78+6(0.23)=79.38$$ $$=79.4$$	**Scale 10D (0, 3, 5, 7, 10)** *Low Partial Credit:* • Work of merit, for example, relevant diagram drawn or substitution into formula *Mid Partial Credit:* • Probability of two results set up *High Partial Credit:* • Probability of three results set up *Full Credit -1* • Apply a * for no or incorrect rounding
(b)	**Null Hypothesis**:$\mu=78$ **Alternative Hypothesis**: :$\mu\neq 78$ **Calculations**: $$Z=\frac{71-78}{\frac{6}{\sqrt{500}}}=-26.087\ldots$$ **Conclusion**: Reject H_O Driving times have changed **Reason**: $$-26.087<-1.96$$	**Scale 10D (0, 3, 5, 7, 10)** Note: 4 steps to check: **1.** Hypotheses **2.** Calculations **3.** Conclusion **4.** Reason Reason may be included with Calculations (or Conclusion), and must be based on relevant calculations – if either a confidence interval or test statistic is not found, a conclusion cannot be drawn If the null or alternative hypothesis is incorrect, then Step 1 is not considered correct. In this case, mark Steps 2 and 4 as if the null and alternative hypothesis had been given. However, Step 3 (conclusion) cannot be considered correct, so award *Mid Partial Credit* at most. *Low Partial Credit:* • Work of merit in one step *Mid Partial Credit:* • Two steps correct *High Partial Credit* • Three steps correct

10	Model Solution – 50 Marks	Marking Notes
(c) (i)	$\binom{4}{2}\binom{6}{3}$ $= 120$	**Scale 10C (0, 4, 7, 10)** *Low Partial Credit:* • $\binom{4}{2}$ or $\binom{6}{3}$ *High Partial Credit:* • $\binom{4}{2}$ and $\binom{6}{3}$
(c) (ii)	5W $\binom{6}{5} = 6$ 4W 1M $\binom{6}{4}\binom{4}{1} = 60$ 3W 2M $\binom{6}{3}\binom{4}{2} = 120$ $= 186$	**Scale 5C (0, 2, 3, 5)** *Low Partial Credit:* • Work of merit, for example, one possible committee written • One possible outcome formulated *High Partial Credit* • Two possible outcomes formulated
(c) (iii)	$\binom{10}{5} = 252$ $\frac{1}{251}$	**Scale 5C (0, 2, 3, 5)** *Low Partial Credit:* • Work of merit, for example, effort towards finding a relevant combination *High Partial Credit* • 252 and stops