OCR
Oxford Cambridge and RSA

GCE

Mathematics B MEI

H640/03: Pure Mathematics and Comprehension

A Level

Mark Scheme for June 2023

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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MARKING INSTRUCTIONS

PREPARATION FOR MARKING
RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor Online Training*; *OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **number of required** standardisation responses.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the RM Assessor 50% and 100% (traditional 40% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. **Annotations**

Annotation	Meaning
✓and ✗	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
E	Explanation mark 1
SC	Special case
^	Omission sign
MR	Misread
BP	Blank Page
Seen	
Highlighting	

Other abbreviations in mark scheme	Meaning
E1	Mark for explaining a result or establishing a given result
dep*	Mark dependent on a previous mark, indicated by *. The * may be omitted if only one previous M mark
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working
AG	Answer given
awrt	Anything which rounds to
BC	By Calculator
DR	This question included the instruction: In this question you must show detailed reasoning.
BP	Blank Page
Seen	
Highlighting	

5. **Subject Specific Marking Instructions**

a. Annotations must be used during your marking. For a response awarded zero (or full) marks a single appropriate annotation (cross, tick, M0 or ^) is sufficient, but not required.

For responses that are not awarded either 0 or full marks, you must make it clear how you have arrived at the mark you have awarded and all responses must have enough annotation for a reviewer to decide if the mark awarded is correct without having to mark it independently.

It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

Award NR (No Response)
- if there is nothing written at all in the answer space and no attempt elsewhere in the script
- OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
- OR if there is a mark (e.g. a dash, a question mark, a picture) which isn't an attempt at the question.

Note: Award 0 marks only for an attempt that earns no credit (including copying out the question).

If a candidate uses the answer space for one question to answer another, for example using the space for 8(b) to answer 8(a), then give benefit of doubt unless it is ambiguous for which part it is intended.

b. An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct solutions leading to correct answers are awarded full marks but work must not always be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly. Correct but unfamiliar or unexpected methods are often signalled by a correct result following an apparently incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.

If you are in any doubt whatsoever you should contact your Team Leader.

c. The following types of marks are available.

M

A suitable method has been selected and applied in a manner which shows that the method is essentially understood. Method marks are not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using

some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an M mark may be specified.
A method mark may usually be implied by a correct answer unless the question includes the DR statement, the command words “Determine” or “Show that”, or some other indication that the method must be given explicitly.

A
Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated Method mark is earned (or implied). Therefore M0 A1 cannot ever be awarded.

B
Mark for a correct result or statement independent of Method marks.

E
A given result is to be established or a result has to be explained. This usually requires more working or explanation than the establishment of an unknown result.

Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to a case where a candidate passes through the correct answer as part of a wrong argument.

d. When a part of a question has two or more ‘method’ steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. (The notation ‘dep*’ is used to indicate that a particular mark is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.

e. The abbreviation FT implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A and B marks are given for correct work only – differences in notation are of course permitted. A (accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, what is acceptable will be detailed in the mark scheme. If this is not the case please, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.

Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be 'follow through'. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

f. Unless units are specifically requested, there is no penalty for wrong or missing units as long as the answer is numerically correct and expressed either in SI or in the units of the question. (e.g. lengths will be assumed to be in metres unless in a particular question all the lengths are in km, when this would be assumed to be the unspecified unit.)
We are usually quite flexible about the accuracy to which the final answer is expressed; over-specification is usually only penalised where the scheme explicitly says so.
- When a value is given in the paper only accept an answer correct to at least as many significant figures as the given value.
- When a value is not given in the paper accept any answer that agrees with the correct value to 2 s.f. unless a different level of accuracy has been asked for in the question, or the mark scheme specifies an acceptable range.
  NB for Specification A the rubric specifies 3 s.f. as standard, so this statement reads "3 s.f".

Follow through should be used so that only one mark in any question is lost for each distinct accuracy error.
Candidates using a value of 9.80, 9.81 or 10 for g should usually be penalised for any final accuracy marks which do not agree to the value found with 9.8 which is given in the rubric.

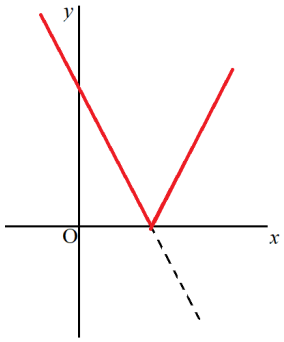
g. Rules for replaced work and multiple attempts:
- If one attempt is clearly indicated as the one to mark, or only one is left uncrossed out, then mark that attempt and ignore the others.
- If more than one attempt is left not crossed out, then mark the last attempt unless it only repeats part of the first attempt or is substantially less complete.
- if a candidate crosses out all of their attempts, the assessor should attempt to mark the crossed out answer(s) as above and award marks appropriately.

h. For a genuine misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A or B mark in the question. Marks designated as cao may be awarded as long as there are no other errors.
If a candidate corrects the misread in a later part, do not continue to follow through. E marks are lost unless, by chance, the given results are established by equivalent working. Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

i. If a calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers, provided that there is nothing in the wording of the question specifying that analytical methods are required such as the bold “In this question you must show detailed reasoning”, or the command words “Show” or “Determine”. Where an answer is wrong but there is some evidence of method, allow appropriate method marks. Wrong answers with no supporting method score zero. If in doubt, consult your Team Leader.

j. If in any case the scheme operates with considerable unfairness consult your Team Leader.

Question			Answer	Marks	AO	Guidance
1			**DR** $\frac{4}{13}+\cos^2\theta=1$ oe	**M1**	**1.1a**	**M0** if decimal angles (d, r, g) seen unless superceded by correct method
			$\cos^2\theta=\frac{9}{13}$	**A1**	**1.1**	
			$\cos\theta=-\frac{3}{\sqrt{13}}$	**A1**	**2.2a**	OR $\cos\theta=-\frac{3\sqrt{13}}{13}$ If decimals seen (as check) isw
			Alternative method $13=4+a^2$ or correct triangle $\left(2,\ 3,\ \sqrt{13}\right)$ seen	**M1**		
			$a=(\pm)3$ soi	**A1**		
			$\cos\theta=-\frac{3}{\sqrt{13}}$	**A1**		
				[3]		

Question			Answer	Marks	AO	Guidance
2	(a)			B1 [1]	1.1	Going over the given line above the x-axis and to the left of the y-axis and then going up from the x-axis at the same angle (by eye) Condone right hand line segment dotted/dashed
2	(b)		$-3 < 5 - 2x < 3$ $2 < 2x < 8$ $1 < x < 4$ oe e.g. '$1 < x$ and $x < 4$'	M1 A2 [3]	1.1a 1.1 1.1	Could be treated as two separate inequalities (at least one correct) in x not $\lvert x \rvert$ OR $(5-2x)^2 < 9$ If only one linear inequality in x stated scores **M0 A0 A0** OR $4x^2 - 20x + 16 < 0$ or $x^2 - 5x + 4 < 0$ OR $(x-1)(x-4) < 0$ Allow **M1** if treated as equations in x not $\lvert x \rvert$ **A1** if only one inequality correct OR for $1 \leq x \leq 4$ OR for $1 < x$, $x < 4$ OR for '$1 < x$ or $x < 4$'

Question			Answer	Marks	AO	Guidance
3			**DR** $\frac{\sqrt{6}-\sqrt{5}}{6-5}+\frac{\sqrt{7}-\sqrt{6}}{7-6}$ oe	**M1**	**3.1a**	Rationalising denominators. This is the minimum working needed for **M1** Accept 1 for "6 – 5" and – 1 for "5 – 6" etc
			$\sqrt{7}-\sqrt{5}$ or $\frac{\sqrt{5}-\sqrt{7}}{-1}$	**A1**	**1.1**	
			$\frac{k}{\sqrt{5}+\sqrt{7}}=\frac{k\left(\sqrt{7}-\sqrt{5}\right)}{7-5}=\sqrt{7}-\sqrt{5}$		**2.2a**	
			so $k=2$	**A1**		Finding k convincingly after **M1**
			Alternative $\left(\sqrt{6}+\sqrt{7}\right)\left(\sqrt{5}+\sqrt{7}\right)+\left(\sqrt{5}+\sqrt{6}\right)\left(\sqrt{5}+\sqrt{7}\right)$ $=k\left(\sqrt{5}+\sqrt{6}\right)\left(\sqrt{6}+\sqrt{7}\right)$	**M1**		For dealing appropriately with fractions (working with both sides) e.g. clearing the fractions or making k the subject with the RHS as a single fraction. $k=\frac{\left(\sqrt{5}+\sqrt{7}+2\sqrt{6}\right)\left(\sqrt{5}+\sqrt{7}\right)}{\left(\sqrt{5}+\sqrt{6}\right)\left(\sqrt{6}+\sqrt{7}\right)}$
			$\left(2\sqrt{5}\sqrt{6}+2\sqrt{5}\sqrt{7}+2\sqrt{6}\sqrt{7}+12\right)$ $=k\left(\sqrt{5}\sqrt{6}+\sqrt{5}\sqrt{7}+\sqrt{6}\sqrt{7}+6\right)$	**A1**		Expanding brackets and collecting like surds $k=\frac{12+2\sqrt{5}\sqrt{7}+2\sqrt{5}\sqrt{6}+2\sqrt{6}\sqrt{7}}{6+\sqrt{5}\sqrt{7}+\sqrt{5}\sqrt{6}+\sqrt{6}\sqrt{7}}$
			$2\left(\sqrt{5}\sqrt{6}+\sqrt{5}\sqrt{7}+\sqrt{6}\sqrt{7}+6\right)$ $=k\left(\sqrt{5}\sqrt{6}+\sqrt{5}\sqrt{7}+\sqrt{6}\sqrt{7}+6\right)$ so $k=2$	**A1**		Finding k convincingly after **M1**
				[3]		

Question			Answer	Marks	AO	Guidance
4			**DR**			
			$x^3 - 2x^2 - 5x + 6 = 0$			
			For $x = 1$, $1^3 - 2(1)^2 - 5(1) + 6 = 0$ oe so $x = 1$ is a root or $(x-1)$ is a factor	**M1**	**1.1a**	Finding one root or factor by factor theorem or division to a remainder of 0. A conclusion is needed for this **M1**.
			$(x-1)(x^2 - x - 6)$	**M1**	**1.1**	Factorising to find quadratic factor or division (method seen) or factor theorem again (substitution shown) to get a different root/factor
			$(x-1)(x-3)(x+2)$	**DM1**	**1.1**	Completion, all 3 factors/roots seen, dep on previous **M1** Might not be in same place
			(1, 0), (3, 0), (–2, 0)	**A1**	**1.1**	All 3 points as coordinates or pairs of values Dep on **M3**
				[4]		

Question			Answer	Marks	AO	Guidance	
5	(a)		**DR** $\frac{dy}{dx} = 3x^2 - 10x + 6$ When $x = 0$ $\frac{dy}{dx} = 6$ Tangent goes through origin so equation is $y = 6x$ cao	**M1** **M1** **A1** **[3]**	**1.1** **1.1** **1.1**	At least two terms correct FT *their* $\frac{dy}{dx}$ **Need reasoning** eg $y - 0 = 6(x - 0)$ or use of $y = mx + c$ $y = 6x$ implies previous **M** mark	
5	(b)		**DR** When $x = 1$ $\frac{dy}{dx} = -1$ Gradient of normal is 1 $[(y-2) = (x-1)$ so$]$ $y = x + 1$	**M1** **M1** **A1** **[3]**	**1.1** **1.1** **1.1**	FT *their* $\frac{dy}{dx}$ from (a) FT negative reciprocal of *their* $\frac{dy}{dx}$. oe but constant terms should be collected	
5	(c)		**DR** $6x = x + 1$ $x = \frac{1}{5}$, $y = \frac{6}{5}$ oe	**M1** **A1** **[2]**	**1.1** **1.1**	Eliminate a variable FT their equations from (a) and (b) for **M1** only	

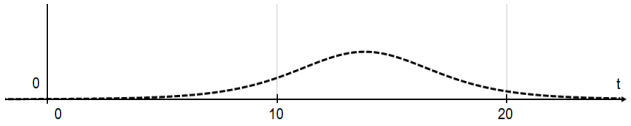
Question			Answer	Marks	AO	Guidance	
6	(a)	(i)	P (0.5, 0) Q (5.5, 0.5) R (4, 3.5) S (–1, 3) **[2]**	**B1** **B1**	**1.1** **1.1**	Any midpoint correct All midpoints correct If no labels BOD for 1 or 2 marks	

6	**(a)**	**(ii)**	Gradient PQ $= 0.1$ or length of PQ $= \frac{\sqrt{101}}{2}$ or vector $\overrightarrow{PQ} = \begin{pmatrix} 5 \\ 0.5 \end{pmatrix}$	**B1**	**1.1**	Gradient, length or vector of any one side of PQRS Or **SC1** if KLMN used	
			Gradient SR is $\frac{0.5}{5} = 0.1 =$ gradient PQ or length of SR $= \sqrt{0.5^2 + 5^2} = \frac{\sqrt{101}}{2}$ or vector $\overrightarrow{SR} = \begin{pmatrix} 4 - -1 \\ 3.5 - 3 \end{pmatrix} = \begin{pmatrix} 5 \\ 0.5 \end{pmatrix}$	**M1**	**2.2a**	Gradient of opposite side of PQRS **shown** to be equal or length or vector of opposite side **shown** to be equal. ie some working must be seen	Condone confusion of labels (eg length for gradient etc) for **M1/B1**
			Gradient PS $= -2$ or length of PS $= \frac{3\sqrt{5}}{2}$ or vector $\overrightarrow{PS} = \begin{pmatrix} -1.5 \\ 3 \end{pmatrix}$ Gradient QR is $\frac{3}{-1.5} = -2$ or length of QR $= \sqrt{1.5^2 + 3^2} = \frac{3\sqrt{5}}{2}$ or vector $\overrightarrow{QR} = \begin{pmatrix} 4 - 5.5 \\ 3.5 - 0.5 \end{pmatrix} = \begin{pmatrix} -1.5 \\ 3 \end{pmatrix}$				Watch out for valid alternatives e.g. 2 sides equal length and equal gradient
			Repeat process (as above) for other pair of opposite sides and conclude it's a parallelogram	**E1** **[3]**	**2.4**	Convincing completion dep on **M1**	

6	(b)	(i)	$\overrightarrow{WX} = -3\mathbf{c} - 3\mathbf{a} + 3\mathbf{b}$ $= 3(-\mathbf{a} + \mathbf{b} - \mathbf{c})$	**B1** **[1]**	**2.2a**	Convincing completion $\overrightarrow{WX} = \overrightarrow{WV} + \overrightarrow{VT} + \overrightarrow{TX}$	
6	(b)	(ii)	$\overrightarrow{AH} = -\mathbf{a} + \mathbf{b}$ $\overrightarrow{WX} = -3\mathbf{c} - 3\mathbf{a} + 3\mathbf{b}$ $\overrightarrow{WE} = -\mathbf{c} - \mathbf{a} + \mathbf{b}$ $\overrightarrow{DE} = \mathbf{c} - \mathbf{c} - \mathbf{a} + \mathbf{b} = -\mathbf{a} + \mathbf{b}$ So AH is parallel to DE	**B1** **E1** **[2]**	**1.1** **2.4**	$\overrightarrow{DE}$ from any correct route, must be shown Convincing completion with conclusion	
6	(b)	(iii)	$\overrightarrow{BC} = \mathbf{a} + \mathbf{c}$ $\overrightarrow{GF} = \mathbf{b} - (-\mathbf{c} - \mathbf{a} + \mathbf{b}) = \mathbf{c} + \mathbf{a}$ $\overrightarrow{BC} = \overrightarrow{GF}$ so they are parallel	**B1** **E1** **[2]**	**2.2a** **2.4**	$\overrightarrow{GF}$ from any correct route, must be shown Convincing completion with conclusion	

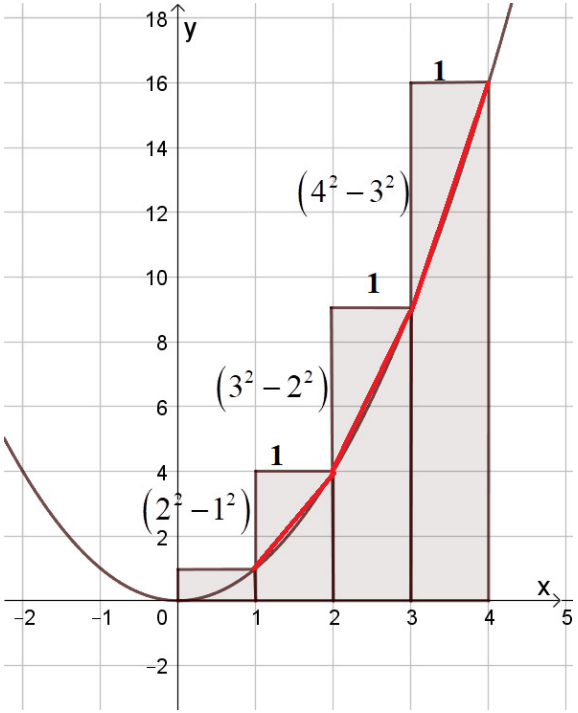
Question			Answer	Marks	AO	Guidance	
7			[Perimeter =] $2r + r\theta = 10$	M1	1.1		
			$\theta = \dfrac{10-2r}{r}$	B1	3.1a	OR $r = \dfrac{10}{2+\theta}$	Expression for one of r, θ in terms of the other
			$A = \dfrac{1}{2}r^2\theta$ so $A = \dfrac{r(10-2r)}{2} = 5r - r^2$	M1	3.1a	OR $A = \dfrac{100\theta}{2(2+\theta)^2} = \dfrac{50\theta}{(2+\theta)^2}$	Area in terms of either *their* r or *their* θ. Need not expand brackets.
			$A = 2.5^2 - (2.5-r)^2$	M1	3.1a	Completing the square	
			This has a max when $2.5 - r = 0$	B1	2.4	Convincing explanation that there is a max	
			Max = 6.25 [cm^2]	A1	2.2a		
			Alternative method 1				
			$\dfrac{dA}{dr} = 5 - 2r$	M1			
			$\dfrac{d^2A}{dr^2} = -2$ so max	B1			
			$\dfrac{dA}{dr} = 0 \Rightarrow r = 2.5$; Max = 6.25 [cm^2]	A1			
			Alternative method 2				
			$\dfrac{dA}{d\theta} = \dfrac{50(2+\theta)^2 - 100\theta(2+\theta)}{(2+\theta)^4} = \dfrac{100-50\theta}{(2+\theta)^3}$	M1		Reasonable attempt at quotient rule	
			$\dfrac{dA}{d\theta} = 0 \Rightarrow \theta = 2$; $A = 6.25$ [cm^2]	A1		For information	
			$\theta = 1.5 \Rightarrow \dfrac{dA}{d\theta} > 0$, $\theta = 2.5 \Rightarrow \dfrac{dA}{d\theta} < 0$ so max	B1		$\dfrac{d^2A}{d\theta^2} = -\dfrac{200}{256} = -0.78125$ at $\theta = 2$	
				[6]			

Question			Answer	Marks	AO	Guidance	
8			Sketch diagram consistent with information in the question	**B1**	**2.5**	Triangle ADC or ABC or quadrilateral ABCD and 8 and 12 indicated eg side lengths or radii. Circles may or may not be shown.	
			$60 = 2\times\frac{1}{2}\times 8\times 12\times\sin B$	**M1**	**3.1a**	**M1** implies previous **B1** These next 3 marks can be for angles *B* or *D*.	
			$\sin B = \frac{5}{8}$ so $B = 38.7°$ (0.675 rads)	**A1**	**1.1a**	One value of *B* or cos *B*	$\cos B = \frac{\sqrt{39}}{8}$
			OR $B = 141.3°$ (2.47 rads)	**A1**	**3.2a**	Other value of *B* or cos *B*	$\cos B = -\frac{\sqrt{39}}{8}$
			$AC^2 = 8^2 + 12^2 - 2\times 8\times 12\cos 38.7$ $= 58.1$	**M1**	**3.1a**	Use of cosine rule	
			AC = 7.62 cm	**A1**	**1.1**	Accept 7.6 www	
			$AC^2 = 8^2 + 12^2 - 2\times 8\times 12\cos 141.3$ $= 357.9$				
			AC = 18.9 cm	**A1**	**1.1**	Accept 19 www **A0** if more than 2 answers	
				[7]			

Question			Answer	Marks	AO	Guidance	
9	(a)	(i)	0.3 [MWh]	B1 [1]	3.4		
9	(a)	(ii)	27 [MWh]	B1 [1]	3.4	$P = 0.3e^{0.5\times9} = 27.0051...$	
9	(b)		Reason why model is not suitable, e.g. • The model is only based on data up to 2009 • The model predicts unlimited growth in solar energy and that is not possible	B1 [1]	3.5b	Very large prediction in 2025 (80 501MWh) in unrealistic "Extrapolation" alone does not score, it would need explaining/clarifying	
9	(c)		The graph gives a value close to 27 when $t = 9$	E1 [1]	3.2b	Correct reasoning (answer given)	
9	(d)	(i)		B1 B1 [2]	2.2a 2.2a	Gradient increasing from near zero to maximum for value of t somewhere between 10 and 20 Gradient decreasing to near zero from max value	
9	(d)	(ii)	14	B1 [1]	1.2	Answer in range 13 to 15	
9	(d)	(iii)	This is when the rate of increase of electricity production is greatest	E1 [1]	3.2a		
9	(e)		300 [MWh]	B1 [1]	2.2a	Accept answer in range 300 to 305	

Question			Answer	Marks	AO	Guidance
10	(a)		$1-\frac{3}{4}\sin^2 2\theta = 1-\frac{3}{4}(2\sin\theta\cos\theta)^2$ $= 1-3\sin^2\theta\cos^2\theta$	M1	3.1a	Use of double angle formula Allow 1 error
			$\left(\sin^2\theta+\cos^2\theta\right)^3 = \sin^6\theta+\cos^6\theta+3\sin^4\theta\cos^2\theta+3\sin^2\theta\cos^4\theta$	M1	3.1a	Use of given result with sin and cos Both sides seen but might not be equated
			$\sin^6\theta+\cos^6\theta = 1-\left(3\sin^4\theta\cos^2\theta+3\sin^2\theta\cos^4\theta\right)$	M1	2.2a	Use of $\sin^2\theta+\cos^2\theta=1$
			$\sin^6\theta+\cos^6\theta = 1-3\sin^2\theta\cos^2\theta\left(\sin^2\theta+\cos^2\theta\right)$ $= 1-3\sin^2\theta\cos^2\theta$ So LHS = RHS as required	E1 [4]	2.1	Convincing completion
10	(b)		$1-\frac{3}{4}\sin^2 2\theta$ has min value when $\sin^2 2\theta = 1$ oe	M1	1.1	
			Min value is $\frac{1}{4}$	A1 [2]	2.2a	$\frac{1}{4}$ unsupported does not score

Question			Answer	Marks	AO	Guidance	
11	(a)		55	B1 [1]	1.1	Method need not be shown	May be done BC
11	(b)		$\int_1^5 x^2 \mathrm{d}x + \frac{5^2+1^2}{2} + \frac{1^2-2^2}{12} - \frac{5^2-6^2}{12}$	M1	1.1	Correct substitution into formula Condone r but not n instead of x Square numbers may be evaluated	
			$\left[\frac{x^3}{3}\right]_1^5 + \frac{26}{2} - \frac{3}{12} + \frac{11}{12} = \frac{124}{3} + \frac{41}{3} = 55$	A1 [2]	2.2a	Correct completion. Integration may be done BC At least one step to be shown	

Question			Answer	Marks	AO	Guidance
12				B1 B1	3.2a 2.2a	Correct triangles identified At least one height correctly found and related to diagram
			Each triangle has area half base times height so $\frac{(2^2-1^2)}{2}$, $\frac{(3^2-2^2)}{2}$ and $\frac{(4^2-3^2)}{2}$.	B1 [3]	2.4	Correct completion (including base =1 either labelled on at least one triangle or stated (probably in calculation)) Dep on **B2**

Question			Answer	Marks	AO	Guidance	
13			$\int_1^n x^2\,\mathrm{d}x + \frac{n^2+1^2}{2} + \frac{1^2-2^2}{12} - \frac{n^2-(n+1)^2}{12}$	B1	1.1a	Substitute correctly into formula Condone r but not n instead of x	
			$\left[\frac{x^3}{3}\right]_1^n + \frac{6n^2+6+1-4-n^2+n^2+2n+1}{12}$				
			$\frac{n^3-1}{3} + \left[\frac{6n^2+2n+4}{12}\right]$	B1	1.1	Integral correctly evaluated	
			$\frac{2n^3+3n^2+n}{6}$	B1	2.1	Correct single fraction – may not be fully simplified	OR $\frac{n(n+1)(2n+1)}{6}$ $= \frac{2n^3+3n^2+n}{6}$
			$\frac{n(2n^2+3n+1)}{6} = \frac{n(n+1)(2n+1)}{6}$	B1	2.2a	Correct completion Intermediate step needed Dep on **B3**	OR convincing comparison of $\frac{n(n+1)(2n+1)}{6}$ and $\frac{n^3-1}{3} + \frac{6n^2+2n+4}{12}$
				[4]			

Question			Answer	Marks	AO	Guidance	
14			$\frac{1}{2n}+\frac{1}{2}+\frac{1}{12}-\frac{1}{24}-\frac{1}{12n}+\frac{1}{12(n+1)}$	**M1**	**1.1a**	Or better	
			$\left[\int_1^n \frac{1}{x}\,\mathrm{d}x\right]=\left[\ln x\right]_1^n=\ln n-\ln 1=\ln n$	**B1**	**1.1**	Integral correctly evaluated ln 1 or "ln n – 0" seen.	
			$\ln n+\frac{13}{24}+\frac{6(n+1)-1}{12n(n+1)}=\ln n+\frac{13}{24}+\frac{6n+5}{12n(n+1)}$	**A1**	**2.2a**	AG. Convincing completion	
				[3]			

Question			Answer	Marks	AO	Guidance	
15			$\sum_{r=1}^{6}\frac{1}{r}=\frac{49}{20}$	B1	1.1	2.45 (need not have working)	May be done BC
			$\ln 6+\frac{13}{24}+\frac{36+5}{12\times 6\times 7}=2.41477..$ % error = $100\times\frac{0.0352..}{2.45}=1.438\%$ This is less than 1.5% OR 1.5 % of actual and compare with 0.03523	B1 [2]	2.2a	Convincing completion	

APPENDIX

Exemplar responses for Q9(b)

Response	Mark

Exemplar responses for Q9(d)(iii)

Response	Mark

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