OCR
Oxford Cambridge and RSA

Friday 24 June 2016 – Morning

A2 GCE MATHEMATICS (MEI)

4754/01A Applications of Advanced Mathematics (C4) Paper A

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:
- Printed Answer Book 4754/01A
- MEI Examination Formulae and Tables (MF2)

Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

These instructions are the same on the Printed Answer Book and the Question Paper.

- The Question Paper will be found inside the Printed Answer Book.
- Write your name, centre number and candidate number in the spaces provided on the Printed Answer Book. Please write clearly and in capital letters.
- **Write your answer to each question in the space provided in the Printed Answer Book**. If additional space is required, you should use the lined page(s) at the end of the Printed Answer Book. The question number(s) must be clearly shown.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- You are permitted to use a scientific or graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.

INFORMATION FOR CANDIDATES

This information is the same on the Printed Answer Book and the Question Paper.

- The number of marks is given in brackets **[ ]** at the end of each question or part question on the Question Paper.
- You are advised that an answer may receive **no marks** unless you show sufficient detail of the working to indicate that a correct method is being used.
- The total number of marks for this paper is **72**.
- The Printed Answer Book consists of **16** pages. The Question Paper consists of **8** pages. Any blank pages are indicated.
- This paper will be followed by **Paper B: Comprehension**.

INSTRUCTION TO EXAMS OFFICER/INVIGILATOR

- Do not send this Question Paper for marking; it should be retained in the centre or recycled. Please contact OCR Copyright should you wish to re-use this document.

Section A (36 marks)

1 Express $\cos\theta - 3\sin\theta$ in the form $R\cos(\theta+\alpha)$, where $R > 0$ and $0 < \alpha < \frac{\pi}{2}$.

Hence show that the equation $\cos\theta - 3\sin\theta = 4$ has no solution. **[6]**

2 Given that $\left(1+\frac{x}{p}\right)^q = 1 - x + \frac{3}{4}x^2 + \ldots$, find p and q, and state the set of values of x for which the expansion is valid. **[7]**

3 Fig. 3 shows the curve $y = x^4$ and the line $y = 4$.

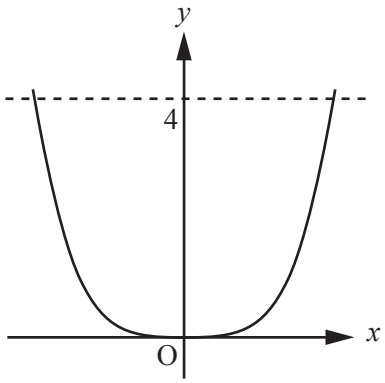

Fig. 3

The finite region enclosed by the curve and the line is rotated through 180° about the y-axis. Find the exact volume of revolution generated. **[4]**

4 Solve the equation $2\sin 2\theta = 1 + \cos 2\theta$ for $0° \leqslant \theta \leqslant 180°$. **[5]**

5 In Fig. 5, triangles ABC, ACD and ADE are all right-angled, and angles BAC, CAD and DAE are all θ.

AB = x and AE = $2x$.

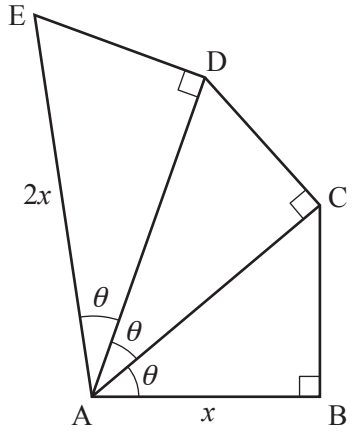

Fig. 5

(i) Show that $\sec^3\theta = 2$. **[3]**

(ii) Hence show the ratio of lengths ED to CB is $2^{\frac{2}{3}} : 1$. **[4]**

6 P is a general point on the curve with parametric equations $x = 2t, y = \frac{2}{t}$. This is shown in Fig. 6. The tangent at P intersects the x- and y-axes at the points Q and R respectively.

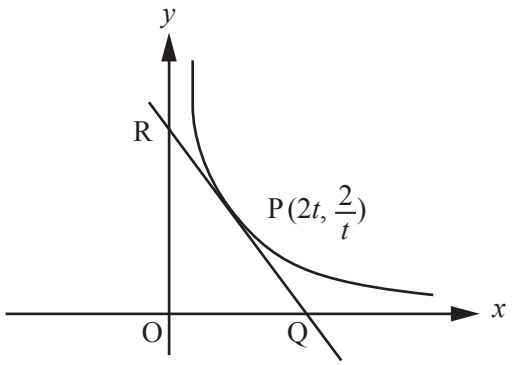

Fig. 6

Show that the area of the triangle OQR, where O is the origin, is independent of t. **[7]**

Section B (36 marks)

7 Fig. 7 shows a cuboid OABCDEFG with coordinates as shown. The point P has coordinates (4, 2, 0).

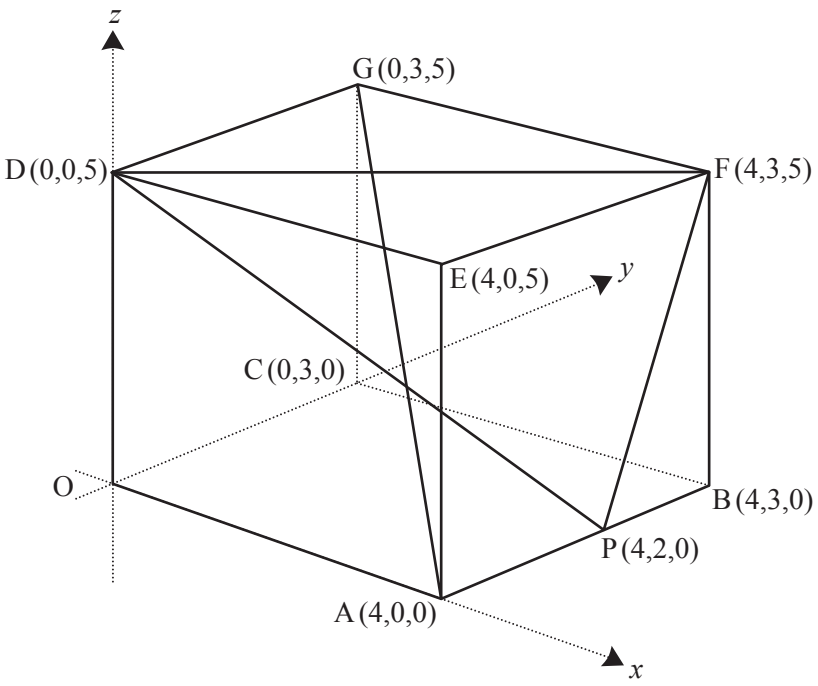

Fig. 7

(i) Find the length of the diagonal AG. **[2]**

(ii) Show that the vector $\mathbf{n} = 15\mathbf{i} - 20\mathbf{j} + 4\mathbf{k}$ is normal to the plane DPF. Hence find the cartesian equation of this plane. **[6]**

The diagonal AG intersects the plane DPF at Q.

(iii) Write down a vector equation of the line AG. Hence find the coordinates of the point Q, and the ratio AQ : QG. **[6]**

(iv) Find the acute angle between the line AG and the plane DPF. **[4]**

8 **(i)** Show that $\frac{1}{2+x}+\frac{1}{2-x}=\frac{4}{(2+x)(2-x)}$. **[1]**

In a chemical reaction, the time t minutes taken for a mass x mg of a substance to be produced is modelled by the equation

$$t=\ln\left(\frac{2+x}{2-x}\right).$$

(ii) Show that when $t = 0$, $x = 0$. **[2]**

(iii) Show that the rate of change of x is proportional to the product of $(2 + x)$ and $(2 – x)$, and find the constant of proportionality. **[4]**

(iv) Show that $x=\frac{2(1-\mathrm{e}^{-t})}{1+\mathrm{e}^{-t}}$.

Hence determine the long-term mass of the substance predicted by this model. **[4]**

In another chemical reaction, the mass x mg at time t minutes is modelled by the differential equation

$$\frac{\mathrm{d}x}{\mathrm{d}t}=k(2+x)(2-x)\mathrm{e}^{-t},$$

where k is a positive constant, and $x = 0$ when $t = 0$.

(v) Show by integration that, for this reaction, $\ln\left(\frac{2+x}{2-x}\right)=4k(1-\mathrm{e}^{-t})$. **[5]**

(vi) Given that the long-term mass of this substance is 1.85 mg, find the value of k. **[2]**

END OF QUESTION PAPER

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Friday 24 June 2016 – Morning

A2 GCE MATHEMATICS (MEI)

4754/01 Applications of Advanced Mathematics (C4)

INSTRUCTIONS

The examination is in two parts:

Paper A (1 hour 30 minutes)
Paper B (up to 1 hour)

Supervisors are requested to ensure that Paper B **is not issued** until Paper A has been collected in from the candidates.

Centres may, if they wish, grant a supervised break between the two parts of this examination.

Paper B should not be attached to the corresponding Paper A script. For Paper A only the candidates' Printed Answer Books, in the same order as the attendance register, should be sent for marking; the Question Paper should be retained in the centre or recycled. For Paper B only the Question Papers, on which the candidates have written their answers, should be sent for marking; the Insert should be retained in the centre or recycled. Any additional sheets used must be carefully attached to the correct paper.

For Paper B (Comprehension) only.

A standard English dictionary is allowed for the comprehension.
(Dictionaries to be used in the examination must be thoroughly checked before the examination.) Full regulations are in the JCQ Regulations and Guidance booklet.

This notice must be on the invigilator's desk at all times during the morning of Friday 24 June 2016.

OCR
Oxford Cambridge and RSA

Friday 24 June 2016 – Morning

A2 GCE MATHEMATICS MEI

4754/01A Applications of Advanced Mathematics (C4) Paper A

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* 4 7 5 4 0 1 A *

Candidate forename		Candidate surname	

Centre number						Candidate number				

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Section A (36 marks)

1	

2	

3	

4	

5 (i)	
5 (ii)	

6	

Section B (36 marks)

7 (i)	
7 (ii)	

7 (iii)	

7 (iv)	

8 (i)

8 (ii)

8 (iii)	

8 (iv)

8 (v)

8 (vi)	

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

OCR
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GCE

Mathematics (MEI)

Unit **4754A**: Applications of Advanced Mathematics: Paper A

Advanced GCE

Mark Scheme for June 2016

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

Annotations and abbreviations

Annotation in scoris	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
SC	Special case
^	Omission sign
MR	Misread
Highlighting	
Other abbreviations in mark scheme	**Meaning**
E1	Mark for explaining
U1	Mark for correct units
G1	Mark for a correct feature on a graph
M1 dep*	Method mark dependent on a previous mark, indicated by *
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working

Subject-specific Marking Instructions for GCE Mathematics (MEI) Pure strand

a Annotations should be used whenever appropriate during your marking.

The A, M and B annotations must be used on your standardisation scripts for responses that are not awarded either 0 or full marks. It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

For subsequent marking you must make it clear how you have arrived at the mark you have awarded.

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 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, award marks according to the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involved) 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, eg 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
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, eg 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, exactly what is acceptable will be detailed in the mark scheme rationale. If this is not the case please consult your Team Leader.

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 Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise. Candidates are expected to give numerical answers to an appropriate degree of accuracy, with 3 significant figures often being the norm. Small variations in the degree of accuracy to which an answer is given (e.g. 2 or 4 significant figures where 3 is expected) should not normally be penalised, while answers which are grossly over- or under-specified should normally result in the loss of a mark. The situation regarding any particular cases where the accuracy of the answer may be a marking issue should be detailed in the mark scheme rationale. If in doubt, contact your Team Leader.

g Rules for replaced work

If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests.

If there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others.

NB Follow these maths-specific instructions rather than those in the assessor handbook.

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 mark in the question.

Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

Question	Answer	Marks	Guidance
1	$\cos\theta - 3\sin\theta = R(\cos\theta\cos\alpha - \sin\theta\sin\alpha)$ $\Rightarrow 1 = R\cos\alpha, 3 = R\sin\alpha$	M1 A1	Correct pairs. Condone sign errors for the M mark (so accept $R\sin\alpha = -3$)
	$R^2 = 1^2 + 3^2 = 10 \Rightarrow R = \sqrt{10}$	B1	Or 3.2 or better, not $\pm\sqrt{10}$ unless $+\sqrt{10}$ chosen
	$\tan\alpha = 3 \Rightarrow \alpha = 1.249$	M1 A1	ft their pairs (condone sign errors but division must be the correct way round), A1 for 1.249 or better (accept 1.25), with no errors seen in method for angle
	Maximum value of $\cos\theta - 3\sin\theta$ is $\sqrt{10} < 4$	B1	Or equivalent convincing numerical statement that no solutions exist e.g. $\frac{4}{\sqrt{10}} > 1$. Maybe embedded in an attempt at a solution. Do not accept general statements e.g. 'doesn't work' – must be clear why no solutions exist – **dependent on first B1** **SC**: If candidates state that $\cos\alpha = 1, \sin\alpha = 3 \Rightarrow \tan\alpha = 3$ this could score M0A0B1M1A1B1 (so max 4/6) **Note that those candidates who state $R = \sqrt{10}$ and $\tan\alpha = 3$ with no (wrong) working seen could go on to score full marks**
		[6]	

Question	Answer	Marks	Guidance
2	$\left(1+\frac{x}{p}\right)^q = 1+q\frac{x}{p}+\frac{q(q-1)}{2!}\left(\frac{x}{p}\right)^2+\cdots$	M1*	One of $\frac{q}{p}x$ or $\frac{q(q-1)}{2!}\left(\frac{x}{p}\right)^2$ (soi), for example, $\frac{q}{p}=-1$ scores M1 A1
	$\frac{q}{p}=-1 \qquad \frac{q(q-1)}{2p^2}=\frac{3}{4}$	A1 A1	Allow x's on both sides of equations (if correct)
	$q=-p \Rightarrow \frac{-p(-p-1)}{2p^2}=\frac{3}{4}$ or $\frac{q(q-1)}{2q^2}=\frac{3}{4}$	M1dep*	Eliminating p (or q) from simultaneous equations (not involving x) involving both variables oe – if M1A1A1 awarded followed by either p or q correct (www) this implies this M mark
	$\Rightarrow p=2$	A1	$p=2$ www (or $q=-2$)
	$\Rightarrow q=-2$	A1ft	$q=-2$ (or $p=2$) for second value, ft their p or q (e.g. the negative of their p or q) provided first 4 marks awarded and only a single computational error in the method – so must be a correct method for solving their equation in p or q (ignore mention of p and/or $q=0$)
	Valid for $\left\|\frac{x}{2}\right\|<1 \Rightarrow \|x\|<2$	A1	or $-2<x<2$ www, allow $-2<\|x\|<2$ but not say, $x<2$
			SC If M0 M0 awarded and no wrong working seen then B1 for $p = 2$ <u>and</u> $q = -2$, B1 for $-2 < x < 2$ (oe) so max 2 marks
			Guidance for solving quadratics on this paper: use of correct quadratic equation formula (if formula is quoted correctly then only one sign slip is permitted, if the formula is quoted incorrectly M0, if not quoted at all substitution must be completely correct to earn the M1) or factorising (giving their x^2 term and one other term when factors multiplied out) or completing the square (must get to the square root stage involving ± and arithmetical errors may be condoned provided that perfect square term was correct)
		[7]	

Question	Answer	Marks	Guidance
3	$V = \pi\int_0^4 x^2 \mathrm{d}y$	M1	M1 for $k(\pi)\int_0^4 x^2(\mathrm{d}y)$ with correct limits and $k=1$ or $\frac{1}{2}$, allow correct limits seen or implied later, if formula not stated then must substitute for their x^2 correctly to imply this formula – condone lack of π for the M mark and $\mathrm{d}y$ throughout (condone incorrect use of $\mathrm{d}x$ too)
	$V = \pi\int_0^4 y^{\frac{1}{2}} \mathrm{d}y$	A1	Correct (**or** with a 1/2) – limits may be seen or implied through later working
	$\frac{2}{3}y^{\frac{3}{2}}$	B1	$\frac{2}{3}y^{\frac{3}{2}}$ or $\frac{1}{3}y^{\frac{3}{2}}$ (but only if $k=\frac{1}{2}$), condone $\frac{y^{1.5}}{1.5}$ (oe)
	$= \pi\left[\frac{2}{3}y^{\frac{3}{2}}\right]_0^4 = \frac{16\pi}{3}$	A1	Exact – mark **final** answer (so no isw if correct answer is subsequently halved) but if exact value seen and is then followed by 16.755… then isw
		[4]	

Question	Answer	Marks	Guidance
4	$4\sin\theta\cos\theta = 1 + 2\cos^2\theta - 1$	M1*	Use of correct double angle formulae: $\sin 2\theta \equiv 2\sin\theta\cos\theta$ **and** any one of $\cos 2\theta \equiv \cos^2\theta - \sin^2\theta$ or $1 - 2\sin^2\theta$ or $2\cos^2\theta - 1$
	$2\cos\theta(2\sin\theta - \cos\theta) = 0$	A1	Correct equation in solvable form e.g. $2\sin\theta - \cos\theta = 0$ (oe) or $5\sin^4\theta - 6\sin^2\theta + 1 = 0$ or $5\cos^4\theta - 4\cos^2\theta = 0$ but not $4\sin\theta\cos\theta = 2\cos^2\theta$
	$\Rightarrow \tan\theta = \frac{1}{2}$	M1dep*	Use of $\frac{\sin\theta}{\cos\theta} \equiv \tan\theta$ on their $\alpha\sin\theta + \beta\cos\theta = 0$ or correct method for solving quadratic in either $\sin^2\theta$ or $\cos^2\theta$ (See guidance in question 2 for solving quadratics)
	$\theta = 26.6^\circ$	A1	www (26.6 or better)
	$\theta = 90^\circ$	B1	Not from incorrect working
			Ignore additional solutions outside the range. If any additional solutions given inside the range $0 \le \theta \le 180^\circ$ **and** full marks would have been awarded then remove last mark (so 4/5)
			Both answers in radians: 0.464 (or better) and $\pi / 2$ scores B1
		[5]	Answers with no working scores B1 B1(so max 2/5)

Question			Answer	Marks	Guidance
5	(i)		$AC = x\sec\theta$	B1	Accept any equivalent form $(\text{e.g. } AC\cos\theta = x)$. If AC not seen then there must be a diagram as evidence of correct sides - $x\sec\theta$ with no AC is B0
			$AD = x\sec^2\theta$ and $AE = x\sec^3\theta$	B1	Accept $2x = x\sec^3\theta$ (as AE = 2*x*) or any equivalent form. Otherwise there must be a corresponding diagram as evidence of correct sides. Accept $\cos^3\theta = x / AC \times AC / AD \times AD / 2x$ for the first two marks
			$\Rightarrow x\sec^3\theta = 2x$		This line (oe) must be seen before the *x*'s cancelled
			$\Rightarrow \sec^3\theta = 2$*	B1	**NB AG** – dependent on all previous marks
				[3]	
			OR $AD = 2x\cos\theta$	B1	Same principles as above for each corresponding mark
			$AC = 2x\cos^2\theta$ and $AB = 2x\cos^3\theta$	B1	or $x = 2x\cos^3\theta$ (as AB = *x*)
			$2x\cos^3\theta = x \Rightarrow \sec^3\theta = 2$*	B1	Must see $2x\cos^3\theta = x$ (oe) before given answer
5	(ii)		$ED = 2x\sin\theta$	B1	oe e.g. $ED = \sqrt{4x^2 - AD^2}$ or $ED = AD\tan\theta$ with AD correctly expressed in terms of *x* and θ (or using $\theta = 37.5$ or better) - see (i) for alternatives for AD. Allow ED = 1.22*x* (or better) but B0 if ED = … missing
			$CB = x\tan\theta$	B1	oe e.g. $CB = \sqrt{AC^2 - x^2}$ or $CB = AC\sin\theta$ with AC correctly expressed in terms of *x* and θ (or using $\theta = 37.5$ or better) - see (i) for alternatives for AC. Allow CB = 0.77*x* (or better) but B0 if CB = … missing
			$\frac{ED}{CB} = \frac{2x\sin\theta}{x\tan\theta} = 2\cos\theta$	B1	www must come from exact working (so not using $\theta = 37.46...$ oe) - accept $\frac{ED}{CB} = \frac{2}{\sec\theta}$ or $\frac{ED}{CB} = \sec^2\theta$ (oe) (as from (i): $\sec^3\theta = 2$)
			$= 2 / 2^{\frac{1}{3}} = 2^{\frac{2}{3}}$*	B1	**NB AG** – dependent on all previous marks in (ii) – must be one step of intermediate working from $2\cos\theta$ to given answer
				[4]	

Question	Answer	Marks	Guidance
6	$\frac{dy}{dx} = \frac{dy/dt}{dx/dt} = \frac{-2/t^2}{2}\left(=-\frac{1}{t^2}\right)$	M1*	M1 for their (dy/dt) / their (dx/dt) in terms of t with at least one term correct
		A1	A1 cao (oe) – allow unsimplified even if subsequently cancelled incorrectly i.e. can isw
		M1dep*	$y-\frac{2}{t}=f(t)(x-2t)$ with any non-zero gradient expressed as a function of t - or any equivalent form (e.g. $y = mx + c$) but must have used the correct point $\left(2t, \frac{2}{t}\right)$ - if using $y = mx + c$ must explicitly have $c =$ ... before M1 can be awarded
	$y-\frac{2}{t}=-\frac{1}{t^2}(x-2t)$	A1	oe – need not be simplified
	When $x = 0$, $y=\frac{4}{t}$	A1ft	Must be a function of t
	When $y = 0$, $x = 4t$	A1ft	Must be a function of t
	So area of triangle = $\frac{1}{2}\times\frac{4}{t}\times 4t = 8$ (which is independent of t)	A1	No ft on this mark – an answer of 8 (www) with no additional comment is sufficient to award this mark
		[7]	
	OR (for the first two marks)		
	$y=\frac{2}{\left(\frac{x}{2}\right)}=\frac{4}{x}\Rightarrow\frac{dy}{dx}=-\frac{4}{x^2}$	M1*	Attempt to eliminate t and correctly differentiates their Cartesian equation
	$\Rightarrow\left(\frac{dy}{dx}\right)=-\frac{4}{(2t)^2}$	A1	

Question			Answer	Marks	Guidance
7	(i)		$AG = \sqrt{4^2 + 3^2 + 5^2}$ $= \sqrt{50}\ \left(= 5\sqrt{2}\right)$	B1 B1 **[2]**	Condone -4^2 etc. if recovered Correct answer implies both marks – accept 7.1 or better
7	(ii)		$\overrightarrow{DP} = 4\mathbf{i} + 2\mathbf{j} - 5\mathbf{k}$ or $\overrightarrow{PD} = -4\mathbf{i} - 2\mathbf{j} + 5\mathbf{k}$ $\overrightarrow{DF} = 4\mathbf{i} + 3\mathbf{j}$ (or $\overrightarrow{PF} = \mathbf{j} + 5\mathbf{k}$) $\mathbf{n} \cdot \overrightarrow{DP} = 15\times4 - 20\times2 + 4\times(-5) = 0$ $\mathbf{n} \cdot \overrightarrow{DF} = 15\times4 - 20\times3 = 0$ (or $\mathbf{n} \cdot \overrightarrow{PF} = -20\times1 + 4\times5 = 0$) $\mathbf{r} \cdot \mathbf{n} = \mathbf{a} \cdot \mathbf{n} \Rightarrow 15x - 20y + 4z = 20$	B1 B1 B1 B1 M1 A1 **[6]**	One correct direction vector in plane DPF (oe e.g. expressed as a column vector) Any other correct direction vector in plane DPF Scalar product with a **direction** vector in the plane (including evaluation and = 0) (**OR** M1 forms vector cross product with at least two correct terms in solution) Scalar product with a second **direction** vector in the plane (including evaluation and = 0) (following **OR** above, A1 all correct ie a multiple of $15\mathbf{i} - 20\mathbf{j} + 4\mathbf{k}$) (NB finding only one direction vector and its scalar product is B1 B0 B1 B0) $15x - 20y + 4z = c$ oe (accept any non-Cartesian form for M1 only) M1A0 for $15\mathbf{i} - 20\mathbf{j} + 4\mathbf{k} = 20$ **or** $15x - 20y + 4z - 20$ **SC1**: if states 'if $15\mathbf{i} - 20\mathbf{j} + 4\mathbf{k}$ is normal then of the form $15x - 20y + 4z = c$' and substitutes one coordinate gets M1A1, then substitutes the other two coordinates A3 (not A1, A1, A1). Then states 'so $15\mathbf{i} - 20\mathbf{j} + 4\mathbf{k}$ is normal' and states the correct equation of the plane this can get B1 provided that there is a clear argument ie M1A1A3B1. Without a clear argument this is B0 **SC2**: if finds two relevant **direction** vectors B1 B1 and then finds equation of the plane from vector form, $\mathbf{r} = \mathbf{a} + \lambda\mathbf{b} + \mu\mathbf{c}$ gets B1. Eliminating parameters B1 cao. If then states 'so $15\mathbf{i} - 20\mathbf{j} + 4\mathbf{k}$ is normal' can get B1, and then a valid reason why $15\mathbf{i} - 20\mathbf{j} + 4\mathbf{k}$ is normal scores the final B mark (each B mark is dependent on the previous one)

Question			Answer	Marks	Guidance
7	(iii)		$\mathbf{r} = 4\mathbf{i} + \ldots$	B1	Need $\mathbf{r}$ (or another single letter) =… **or** $\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \ldots$ for first B1
			$\ldots. + \lambda(-4\mathbf{i} + 3\mathbf{j} + 5\mathbf{k})$	B1	**NB answer is not unique** e.g. $\mathbf{r} = 3\mathbf{j} + 5\mathbf{k} + \mu(4\mathbf{i} - 3\mathbf{j} - 5\mathbf{k})$ - accept column vector form and condone row vectors (non-vector form scores B1 only)
			$15(4 - 4\lambda) - 20(3\lambda) + 4(5\lambda) = 20$	M1	Substituting their line in their plane equation from (ii) (condone a slip if intention clear) – their line and plane must be of the correct form (e.g. the line must be of the form $\mathbf{r} = \mathbf{a} + t\mathbf{b}$)
			$\Rightarrow 40 = 100\lambda$, $\lambda = 0.4$	A1	www cao **NB λ is not unique as depends on choice of line seen in this part**
			Q is (2.4, 1.2, 2)	A1	www - condone answer given as a position vector
			AQ : QG = 2:3	A1 **[6]**	oe www
7	(iv)			M1*	Selecting $15\mathbf{i} - 20\mathbf{j} + 4\mathbf{k}$ and **their** direction vector from (iii)
			Angle between $(-4\mathbf{i} + 3\mathbf{j} + 5\mathbf{k})$ and $(15\mathbf{i} - 20\mathbf{j} + 4\mathbf{k})$ is θ where $\cos\theta = \dfrac{(-4\times15) + (3\times-20) + (5\times4)}{\sqrt{50}\sqrt{641}}$	M1dep*	Correct formula (including cosine), with correct substitution, using their direction vector from (iii) and the correct normal vector - condone either a single numerical slip **or** a single sign slip (but not one of each) if intention is clear. So it must be clear where the slip comes from e.g. if the magnitude of one vector is stated incorrectly **with no working** then this is M0
			$\theta = 56.0$ or 124.0	A1	www cao (accept 56 or better, 124 or better, 2.16 radians or better, 0.978 radians or better)
			angle between line and plane = 34.0°	A1 **[4]**	www cao (accept 34 or better, 0.593 radians or better)

Question			Answer	Marks	Guidance
8	(i)		$\frac{1}{2+x}+\frac{1}{2-x}=\frac{2-x+2+x}{(2+x)(2-x)}=\frac{4}{(2+x)(2-x)}$*	B1 **[1]**	**NB AG** – must be at least one intermediate step before given answer – correct application of partial fractions is fine
8	(ii)		$\ln\left(\frac{2+x}{2-x}\right)=0\Rightarrow\frac{2+x}{2-x}=1$ $2+x=2-x\Rightarrow x=0$	B1 B1 **[2]**	or $=e^0$ or $\ln(2+x)=\ln(2-x)$ If only this line seen then award B0B1 **SC: Allow B1 only for verifying that when $x = 0$, $t = 0$**
8	(iii)		$t=\ln\left(\frac{2+x}{2-x}\right)=\ln(2+x)-\ln(2-x)$ $\left(\frac{dt}{dx}=\right)\frac{1}{2+x}+\frac{1}{2-x}$ $\frac{dt}{dx}=\frac{4}{(2+x)(2-x)}\Rightarrow\frac{dx}{dt}=\frac{1}{4}(2+x)(2-x)$ $k=\frac{1}{4}$ **See next page for an alternative solution**	B1 M1 A1 A1 **[4]**	 **Correct** differentiation of their t **OR for first two marks** - If no subtraction law of logs seen e.g. $\frac{dt}{dx}=\left(\frac{1}{\left(\frac{2+x}{2-x}\right)}\right)\left(\frac{(2-x)(1)-(2+x)(-1)}{(2-x)^2}\right)$ award B1 for correct first bracket (reciprocal expression) and B1 for second correct bracket (quotient/chain rule)(oe) – if additional constant(s) added (e.g. $t = k\ln(\ldots)$) then award B1 only for a constant times a fully correct derivative $\frac{dt}{dx}$ and $\frac{dx}{dt}$ must be correctly attributed to the correct expression for this mark Explicitly stating (that the constant of proportionality is) $\frac{1}{4}$ - therefore it is possible to score A0A1in this part

Question			Answer	Marks	Guidance
			OR		
			$\frac{dx}{dt} = k(2+x)(2-x) \Rightarrow \int \frac{dx}{(2+x)(2-x)} = k\int dt$	B1	Allow omission of dx and/or dt
			$\lambda \ln(2+x) + \mu \ln(2-x) = kt(+c)$	M1	Any non-zero constant λ, μ - further guidance in (v) for this and the next mark
			$\frac{1}{4}\left[\ln(2+x) - \ln(2-x)\right] = kt(+c)$	A1	www oe (condone absence of c)
			$x = 0, t = 0 \Rightarrow c = 0$		
			$\ln\left(\frac{2+x}{2-x}\right) = 4kt \Rightarrow k = \frac{1}{4}$	A1	www – must include c and show that $c = 0$. Must explicitly state that $k = \frac{1}{4}$
8	**(iv)**		$e^t = \frac{2+x}{2-x}$	B1	
			$(2-x)e^t = 2+x$		
			$\Rightarrow 2e^t - xe^t = 2+x$		Multiplying out, collecting x terms (condone sign slips and numerical errors (eg
			$\Rightarrow x(1+e^t) = 2e^t - 2$	M1	loss of a 2) only but M0 if e^t incorrectly replaced with e^{-t}) **and** factorising their x terms correctly
			$x = \frac{2(e^t-1)}{1+e^t} = \frac{2(e^t-1)e^{-t}}{(1+e^t)e^{-t}} = \frac{2(1-e^{-t})}{1+e^{-t}}$ *	A1	www **NB AG** – as AG must be an indication of how previous line leads to the required result (eg stating or showing multiplying by e^{-t})
			$(x \to)2$ (as $t \to \infty$)	B1	
				[4]	
			OR (for first three marks)		
			$e^{-t} = \frac{2-x}{2+x}$	B1	
			$(2+x)e^{-t} = 2-x$		
			$\Rightarrow 2e^{-t} + xe^{-t} = 2-x$	M1	Multiplying out, collecting x terms (condone sign slips as above) and factorising their x terms correctly
			$\Rightarrow x(1+e^{-t}) = 2-2e^{-t}$		
			$x = \frac{2(1-e^{-t})}{1+e^{-t}}$ *	A1	www **NB AG**

Question			Answer	Marks	Guidance
8	(v)		$\int \frac{1}{(2-x)(2+x)}\,\mathrm{d}x = k\int \mathrm{e}^{-t}\,\mathrm{d}t$	M1*	Separating variables - condone sign slips and issues with placement of *k* but M0 for $\int (2-x)(2+x)\mathrm{d}x = \ldots$ or equivalent algebraic error in separating variables unless recovered. If no subsequent work integral signs needed, but allow omission of d*x* and/or d*t* but must be correctly placed if present
			$\alpha\ln(2+x)+\beta\ln(2-x) = \gamma\mathrm{e}^{-t}(+c)$	A1	Any non-zero constants α, β, γ - **this line must be seen and cannot be implied by later working (as this is an AG) –** condone absence of *c* or if a constant present condone the use of *k* for their constant. Do not condone invisible brackets e.g. ln 2 + *x* unless recovered before subtraction law of logs applied – all of these points apply to the next A mark too
			$\ln(2+x)-\ln(2-x) = -4k\mathrm{e}^{-t}(+c)$	A1	www oe
			When $t=0, x=0 \Rightarrow c = 4k$	M1dep*	Substituting $x=0, t=0$ into each term in an attempt to find their *c* (must get *c* = …) – if they integrate and use *k* as their constant they must use $x=0, t=0$ to find this single *k* term only
			$\Rightarrow \ln\left(\frac{2+x}{2-x}\right) = 4k(1-\mathrm{e}^{-t})$*	A1	www **NB AG** must have obtained all previous marks in this part
				[5]	
			OR (for first 3 marks) – final M1A1 as above		
			$\int \frac{1}{(2-x)(2+x)}\,\mathrm{d}x = k\int \mathrm{e}^{-t}\,\mathrm{d}t$	M1*	Separating variables. If no subsequent work integral signs needed, but allow omission of d*x* or d*t*, but must be correctly placed if present
			$\int \frac{1}{4-x^2}\,\mathrm{d}x = k\int \mathrm{e}^{-t}\,\mathrm{d}t \Rightarrow \frac{1}{4}\ln\left(\frac{2+x}{2-x}\right) = -k\mathrm{e}^{-t}(+c)$	A2	**Must see** $1/(4-x^2)$ on lhs – please note that one A mark cannot be awarded
8	(vi)		as $t\to\infty$, $x\to 1.85 \Rightarrow \ln 3.85/0.15 = 4k$	M1	Sets e^{-t} to 0 and substitutes *x* = 1.85 – condone substitution of a 'large' value of *t* only if it leads to the correct value of *k*
			$\Rightarrow k = 0.811$	A1	$k = 0.25\ln(77/3)$ or 0.81 or better
				[2]	

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4754 Applications of Advanced Mathematics (C4)

General Comments:

The performance of candidates on Paper A was similar and comparable to recent papers and the standard of work in the majority of cases was very high. This paper was accessible to all candidates but there were sufficient questions for the more able candidates to show their skills.

Paper B, the comprehension, was well understood and most candidates scored good marks here.

Candidates made similar errors as in previous years and these included:

- Sign and basic algebraic errors (Question 2)
- Failure to include a constant of integration (Question 8(v))
- Poor anti-logging and rules of logarithms (Questions 8(iv) and 8(v))
- Failure to give clear descriptions in the comprehension paper (Questions 2 and 6)
- Inappropriate accuracy, for example in Question 4, candidates either gave insufficient accuracy (answers to the nearest integer) or they gave too much accuracy (answers to 2 or more decimal places) – candidates are reminded to give answers to 1 decimal place for questions involving trigonometry
- Failure to give exact answers when required (Questions 3 and 5(ii))
- Failure to give sufficient detail when verifying given results (Questions 5(i), 5(ii), 6, 7(ii), 8(i), 8(ii), 8(iii), 8(iv) and 8(v)).

Some candidates assume that showing that a vector is perpendicular to one vector in the plane is sufficient to show that it is a normal vector.

Quite a number of candidates failed to attempt some parts but there did not appear to be a shortage of time for either Paper.

Centres are again reminded that as Papers A and B are marked separately any supplementary sheets used must be attached to the appropriate paper. Furthermore, centres are requested that Papers A and B are not attached to each other and they must be sent separately for marking.

Comments on Individual Questions:

Paper A

Question 1

The majority of candidates correctly worked out the values of R and α although some candidates lost the first method mark by not including R in the expanded trigonometric statements $R\cos\alpha = 1$ and $R\sin\alpha = 3$. Some failed to give α in radians and a small minority stated R as10 rather than the correct $\sqrt{10}$. Candidates were less successfully in showing that $\cos\theta - 3\sin\theta = 4$ had no solutions with many simply stating that $\theta + 1.249 = \arccos\left(\frac{4}{\sqrt{10}}\right)$ 'does not work' or gives a 'math error'.

Many candidates failed to explain or give an equivalent mathematical statement that the maximum value of $\cos\theta - 3\sin\theta$ is $\sqrt{10}$ which is less than 4 and so did not score the final mark in this question.

Question 2

The binomial expansion of $\left(1+\frac{x}{p}\right)^q$ was done extremely well by the vast majority of candidates with the most common error being the failure to correctly deal with the x^2 term with many giving the coefficient (of this term) as $\frac{q(q-1)}{2p}$ rather than the correct $\frac{q(q-1)}{2p^2}$. It was surprising how few candidates could go on to form the correct pair of simultaneous equations and fewer still who could solve this pair of equations accurately and successfully. Those candidates who correctly found the value of p usually went on to state the set of values of x for which the expansion was valid.

Question 3

The vast majority of candidates considered the correct integral (with correct limits and including the factor of π) for the volume of revolution generated by rotating the given curve about the y-axis and most went on to integrate $\sqrt{y}$ correctly. A number of candidates, however, misread the question and instead tried to calculate the volume or revolution generated by rotating the curve about the x-axis. It was the mention of a rotation of 180° that seemed to concern many candidates and a considerable number divided the correct answer of $\frac{16}{3}\pi$ by 2.

Question 4

The majority of candidates correctly replaced $\sin 2\theta$ with $2\sin\theta\cos\theta$ and $\cos 2\theta$ with one of $\cos^2\theta-\sin^2\theta$ or $1-2\sin^2\theta$ or $2\cos^2\theta-1$, although a minority of candidates made the costly mistake of forgetting the 2 in the latter two identities. While a majority of candidates correctly obtained $2\sin\theta\cos\theta=\cos^2\theta$ many then cancelled $\cos\theta$ from both sides of the equation instead of factorising to obtain $\cos\theta(2\sin\theta-\cos\theta)=0$ and so lost the solution to the equation $\cos\theta=0$.

Most candidates correctly simplified $2\sin\theta-\cos\theta=0$ to $\tan\theta=\frac{1}{2}$ and obtained the correct answer of 26.6° although a small minority gave an answer in radians or additional answers both inside and outside of the given range. A number of candidates, after applying suitable double angle identities, squared their equation leading to either a quadratic equation in either $\sin^2\theta$ or $\cos^2\theta$. These attempts usually contained sign and/or algebraic errors or even, when the correct disguised quadratic was obtained, and solved, additional incorrect solutions (coming from the earlier squaring of the single angle equation) were given.

Question 5

This question provided a certain amount of discrimination between candidates with some producing clear, concise arguments for why $\sec^3\theta=2$ and why the ratio of the lengths ED to CB was $2^{\frac{2}{3}}:1$ while a significant number left both parts of this question blank or scored no marks. The majority of candidates, however, scored at least one mark in (i) for starting that $\mathrm{AC}=x\sec\theta$ (or equivalent) or that $\mathrm{AD}=2x\cos\theta$ but many failed to find corresponding expressions for either AD and AE or AC and AB in terms of x and one of $\sec\theta$ or $\cos\theta$. Examiners noted that many candidates did not make it clear which expression corresponded to which side of the three triangles given in the question making it almost impossible for examiners to award any marks.

In part (ii) many candidates scored at least two marks for stating that $\mathrm{ED} = 2x\sin\theta$ and $\mathrm{CB} = x\tan\theta$ although many then substituted in the angle from part (i) and tried to derive the exact value of $2^{\frac{2}{3}}$ using approximate values for these two lengths. Candidates who correctly found that $\frac{\mathrm{ED}}{\mathrm{CB}} = 2\cos\theta$ usually went on to obtain the correct ratio although many did not show sufficient steps of working to explain how they obtained the given answer.

Question 6

Candidates found this unstructured question on parametric equations quite demanding with the modal mark scored being 2 out of a possible 7. Most candidates scored these two marks by correctly obtaining $\frac{\mathrm{d}y}{\mathrm{d}x} = -\frac{1}{t^2}$ although the vast majority failed to make any further progress worthy of merit with many trying to argue that the area of triangle OQR is independent of *t* without any further working of a mathematical nature. Of those that failed to obtain the correct derivative a number incorrectly stated that $\frac{\mathrm{d}y}{\mathrm{d}t} = 2\ln t$ or implied that $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{\mathrm{d}y}{\mathrm{d}t} \times \frac{\mathrm{d}x}{\mathrm{d}t}$. All that was required from those candidates who had obtained the correct gradient function in terms of *t* was to write down the equation of the tangent $\left(y - \frac{2}{t} = -\frac{1}{t^2}(x - 2t) \right)$, substitute $x = 0$ and $y = 0$ to obtain $\mathrm{R}\left(0, \frac{4}{t}\right)$ and $\mathrm{Q}(4t, 0)$ respectively and hence calculate the area of the triangle as $8\left(= \frac{1}{2} \times 4t \times \frac{4}{t} \right)$ which is clearly independent of *t*. A number of candidates began by finding the Cartesian equation of the curve and correctly obtaining $\frac{\mathrm{d}y}{\mathrm{d}x} = -\frac{4}{x^2}$ but they then incorrectly used this gradient function in their equation of the tangent.

Question 7

Nearly all candidates correctly obtained the length of the diagonal AG in part (i) with only a small minority stating only the direction vector $\overrightarrow{\mathrm{AG}}$.

In part (ii) a number of candidates seemed to think that just showing one direction vector was normal to the plane was sufficient and some candidates showed all three. It was unfortunate that so many lost marks by not showing the evaluation of the scalar product(s) even though this was a 'show that' question and so examiners had to be convinced that the candidates were indeed showing the required results and not simply stating them. The vast majority found the correct Cartesian equation of the plane as $15x - 20y + 4z = 20$.

Most candidates correctly found the direction part of the vector equation of the line AG in part (ii) but very few candidates stated a correct vector equation which needed to begin with either $\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \ldots$ or $\mathbf{r} = \ldots$ The rest of this part was answered well with many correctly obtaining the value of the parameter and hence the coordinates of the point Q. The ratio of AQ : QG was often found correctly although a number of candidates stated this ratio as either 3 : 2 or 2 : 5.

Candidates' attempts to find the acute angle between the line AG and the plane DPF in part (iv) were varied with the vast majority considering the correct direction vectors of $-4\mathbf{i} + 3\mathbf{j} + 5\mathbf{k}$ and $15\mathbf{i} - 20\mathbf{j} + 4\mathbf{k}$ although a number attempted to find this angle using one of the direction vectors in

the plane (rather than the normal to the plane). While many correctly obtained an angle of either 56.0 or 124.0 few failed to realise that these were the acute and obtuse angles between the line and the normal and so many did not subtract the relevant right-angle to obtain the correct answer of 34.0°.

Question 8

Nearly all candidates correctly showed the required result in part (i) although a few attempted to use partial fractions with varying degrees of success.

In part (ii) many candidates incorrectly verified that when $x = 0$, $t = 0$ rather than the required result of showing that when $t = 0$, $x = 0$. Those that did begin by setting $t = 0$ usually went on to score both marks in this part.

Part (iii) proved to be quite discriminating with many candidates unable to show that the rate of change of x was proportional to the given product. The most common method seen was to write t as $\ln(2+x) - \ln(2-x)$ and then to differentiate this expression with respect to x and obtain $\frac{\mathrm{d}t}{\mathrm{d}x} = \frac{1}{2+x} + \frac{1}{2-x}$ and then use part (i) to show that $\frac{\mathrm{d}t}{\mathrm{d}x} = \frac{4}{(2+x)(2-x)} \Rightarrow \frac{\mathrm{d}x}{\mathrm{d}t} = \frac{(2+x)(2-x)}{4}$, and hence the constant of proportionality is clearly $\frac{1}{4}$. The most common error was a failure to differentiate *t* correctly with many retaining the negative between the two terms. A number of candidates attempted instead to derive the given result by starting with the differential equation $\frac{\mathrm{d}x}{\mathrm{d}t} = k(2+x)(2-x)$ and attempting to solve this using the method of separation of variables. While a number were successful in obtaining the required constant many failed to deal with $\int \frac{\mathrm{d}x}{(2+x)(2-x)}$ correctly or forgot to include the required constant of integration.

Part (iv) was answered well with many correctly starting by either writing $\mathrm{e}^t = \frac{2+x}{2-x}$ or $\mathrm{e}^{-t} = \frac{2-x}{2+x}$, the latter of these two usually lead to the correct given answer while the former lead to $x = \frac{2\left(\mathrm{e}^t - 1\right)}{1+\mathrm{e}^t}$ with the vast majority of candidates being unable to explain clearly why this would lead to the given result. As this was a show that question there needed to be a clear indication of how this result would leads to $x = \frac{2(1-\mathrm{e}^{-t})}{1+\mathrm{e}^{-t}}$. Finally in this part many candidates correctly stated that the long-term mass of the substance was 2 mg.

Part (v) was answered with varying degrees of success with the vast majority correctly separating the variables to obtain $\int \frac{\mathrm{d}x}{(2-x)(2+x)} = k\int \mathrm{e}^{-t}\mathrm{d}t$ - however, from this point it was all too clear that a number of candidates did not, as requested, show by integration the given result, but simply wrote down the given answer (or an answer only a single step away from the given answer) without clearly showing how either side of the given equation was obtained. In many cases candidates failed to include a constant of integration that needed to be found using the given initial conditions.

Part (vi) was answered extremely well with many candidates obtaining the correct answer of 0.811 which was achieved by setting e^{-t} equal to zero and substituting 1.85 for x. The most common error seen by examiners was to set $\ln\left(\frac{2+x}{2-x}\right)$ equal to 1.85 and solve for k with e^{-t} equal to zero.

Paper B

Question 1

Nearly all candidates correctly stated the hub height of the turbine although a number incorrectly found this height as 59.5 m (which came from using the diameter of the blade rather than the radius).

Question 2

While the majority of candidates correctly explained how the figure of 12 m was obtained with the most common method being via the calculation $\frac{0.8\times 99.5}{6.7}$ which lead to a value of 11.88… many did not give sufficient detail or tried to justify the figure of 12 without showing any calculation at all.

Question 3

Parts (i) and (ii) were nearly always correct although in part (iii) many candidates failed to use the value of 7.3 to show that when the photomontage was printed on A3 paper, the height of the wind turbine was consistent with the angle of elevation found in part (ii).

Question 4

The responses to this question were mixed with many candidates failing to find the height above A of the lowest visible point as 199.5 m with many incorrectly using a height of 219.5 m. Furthermore, many candidates failed to read the question carefully and stated that the distance AC was 140 m rather the horizontal distance from A to C.

Question 5

Nearly all candidates correctly stated that $\alpha = \arctan\left(\frac{72}{800}\right)$ although many assumed incorrectly that triangle TQB was right-angled. Of those that did realise that triangle TQB was not right-angled many took the slightly more long-winded approach of using the cosine rule to find β instead of realising that $\beta = \arctan\left(\frac{90}{800}\right) - \arctan\left(\frac{18}{800}\right)$. Finally, many candidates did not realise that if they are required to show that two answers agree to 2 significant figures then they must quote both value correct to 3 significant figures and so in this case examiners needed to see as a minimum of $\alpha = 5.14$ and $\beta = 5.13$ followed by 5.1.

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GCE Mathematics (MEI)

				Max Mark	a	b	c	d	e	u
4751	01	C1 – MEI Introduction to advanced mathematics (AS)	Raw	72	63	57	52	47	42	0
			UMS	100	80	70	60	50	40	0
4752	01	C2 – MEI Concepts for advanced mathematics (AS)	Raw	72	56	49	42	35	29	0
			UMS	100	80	70	60	50	40	0
4753	01	(C3) MEI Methods for Advanced Mathematics with Coursework: Written Paper	Raw	72	58	52	47	42	36	0
4753	02	(C3) MEI Methods for Advanced Mathematics with Coursework: Coursework	Raw	18	15	13	11	9	8	0
4753	82	(C3) MEI Methods for Advanced Mathematics with Coursework: Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
			UMS	100	80	70	60	50	40	0
4754	01	C4 – MEI Applications of advanced mathematics (A2)	Raw	90	64	57	51	45	39	0
			UMS	100	80	70	60	50	40	0
4755	01	FP1 – MEI Further concepts for advanced mathematics (AS)	Raw	72	59	53	48	43	38	0
			UMS	100	80	70	60	50	40	0
4756	01	FP2 – MEI Further methods for advanced mathematics (A2)	Raw	72	60	54	48	43	38	0
			UMS	100	80	70	60	50	40	0
4757	01	FP3 – MEI Further applications of advanced mathematics (A2)	Raw	72	60	54	49	44	39	0
			UMS	100	80	70	60	50	40	0
4758	01	(DE) MEI Differential Equations with Coursework: Written Paper	Raw	72	67	61	55	49	43	0
4758	02	(DE) MEI Differential Equations with Coursework: Coursework	Raw	18	15	13	11	9	8	0
4758	82	(DE) MEI Differential Equations with Coursework: Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
			UMS	100	80	70	60	50	40	0
4761	01	M1 – MEI Mechanics 1 (AS)	Raw	72	58	50	43	36	29	0
			UMS	100	80	70	60	50	40	0
4762	01	M2 – MEI Mechanics 2 (A2)	Raw	72	59	53	47	41	36	0
			UMS	100	80	70	60	50	40	0
4763	01	M3 – MEI Mechanics 3 (A2)	Raw	72	60	53	46	40	34	0
			UMS	100	80	70	60	50	40	0
4764	01	M4 – MEI Mechanics 4 (A2)	Raw	72	55	48	41	34	27	0
			UMS	100	80	70	60	50	40	0
4766	01	S1 – MEI Statistics 1 (AS)	Raw	72	59	52	46	40	34	0
			UMS	100	80	70	60	50	40	0
4767	01	S2 – MEI Statistics 2 (A2)	Raw	72	60	55	50	45	40	0
			UMS	100	80	70	60	50	40	0
4768	01	S3 – MEI Statistics 3 (A2)	Raw	72	60	54	48	42	37	0
			UMS	100	80	70	60	50	40	0
4769	01	S4 – MEI Statistics 4 (A2)	Raw	72	56	49	42	35	28	0
			UMS	100	80	70	60	50	40	0
4771	01	D1 – MEI Decision mathematics 1 (AS)	Raw	72	48	43	38	34	30	0
			UMS	100	80	70	60	50	40	0
4772	01	D2 – MEI Decision mathematics 2 (A2)	Raw	72	55	50	45	40	36	0
			UMS	100	80	70	60	50	40	0
4773	01	DC – MEI Decision mathematics computation (A2)	Raw	72	46	40	34	29	24	0
			UMS	100	80	70	60	50	40	0
4776	01	(NM) MEI Numerical Methods with Coursework: Written Paper	Raw	72	55	49	44	39	33	0
4776	02	(NM) MEI Numerical Methods with Coursework: Coursework	Raw	18	14	12	10	8	7	0
4776	82	(NM) MEI Numerical Methods with Coursework: Carried Forward Coursework Mark	Raw	18	14	12	10	8	7	0
			UMS	100	80	70	60	50	40	0
4777	01	NC – MEI Numerical computation (A2)	Raw	72	55	47	39	32	25	0
			UMS	100	80	70	60	50	40	0
4798	01	FPT - Further pure mathematics with technology (A2)	Raw	72	57	49	41	33	26	0

		UMS	100	80	70	60	50	40	0

GCE Statistics (MEI)

			Max Mark	a	b	c	d	e	u
G241	01 Statistics 1 MEI (Z1)	Raw	72	59	52	46	40	34	0
		UMS	100	80	70	60	50	40	0
G242	01 Statistics 2 MEI (Z2)	Raw	72	55	48	41	34	27	0
		UMS	100	80	70	60	50	40	0
G243	01 Statistics 3 MEI (Z3)	Raw	72	56	48	41	34	27	0
		UMS	100	80	70	60	50	40	0

GCE Quantitative Methods (MEI)

			Max Mark	a	b	c	d	e	u
G244	01 Introduction to Quantitative Methods MEI	Raw	72	58	50	43	36	28	0
G244	02 Introduction to Quantitative Methods MEI	Raw	18	14	12	10	8	7	0
		UMS	100	80	70	60	50	40	0
G245	01 Statistics 1 MEI	Raw	72	59	52	46	40	34	0
		UMS	100	80	70	60	50	40	0
G246	01 Decision 1 MEI	Raw	72	48	43	38	34	30	0
		UMS	100	80	70	60	50	40	0

Level 3 Certificate and FSMQ raw mark grade boundaries June 2016 series

For more information about results and grade calculations, see www.ocr.org.uk/ocr-for/learners-and-parents/getting-your-results

Level 3 Certificate Mathematics for Engineering

		Max Mark	a*	a	b	c	d	e	u
H860	01 Mathematics for Engineering	This unit has no entries in June 2016							
H860	02 Mathematics for Engineering								

Level 3 Certificate Mathematical Techniques and Applications for Engineers

			Max Mark	a*	a	b	c	d	e	u
H865	01 Component 1	Raw	60	48	42	36	30	24	18	0

Level 3 Certificate Mathematics - Quantitative Reasoning (MEI) (GQ Reform)

			Max Mark	a	b	c	d	e	u
H866	01 Introduction to quantitative reasoning	Raw	72	55	47	39	31	23	0
H866	02 Critical maths	Raw	60	47	41	35	29	23	0
		Overall	132	111	96	81	66	51	0

Level 3 Certificate Mathematics - Quantitive Problem Solving (MEI) (GQ Reform)

			Max Mark	a	b	c	d	e	u
H867	01 Introduction to quantitative reasoning	Raw	72	55	47	39	31	23	0
H867	02 Statistical problem solving	Raw	60	40	34	28	23	18	0
		Overall	132	103	88	73	59	45	0

Advanced Free Standing Mathematics Qualification (FSMQ)

			Max Mark	a	b	c	d	e	u
6993	01 Additional Mathematics	Raw	100	59	51	44	37	30	0

Intermediate Free Standing Mathematics Qualification (FSMQ)

			Max Mark	a	b	c	d	e	u
6989	01 Foundations of Advanced Mathematics (MEI)	Raw	40	35	30	25	20	16	0

Version	Details of change
1.1	Correction to Overall grade boundaries for H866
	Correction to Overall grade boundaries for H867

OCR
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GCE Mathematics (MEI)

				Max Mark	a	b	c	d	e	u
4751	01	C1 – MEI Introduction to advanced mathematics (AS)	Raw	72	63	57	52	47	42	0
			UMS	100	80	70	60	50	40	0
4752	01	C2 – MEI Concepts for advanced mathematics (AS)	Raw	72	56	49	42	35	29	0
			UMS	100	80	70	60	50	40	0
4753	01	(C3) MEI Methods for Advanced Mathematics with Coursework: Written Paper	Raw	72	58	52	47	42	36	0
4753	02	(C3) MEI Methods for Advanced Mathematics with Coursework: Coursework	Raw	18	15	13	11	9	8	0
4753	82	(C3) MEI Methods for Advanced Mathematics with Coursework: Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
			UMS	100	80	70	60	50	40	0
4754	01	C4 – MEI Applications of advanced mathematics (A2)	Raw	90	64	57	51	45	39	0
			UMS	100	80	70	60	50	40	0
4755	01	FP1 – MEI Further concepts for advanced mathematics (AS)	Raw	72	59	53	48	43	38	0
			UMS	100	80	70	60	50	40	0
4756	01	FP2 – MEI Further methods for advanced mathematics (A2)	Raw	72	60	54	48	43	38	0
			UMS	100	80	70	60	50	40	0
4757	01	FP3 – MEI Further applications of advanced mathematics (A2)	Raw	72	60	54	49	44	39	0
			UMS	100	80	70	60	50	40	0
4758	01	(DE) MEI Differential Equations with Coursework: Written Paper	Raw	72	67	61	55	49	43	0
4758	02	(DE) MEI Differential Equations with Coursework: Coursework	Raw	18	15	13	11	9	8	0
4758	82	(DE) MEI Differential Equations with Coursework: Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
			UMS	100	80	70	60	50	40	0
4761	01	M1 – MEI Mechanics 1 (AS)	Raw	72	58	50	43	36	29	0
			UMS	100	80	70	60	50	40	0
4762	01	M2 – MEI Mechanics 2 (A2)	Raw	72	59	53	47	41	36	0
			UMS	100	80	70	60	50	40	0
4763	01	M3 – MEI Mechanics 3 (A2)	Raw	72	60	53	46	40	34	0
			UMS	100	80	70	60	50	40	0
4764	01	M4 – MEI Mechanics 4 (A2)	Raw	72	55	48	41	34	27	0
			UMS	100	80	70	60	50	40	0
4766	01	S1 – MEI Statistics 1 (AS)	Raw	72	59	52	46	40	34	0
			UMS	100	80	70	60	50	40	0
4767	01	S2 – MEI Statistics 2 (A2)	Raw	72	60	55	50	45	40	0
			UMS	100	80	70	60	50	40	0
4768	01	S3 – MEI Statistics 3 (A2)	Raw	72	60	54	48	42	37	0
			UMS	100	80	70	60	50	40	0
4769	01	S4 – MEI Statistics 4 (A2)	Raw	72	56	49	42	35	28	0
			UMS	100	80	70	60	50	40	0
4771	01	D1 – MEI Decision mathematics 1 (AS)	Raw	72	48	43	38	34	30	0
			UMS	100	80	70	60	50	40	0
4772	01	D2 – MEI Decision mathematics 2 (A2)	Raw	72	55	50	45	40	36	0
			UMS	100	80	70	60	50	40	0
4773	01	DC – MEI Decision mathematics computation (A2)	Raw	72	46	40	34	29	24	0
			UMS	100	80	70	60	50	40	0
4776	01	(NM) MEI Numerical Methods with Coursework: Written Paper	Raw	72	55	49	44	39	33	0
4776	02	(NM) MEI Numerical Methods with Coursework: Coursework	Raw	18	14	12	10	8	7	0
4776	82	(NM) MEI Numerical Methods with Coursework: Carried Forward Coursework Mark	Raw	18	14	12	10	8	7	0
			UMS	100	80	70	60	50	40	0
4777	01	NC – MEI Numerical computation (A2)	Raw	72	55	47	39	32	25	0
			UMS	100	80	70	60	50	40	0
4798	01	FPT - Further pure mathematics with technology (A2)	Raw	72	57	49	41	33	26	0

		UMS	100	80	70	60	50	40	0

GCE Statistics (MEI)

			Max Mark	a	b	c	d	e	u
G241	01 Statistics 1 MEI (Z1)	Raw	72	59	52	46	40	34	0
		UMS	100	80	70	60	50	40	0
G242	01 Statistics 2 MEI (Z2)	Raw	72	55	48	41	34	27	0
		UMS	100	80	70	60	50	40	0
G243	01 Statistics 3 MEI (Z3)	Raw	72	56	48	41	34	27	0
		UMS	100	80	70	60	50	40	0

GCE Quantitative Methods (MEI)

			Max Mark	a	b	c	d	e	u
G244	01 Introduction to Quantitative Methods MEI	Raw	72	58	50	43	36	28	0
G244	02 Introduction to Quantitative Methods MEI	Raw	18	14	12	10	8	7	0
		UMS	100	80	70	60	50	40	0
G245	01 Statistics 1 MEI	Raw	72	59	52	46	40	34	0
		UMS	100	80	70	60	50	40	0
G246	01 Decision 1 MEI	Raw	72	48	43	38	34	30	0
		UMS	100	80	70	60	50	40	0

Level 3 Certificate and FSMQ raw mark grade boundaries June 2016 series

For more information about results and grade calculations, see www.ocr.org.uk/ocr-for/learners-and-parents/getting-your-results

Level 3 Certificate Mathematics for Engineering

		Max Mark	a*	a	b	c	d	e	u
H860	01 Mathematics for Engineering	This unit has no entries in June 2016							
H860	02 Mathematics for Engineering								

Level 3 Certificate Mathematical Techniques and Applications for Engineers

			Max Mark	a*	a	b	c	d	e	u
H865	01 Component 1	Raw	60	48	42	36	30	24	18	0

Level 3 Certificate Mathematics - Quantitative Reasoning (MEI) (GQ Reform)

			Max Mark	a	b	c	d	e	u
H866	01 Introduction to quantitative reasoning	Raw	72	55	47	39	31	23	0
H866	02 Critical maths	Raw	60	47	41	35	29	23	0
		Overall	132	111	96	81	66	51	0

Level 3 Certificate Mathematics - Quantitive Problem Solving (MEI) (GQ Reform)

			Max Mark	a	b	c	d	e	u
H867	01 Introduction to quantitative reasoning	Raw	72	55	47	39	31	23	0
H867	02 Statistical problem solving	Raw	60	40	34	28	23	18	0
		Overall	132	103	88	73	59	45	0

Advanced Free Standing Mathematics Qualification (FSMQ)

			Max Mark	a	b	c	d	e	u
6993	01 Additional Mathematics	Raw	100	59	51	44	37	30	0

Intermediate Free Standing Mathematics Qualification (FSMQ)

			Max Mark	a	b	c	d	e	u
6989	01 Foundations of Advanced Mathematics (MEI)	Raw	40	35	30	25	20	16	0

Version	Details of change
1.1	Correction to Overall grade boundaries for H866
	Correction to Overall grade boundaries for H867

OCR
Oxford Cambridge and RSA

Friday 24 June 2016 – Morning

A2 GCE MATHEMATICS (MEI)

4754/01B Applications of Advanced Mathematics (C4) Paper B: Comprehension

QUESTION PAPER

Candidates answer on the Question Paper.

OCR supplied materials:
- Insert (inserted)
- MEI Examination Formulae and Tables (MF2)

Other materials required:
- Scientific or graphical calculator

Duration: Up to 1 hour

* 4 7 5 4 0 1 B *

* 5 9 8 4 3 8 4 9 0 2 *

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The Insert will be found inside this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.
- The Insert contains the text for use with the questions.
- You are permitted to use a scientific or graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- You may find it helpful to make notes and do some calculations as you read the passage.
- You are **not** required to hand in these notes with your question paper.
- You are advised that an answer may receive **no marks** unless you show sufficient detail of the working to indicate that a correct method is being used.
- The total number of marks for this paper is **18**.
- This document consists of **8** pages. Any blank pages are indicated.

1 The blades of a wind turbine sweep out a circle of diameter 90 m. The turbine's blade tip height is 149.5 m.

Calculate the hub height of this turbine. **[1]**

1	

2 In lines 46 and 47, the article says
'So someone at the point of observation would not see the bottom 12 m of the turbine.'

Explain how the figure of 12 m was obtained. **[2]**

2

3 A wind turbine with a blade tip height of 125 m is seen from a distance of 623 m. The ground is level and horizontal so that the whole of the turbine can be seen.

(i) Calculate the angle of elevation of the tip of a blade when it is pointing vertically upwards. You should assume that the viewer's eye is at the same height as the base of the turbine. **[1]**

The wind turbine is shown on a photomontage; the viewing distance is stated to be 51.4 cm.

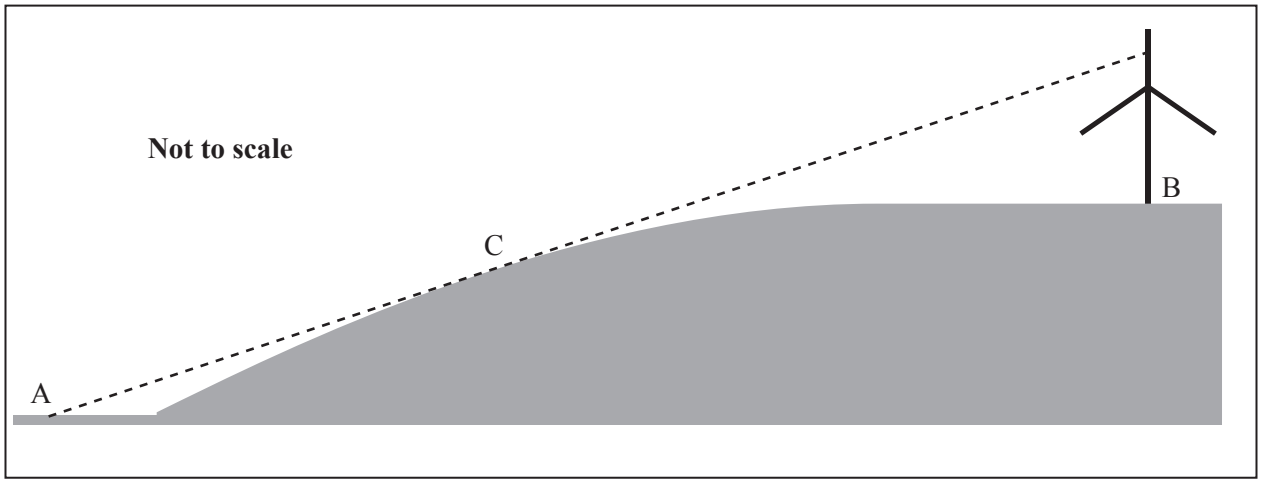
(ii) Calculate the height that the turbine would have on the photomontage if it were seen with the same angle of elevation as that in part **(i)**. **[1]**

The image of the wind turbine is 7.3 cm high when the photomontage is printed on A4 paper.

(iii) Show that when the photomontage is printed on A3 paper, the height of the wind turbine is consistent with the angle of elevation found in part **(i)**. **[2]**

3 (i)	
3 (ii)	

3 (iii)	



4 The diagram illustrates the situation in Fig. 5 of the article.

The blade tip height of the wind turbine is 99.5 m.

The base, B, of the turbine is 120 m higher than A and at a horizontal distance of 320 m from A.

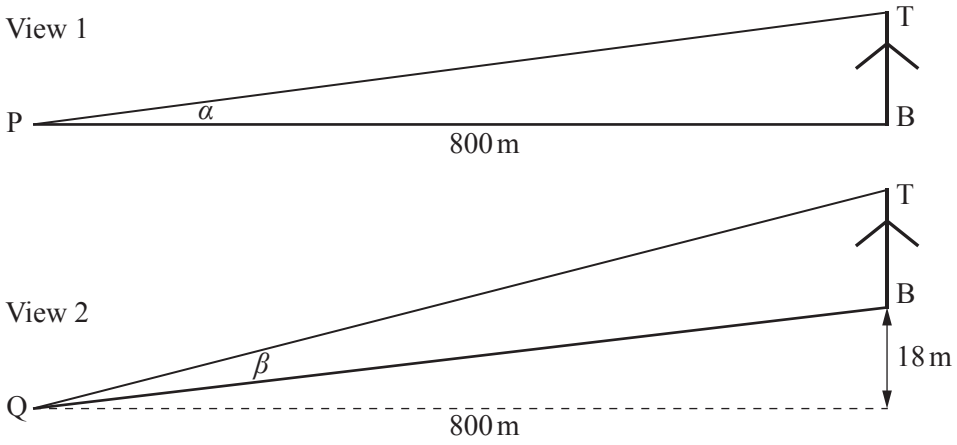
An observer at A can see the top 20 m of a blade when it is pointing vertically upwards, as in the diagram.

The observer's line of vision is a tangent to the hill at C. The horizontal distance from A to C is 140 m.

Find the height of C above A. **[4]**

4

Not to scale



5 In the diagram, the wind turbine BT is observed from two different positions P and Q. The blade tip height of the turbine is 72 m.

Both P and Q are a horizontal distance of 800 m from the turbine.

P is at the same height as the base, B, of the turbine. Q is 18 m below the level of B.

The angle of elevation from P is α; the angle TQB is β.

Show that the angles α and β, in degrees, are the same to 2 significant figures. **[3]**

5	

6 In line 96, the article says

'As a result of the study, it was recommended that a focal length of 75 mm should be used.'

Make a reasoned estimate of the percentages of participants in Stirling University's study who would have thought the photomontages made the wind turbines appear 'Too large', 'About right' and 'Too small' if a lens of focal length 75 mm had been used. You must state your assumptions clearly. **[4]**

6	

END OF QUESTION PAPER

OCR
Oxford Cambridge and RSA

Friday 24 June 2016 – Morning

A2 GCE MATHEMATICS (MEI)

4754/01 Applications of Advanced Mathematics (C4)

INSTRUCTIONS

The examination is in two parts:

Paper A (1 hour 30 minutes)
Paper B (up to 1 hour)

Supervisors are requested to ensure that Paper B **is not issued** until Paper A has been collected in from the candidates.

Centres may, if they wish, grant a supervised break between the two parts of this examination.

Paper B should not be attached to the corresponding Paper A script. For Paper A only the candidates' Printed Answer Books, in the same order as the attendance register, should be sent for marking; the Question Paper should be retained in the centre or recycled. For Paper B only the Question Papers, on which the candidates have written their answers, should be sent for marking; the Insert should be retained in the centre or recycled. Any additional sheets used must be carefully attached to the correct paper.

For Paper B (Comprehension) only.

A standard English dictionary is allowed for the comprehension.
(Dictionaries to be used in the examination must be thoroughly checked before the examination.) Full regulations are in the JCQ Regulations and Guidance booklet.

This notice must be on the invigilator's desk at all times during the morning of Friday 24 June 2016.

OCR
Oxford Cambridge and RSA

Friday 24 June 2016 – Morning

A2 GCE MATHEMATICS (MEI)

4754/01B Applications of Advanced Mathematics (C4) Paper B: Comprehension

INSERT

Duration: Up to 1 hour

5984386873

INFORMATION FOR CANDIDATES

- This Insert contains the text for use with the questions.
- This document consists of **8** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER/INVIGILATOR

- Do not send this Insert for marking; it should be retained in the centre or recycled. Please contact OCR Copyright should you wish to re-use this document.

Photomontages

Introduction

When a new building or structure is proposed, planning permission has to be obtained from the authorities. It is common practice to present an image of what the new building or structure is expected to look like. The image is often an artist's impression but it may also be a photomontage.

Photomontages are commonly used to support applications to develop wind farms and this context is used in this article. Electricity at a wind farm is generated by wind turbines. A wind turbine is illustrated in Fig. 1. This diagram also explains the meanings of the terms used throughout the article.

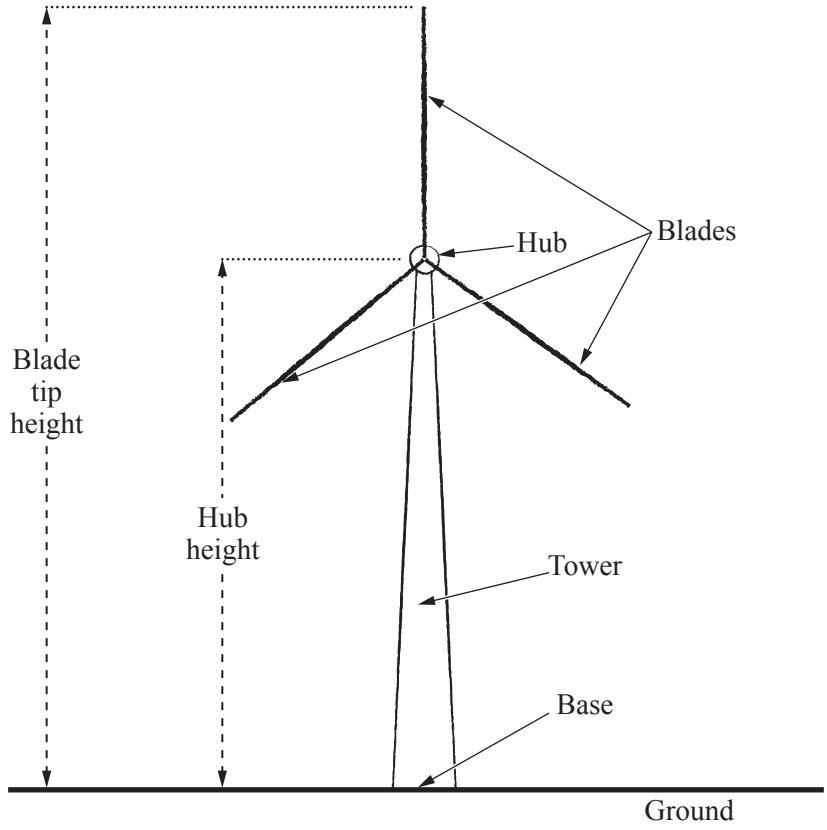


Fig. 1

A photomontage is based on a photograph taken from a particular place. The photograph shows the background before any building work has started. An image of the proposed structure is then superimposed on this. The image may be a photograph or a computer drawing and must be in the right place and to the right scale. Fig. 2 on the next page is typical of many photomontages that have been used for planning applications.

The type of wind turbine in Fig. 2 has blade tip height 99.5 m and hub height 64.5 m. So the blades are 35 m long.

Recommended viewing distance when viewed with both eyes 51.4 cm; distance to turbine 548 m; included angle 38.6°.

Fig. 2

The impression given by photomontages

The purpose of a photomontage is to provide an accurate representation of how the proposed development would appear in reality. A photomontage in which the development is the wrong size, either too large or too small, is misleading.

After a wind farm has been built, local people have sometimes complained that the turbines looked larger than they did in the photomontages. This article looks at three possible explanations.

The angle of elevation

The turbine in Fig. 2 has a blade tip height of 99.5 metres and the photomontage shows the view from a place 548 metres away. So it is possible to work out the angle of elevation of the highest point. This is the angle α in Fig. 3. To simplify the calculations it is assumed that the observer's eye is at the same level as the base of the turbine.

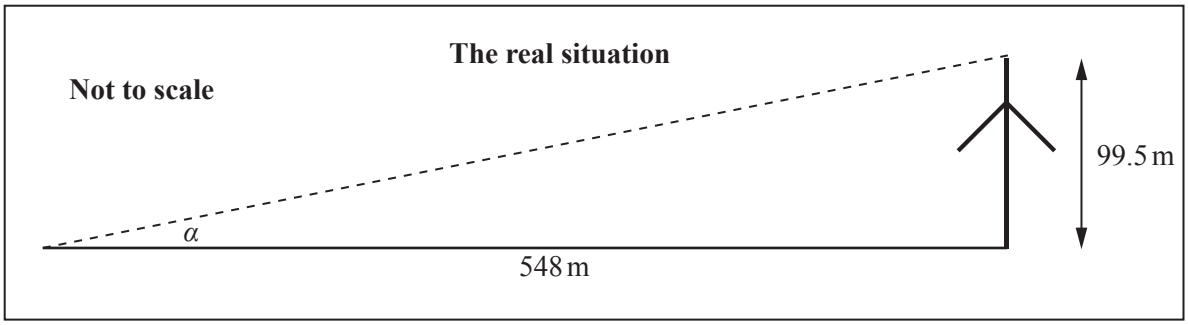


Fig. 3

The information with the photomontage also gives the recommended viewing distance as 51.4 centimetres; this is about an arm's length. So you might expect that, seen from this distance, the turbine in the photomontage should have the same angle of elevation of α if it is to appear the right size to a viewer. This is illustrated in Fig. 4.

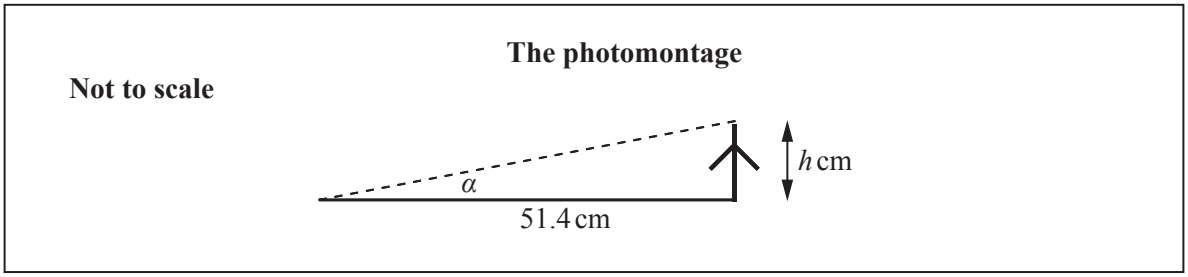


Fig. 4

From the triangles in Figs 3 and 4, you can deduce that the height of the turbine in the photomontage should be 9.3 cm, to 2 significant figures. However, if you measure it in Fig. 2, you obtain the much smaller figure of about 5.9 cm. How can this discrepancy be explained?

Seeing only part of a wind turbine

One possible explanation is that not all of the turbine is being seen.

Wind turbines are often positioned near the tops of hills where the wind is strongest, so you might expect the whole turbine to be visible from nearby. However, that is often not the case. The view may be obstructed as illustrated in Fig. 5. In this case, an observer at point **A** would only ever see the tips of the blades.

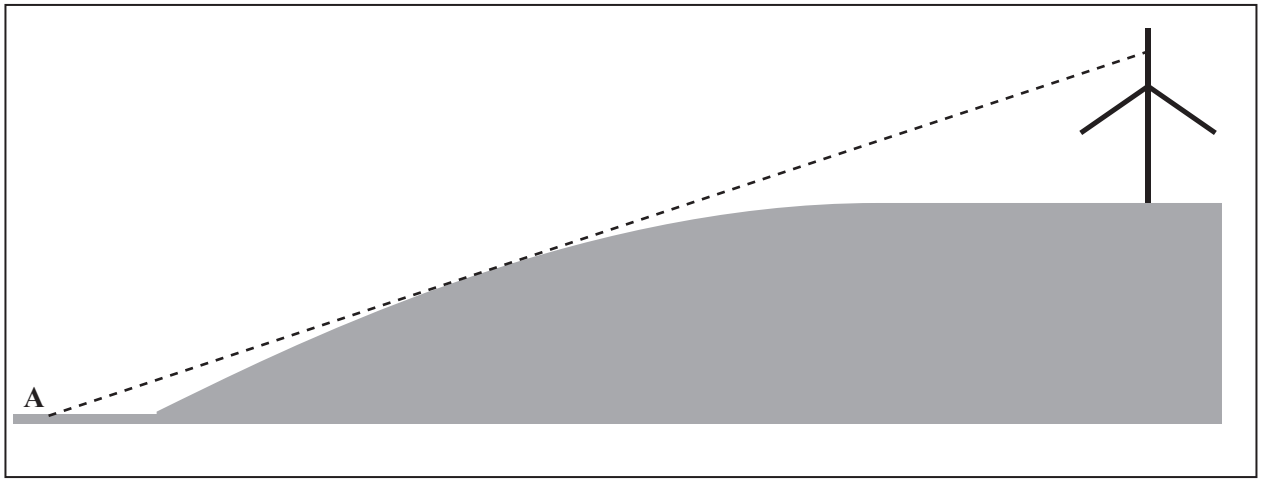


Fig. 5

So a photomontage has to take account of the lie of the land between the observer and the wind turbine. The choice of the observer's position can have a substantial effect on the appearance of the wind turbine. Might this have happened in Fig. 2?

One of the blades in Fig. 2 is upright; its length on the photomontage is about 2.35 cm. As the dimensions of the turbine are known (given on lines 14 and 15), it is possible to work out that the height of the full turbine would be about 6.7 cm on the photomontage. However, as the height seen is only 5.9 cm, this means that about 0.8 cm of the tower must be hidden from view in the photomontage. So someone at the point of observation would not see the bottom 12 m of the turbine.

So the obscuring effect of the land explains some of the discrepancy. However, even though the revised figure of 6.7 cm, is closer than 5.9 cm, it is still much less than the 9.3 cm that is needed for the angle of elevation to be correct.

So other possible causes need to be considered.

Printed size

Another possible explanation relates to the size of paper on which the photomontage is printed.

All of the pages that this article are printed on are A4 size; they are 210 mm wide and 297 mm high, to the nearest mm. When two A4 sheets are laid side by side, the resulting size is 420 mm × 297 mm. This is A3 size and is illustrated in Fig. 6.

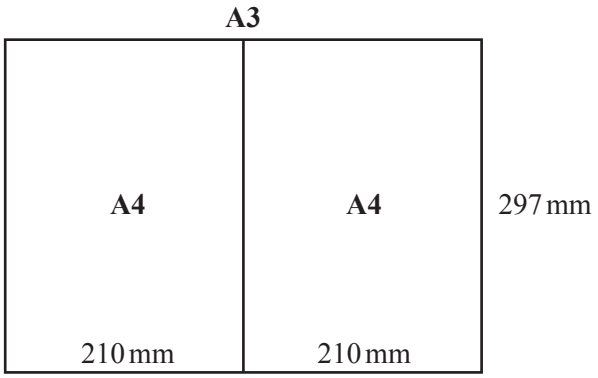


Fig. 6

In the same way, two A3 sheets laid side by side make an A2 sheet, and so on up to A0. The area of an A0 sheet is exactly 1 m^2. For all the A sizes, the ratio *short side* : *long side* is $1 : \sqrt{2}$. Because the ratio is the same, every A-sized sheet of paper is similar to every other sheet.

It follows that a photomontage printed on an A3 sheet would be an exact enlargement of one printed on an A4 sheet, with a scale factor of $\sqrt{2}$ or 1.41, to 3 significant figures. Thus if the photomontage in Fig. 2 were printed on A3 paper, the height of the turbine would be 6.7×1.41 or about 9.45 cm. Given the approximate nature of the measurements, this is very close to 9.3 cm.

So an explanation of the discrepancy is that the photomontage should have been printed on an A3 sheet, rather than on A4. However, it is not clear that this is actually the right explanation.

It is common practice to give the viewing distance at the bottom of a photomontage, as in Fig. 2, but not the recommended printing size. Many people view photomontages on their computers and print them out. A standard printer produces an A4 image and this is also about the size that it appears on many computer monitors. So those people who view photomontages on-screen or from their print-outs would expect the turbines to be smaller than they will appear when they are actually constructed.

However, complaints have also come from some people who only saw the photomontages at public meetings where they were presented at A3 size. These people have also said that the turbines looked too small in the photomontages they were shown.

Visualisation

There are professional people, such as architects and artists, whose expertise includes *visualisation*. They say that arguments about the printed size and viewing distance miss the point, which is that it does not matter whether the size of the photomontage is large or small, as your brain will convert it into an image inside your head. What matters is whether the image in your head from looking at a photomontage is the same as the image from looking at the real thing.

Fig. 7 (top) and Fig. 8 (bottom)

Fig. 7 and Fig. 8 show two views from the same place. Fig. 8 is a rectangular window that has been taken from within Fig. 7 and then enlarged to the same size. It follows that

- Fig. 8 has a narrower field of view than Fig. 7
- objects look larger in Fig. 8 than in Fig. 7.

The key question is which of these two views is the better representation of what a typical person would actually see from that place.

Different fields of view are obtained when photographs are taken with lenses of different focal length. Fig. 9 illustrates the relationship between the focal length and the included angle in the field of view of the photograph. A shorter focal length would give a larger included angle and so a wider field of view.

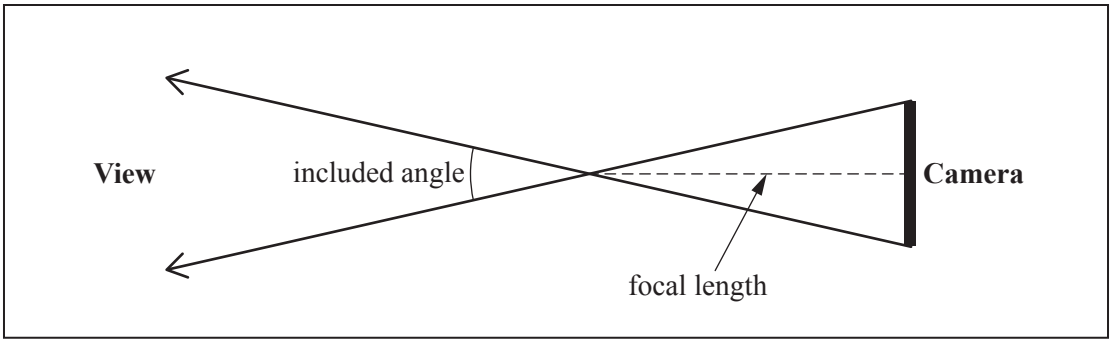


Fig. 9

So photographs taken using a camera with a longer focal length lens have a narrower field of view, resulting in distant objects looking larger.

The question of what is the best focal length was investigated in a study by Stirling University for the Highland Council in 2011 to 2012. Participants were taken to places near existing wind farms and were given 7 photomontages. These used photographs that had been taken with lenses with a range of focal lengths from 50 mm to 110 mm. They were asked to select the one that best represented what they saw.

In total 362 people took part and their responses are given in Table 10.

Focal length (mm)	50	60	70	80	90	100	110
Number of preferences	16	50	85	85	72	37	17

Table 10

As a result of the study, it was recommended that a focal length of 75 mm should be used. This contrasts with the previous common practice of using a focal length of 50 mm.

Fig. 8 is the picture that would have been obtained using a 75 mm lens, which is consistent with this recommendation. If this is enlarged to the same size as Fig. 2, and allowance is made for the part of the tower that is obscured, the height of the turbine would be close to 9.3 cm. So the angle of elevation when an A4 print-out was viewed at arm's length would be about right.

The wide spread of the data in Table 10 indicates that people see things differently. However, for a very large majority of viewers (over 95% of participants in the study) a photomontage based on a photograph taken with a 50 mm lens will under-represent the height of a wind turbine.

Consequently, of the three explanations considered in this article, the use of an unsuitable camera lens has been accepted as the most plausible.

OCR
Oxford Cambridge and RSA

GCE

Mathematics (MEI)

Unit **4754B**: Applications of Advanced Mathematics: Paper B

Advanced GCE

Mark Scheme for June 2016

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

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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.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

Annotations and abbreviations

Annotation in scoris	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
SC	Special case
^	Omission sign
MR	Misread
Highlighting	
Other abbreviations in mark scheme	**Meaning**
E1	Mark for explaining
U1	Mark for correct units
G1	Mark for a correct feature on a graph
M1 dep*	Method mark dependent on a previous mark, indicated by *
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working

Subject-specific Marking Instructions for GCE Mathematics (MEI) Pure strand

a Annotations should be used whenever appropriate during your marking.

The A, M and B annotations must be used on your standardisation scripts for responses that are not awarded either 0 or full marks. It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

For subsequent marking you must make it clear how you have arrived at the mark you have awarded.

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 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, award marks according to the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involved) 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, eg 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
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, eg 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, exactly what is acceptable will be detailed in the mark scheme rationale. If this is not the case please consult your Team Leader.

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 Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise. Candidates are expected to give numerical answers to an appropriate degree of accuracy, with 3 significant figures often being the norm. Small variations in the degree of accuracy to which an answer is given (e.g. 2 or 4 significant figures where 3 is expected) should not normally be penalised, while answers which are grossly over- or under-specified should normally result in the loss of a mark. The situation regarding any particular cases where the accuracy of the answer may be a marking issue should be detailed in the mark scheme rationale. If in doubt, contact your Team Leader.

g Rules for replaced work

If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests.

If there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others.

NB Follow these maths-specific instructions rather than those in the assessor handbook.

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 mark in the question.

Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

Question	Answer	Marks	Guidance
	Note that throughout units are not required		
1.	Blade radius = 45 m $\Rightarrow$ Hub height = 149.5 – 45 = 104.5 m	B1 **[1]**	
2.	Scale Photomontage: Real size = 2.35 cm : 35 m 0.8 cm corresponds to $\frac{0.8\times 35}{2.35}=11.91...$ rounding to 12 m	M1 E1 **[2]**	values 2.35, 35 and 0.8 **or** 6.7, 99.5 and 0.8 **or** 99.5, 35, 2.35 and 5.9 seen in a calculation or $\frac{0.8\times 99.5}{6.7}=11.88\ldots$ - **in both cases must see 11.9 (or better)** **followed by 12** or $99.5-\frac{35}{2.35}(5.9)=11.627...$ leading to 12 so **must see 11.6 (or better) followed by 12** (or equivalent correct calculation)
3. **(i)**	$\tan\alpha=\frac{125}{623}\ \Rightarrow\ \alpha=11.3°$	B1	11.3 or better - allow 11.35 rounded to 11.4 but B0 if only 11.4 seen
(ii)	Height $=\frac{125}{623}\times 51.4\ =10.3$ cm	B1	10.3 or better
(iii)	1.41×7.3 or their(10.3) ÷ 1.41 $1.41\times 7.3=10.3$ or $10.3\div 1.41=7.3$ or $\tan^{-1}\left(\frac{7.3\times '1.41'}{51.4}\right)=11.3...^{\circ}$	M1 A1 **[4]**	1.41 or better $\left(\text{e.g. }\sqrt{2},\ \frac{297}{210}\right)$ Must see 10.3 (or better) or 7.3 (or better) – 10.3 with no working scores M0A0 11.3 or 11.4

Question	Answer	Marks	Guidance
4.	Height above A of lowest visible point is	M1	All three values 99.5, 120, 20 seen in a calculation – 199.5 with no working scores M1A1
	$99.5 + 120 - 20 = 199.5\,\text{m}$	A1	
	Using similar triangles or trigonometry	M1	$\frac{x}{320}\times 140$ **or** $\tan\theta = \frac{x}{320}$ **and** $140\tan\theta$ where $179.5 \le x \le 219.5$ (must be a complete method for finding the height)
	Height of C $= \frac{199.5}{320}\times 140 = 87.3\,\text{m}$	A1	87.3 (or better)
		[4]	
5.	$\alpha = \arctan\left(\frac{72}{800}\right)$ $(=5.142...)$	B1	Beware: QB = 800.2
	$\beta = \arctan\left(\frac{90}{800}\right) - \arctan\left(\frac{18}{800}\right)$ $(=5.129...)$	B1	Or cosine rule e.g. $\cos\beta = \frac{\left(\sqrt{800^2+18^2}\right)^2 + \left(\sqrt{800^2+90^2}\right)^2 - 72^2}{2\left(\sqrt{800^2+90^2}\right)\left(\sqrt{800^2+18^2}\right)}$ (oe)
	The angles are both 5.1° to 2 significant figures.	E1	**Must see 5.14 (or better), 5.13 (or better) and 5.1**
		[3]	

Question	Answer	Marks	Guidance
6.	Those thinking they appear **about right** might be those who opted for **70** mm and **80** mm, so 85 + 85 = **170** people	B1	Assumption stated explicitly and must mention the bolded values/words (for 170 allow 85 + 85 or use of 85 twice – may be seen in % calculation) – **any reasonable assumptions must be justified** (as in the case above) – it must be clear where the numbers are coming from (e.g. 220 is about right which comes from 60, 70 and 80 would score B1)
	Percentage $= \frac{170}{362} \times 100 = 46.96...$ so 47%	B1	For 47% (or better) **or** 23% (or better – accept 23.5%) (comes from using just the value of 85) **or** a percentage which comes from a justified assumption (so if the % is not 47 or 23 then they must have been awarded the first B mark)
	Those saying **too large** would be people who opted for **50** mm or **60** mm, so 16 + 50 = **66** people Those saying **too small** would be people who opted for **90** mm, **100**mm or **110** mm, so 72 + 37 +17 = **126** people	B1	Assumptions stated explicitly and must mention the bolded values/words (allow 'values less than or equal to 60' for 50 and 60, allow 'values greater than or equal to 90' for 90,100 and 110) – see first B mark for further details. **Note that for this mark the 'too large' and 'too small' must be attributed to the correct values**
	Percentages are 18% (too large) and 35% (too small)	B1	For 18% (or better) and 35% (or better) **or** a percentage which comes from a justified assumption (so if the % are not 18 and 35 then they must have been awarded the third B mark). **Note that for this mark the values of 18 and 35 do not need to be attributed correctly but any other values must correspond correctly to 'large' and 'small'**
		[4]	

For guidance:

Focal length	50	60	70	80	90	100	110
Number of …	16	50	85	85	72	37	17
%	4.419…	13.81…	23.48…	23.48…	19.88…	10.22…	4.696…

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4754 Applications of Advanced Mathematics (C4)

General Comments:

The performance of candidates on Paper A was similar and comparable to recent papers and the standard of work in the majority of cases was very high. This paper was accessible to all candidates but there were sufficient questions for the more able candidates to show their skills.

Paper B, the comprehension, was well understood and most candidates scored good marks here.

Candidates made similar errors as in previous years and these included:

- Sign and basic algebraic errors (Question 2)
- Failure to include a constant of integration (Question 8(v))
- Poor anti-logging and rules of logarithms (Questions 8(iv) and 8(v))
- Failure to give clear descriptions in the comprehension paper (Questions 2 and 6)
- Inappropriate accuracy, for example in Question 4, candidates either gave insufficient accuracy (answers to the nearest integer) or they gave too much accuracy (answers to 2 or more decimal places) – candidates are reminded to give answers to 1 decimal place for questions involving trigonometry
- Failure to give exact answers when required (Questions 3 and 5(ii))
- Failure to give sufficient detail when verifying given results (Questions 5(i), 5(ii), 6, 7(ii), 8(i), 8(ii), 8(iii), 8(iv) and 8(v)).

Some candidates assume that showing that a vector is perpendicular to one vector in the plane is sufficient to show that it is a normal vector.

Quite a number of candidates failed to attempt some parts but there did not appear to be a shortage of time for either Paper.

Centres are again reminded that as Papers A and B are marked separately any supplementary sheets used must be attached to the appropriate paper. Furthermore, centres are requested that Papers A and B are not attached to each other and they must be sent separately for marking.

Comments on Individual Questions:

Paper A

Question 1

The majority of candidates correctly worked out the values of R and α although some candidates lost the first method mark by not including R in the expanded trigonometric statements $R\cos\alpha = 1$ and $R\sin\alpha = 3$. Some failed to give α in radians and a small minority stated R as10 rather than the correct $\sqrt{10}$. Candidates were less successfully in showing that $\cos\theta - 3\sin\theta = 4$ had no solutions with many simply stating that $\theta + 1.249 = \arccos\left(\frac{4}{\sqrt{10}}\right)$ 'does not work' or gives a 'math error'.

Many candidates failed to explain or give an equivalent mathematical statement that the maximum value of $\cos\theta - 3\sin\theta$ is $\sqrt{10}$ which is less than 4 and so did not score the final mark in this question.

Part (vi) was answered extremely well with many candidates obtaining the correct answer of 0.811 which was achieved by setting e^{-t} equal to zero and substituting 1.85 for x. The most common error seen by examiners was to set $\ln\left(\frac{2+x}{2-x}\right)$ equal to 1.85 and solve for k with e^{-t} equal to zero.

Paper B

Question 1

Nearly all candidates correctly stated the hub height of the turbine although a number incorrectly found this height as 59.5 m (which came from using the diameter of the blade rather than the radius).

Question 2

While the majority of candidates correctly explained how the figure of 12 m was obtained with the most common method being via the calculation $\frac{0.8\times 99.5}{6.7}$ which lead to a value of 11.88… many did not give sufficient detail or tried to justify the figure of 12 without showing any calculation at all.

Question 3

Parts (i) and (ii) were nearly always correct although in part (iii) many candidates failed to use the value of 7.3 to show that when the photomontage was printed on A3 paper, the height of the wind turbine was consistent with the angle of elevation found in part (ii).

Question 4

The responses to this question were mixed with many candidates failing to find the height above A of the lowest visible point as 199.5 m with many incorrectly using a height of 219.5 m. Furthermore, many candidates failed to read the question carefully and stated that the distance AC was 140 m rather the horizontal distance from A to C.

Question 5

Nearly all candidates correctly stated that $\alpha = \arctan\left(\frac{72}{800}\right)$ although many assumed incorrectly that triangle TQB was right-angled. Of those that did realise that triangle TQB was not right-angled many took the slightly more long-winded approach of using the cosine rule to find β instead of realising that $\beta = \arctan\left(\frac{90}{800}\right) - \arctan\left(\frac{18}{800}\right)$. Finally, many candidates did not realise that if they are required to show that two answers agree to 2 significant figures then they must quote both value correct to 3 significant figures and so in this case examiners needed to see as a minimum of $\alpha = 5.14$ and $\beta = 5.13$ followed by 5.1.

Question 6

While many candidates made reasonable estimates of the percentages of participants many confused the two cases of 'too large' and 'too small', or they did not make the numbers used in their calculations clear. A number of candidates did not calculate any percentages but instead gave the total number of participants in the three different groups. The most common estimates were that those who opted for 70 mm and 80 mm would believe that 75 mm was 'about right', while those who opted for 50 mm and 60 mm would say 'too large' and finally those who opted for 90 mm, 100 mm and 110 mm would say 'too small'. Finally many candidates did not state any of their assumptions clearly even though this was specifically asked for in the question.

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GCE Mathematics (MEI)

				Max Mark	a	b	c	d	e	u
4751	01	C1 – MEI Introduction to advanced mathematics (AS)	Raw	72	63	57	52	47	42	0
			UMS	100	80	70	60	50	40	0
4752	01	C2 – MEI Concepts for advanced mathematics (AS)	Raw	72	56	49	42	35	29	0
			UMS	100	80	70	60	50	40	0
4753	01	(C3) MEI Methods for Advanced Mathematics with Coursework: Written Paper	Raw	72	58	52	47	42	36	0
4753	02	(C3) MEI Methods for Advanced Mathematics with Coursework: Coursework	Raw	18	15	13	11	9	8	0
4753	82	(C3) MEI Methods for Advanced Mathematics with Coursework: Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
			UMS	100	80	70	60	50	40	0
4754	01	C4 – MEI Applications of advanced mathematics (A2)	Raw	90	64	57	51	45	39	0
			UMS	100	80	70	60	50	40	0
4755	01	FP1 – MEI Further concepts for advanced mathematics (AS)	Raw	72	59	53	48	43	38	0
			UMS	100	80	70	60	50	40	0
4756	01	FP2 – MEI Further methods for advanced mathematics (A2)	Raw	72	60	54	48	43	38	0
			UMS	100	80	70	60	50	40	0
4757	01	FP3 – MEI Further applications of advanced mathematics (A2)	Raw	72	60	54	49	44	39	0
			UMS	100	80	70	60	50	40	0
4758	01	(DE) MEI Differential Equations with Coursework: Written Paper	Raw	72	67	61	55	49	43	0
4758	02	(DE) MEI Differential Equations with Coursework: Coursework	Raw	18	15	13	11	9	8	0
4758	82	(DE) MEI Differential Equations with Coursework: Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
			UMS	100	80	70	60	50	40	0
4761	01	M1 – MEI Mechanics 1 (AS)	Raw	72	58	50	43	36	29	0
			UMS	100	80	70	60	50	40	0
4762	01	M2 – MEI Mechanics 2 (A2)	Raw	72	59	53	47	41	36	0
			UMS	100	80	70	60	50	40	0
4763	01	M3 – MEI Mechanics 3 (A2)	Raw	72	60	53	46	40	34	0
			UMS	100	80	70	60	50	40	0
4764	01	M4 – MEI Mechanics 4 (A2)	Raw	72	55	48	41	34	27	0
			UMS	100	80	70	60	50	40	0
4766	01	S1 – MEI Statistics 1 (AS)	Raw	72	59	52	46	40	34	0
			UMS	100	80	70	60	50	40	0
4767	01	S2 – MEI Statistics 2 (A2)	Raw	72	60	55	50	45	40	0
			UMS	100	80	70	60	50	40	0
4768	01	S3 – MEI Statistics 3 (A2)	Raw	72	60	54	48	42	37	0
			UMS	100	80	70	60	50	40	0
4769	01	S4 – MEI Statistics 4 (A2)	Raw	72	56	49	42	35	28	0
			UMS	100	80	70	60	50	40	0
4771	01	D1 – MEI Decision mathematics 1 (AS)	Raw	72	48	43	38	34	30	0
			UMS	100	80	70	60	50	40	0
4772	01	D2 – MEI Decision mathematics 2 (A2)	Raw	72	55	50	45	40	36	0
			UMS	100	80	70	60	50	40	0
4773	01	DC – MEI Decision mathematics computation (A2)	Raw	72	46	40	34	29	24	0
			UMS	100	80	70	60	50	40	0
4776	01	(NM) MEI Numerical Methods with Coursework: Written Paper	Raw	72	55	49	44	39	33	0
4776	02	(NM) MEI Numerical Methods with Coursework: Coursework	Raw	18	14	12	10	8	7	0
4776	82	(NM) MEI Numerical Methods with Coursework: Carried Forward Coursework Mark	Raw	18	14	12	10	8	7	0
			UMS	100	80	70	60	50	40	0
4777	01	NC – MEI Numerical computation (A2)	Raw	72	55	47	39	32	25	0
			UMS	100	80	70	60	50	40	0
4798	01	FPT - Further pure mathematics with technology (A2)	Raw	72	57	49	41	33	26	0

		UMS	100	80	70	60	50	40	0

GCE Statistics (MEI)

			Max Mark	a	b	c	d	e	u
G241	01 Statistics 1 MEI (Z1)	Raw	72	59	52	46	40	34	0
		UMS	100	80	70	60	50	40	0
G242	01 Statistics 2 MEI (Z2)	Raw	72	55	48	41	34	27	0
		UMS	100	80	70	60	50	40	0
G243	01 Statistics 3 MEI (Z3)	Raw	72	56	48	41	34	27	0
		UMS	100	80	70	60	50	40	0

GCE Quantitative Methods (MEI)

			Max Mark	a	b	c	d	e	u
G244	01 Introduction to Quantitative Methods MEI	Raw	72	58	50	43	36	28	0
G244	02 Introduction to Quantitative Methods MEI	Raw	18	14	12	10	8	7	0
		UMS	100	80	70	60	50	40	0
G245	01 Statistics 1 MEI	Raw	72	59	52	46	40	34	0
		UMS	100	80	70	60	50	40	0
G246	01 Decision 1 MEI	Raw	72	48	43	38	34	30	0
		UMS	100	80	70	60	50	40	0

Level 3 Certificate and FSMQ raw mark grade boundaries June 2016 series

For more information about results and grade calculations, see www.ocr.org.uk/ocr-for/learners-and-parents/getting-your-results

Level 3 Certificate Mathematics for Engineering

		Max Mark	a*	a	b	c	d	e	u
H860	01 Mathematics for Engineering	This unit has no entries in June 2016							
H860	02 Mathematics for Engineering								

Level 3 Certificate Mathematical Techniques and Applications for Engineers

			Max Mark	a*	a	b	c	d	e	u
H865	01 Component 1	Raw	60	48	42	36	30	24	18	0

Level 3 Certificate Mathematics - Quantitative Reasoning (MEI) (GQ Reform)

			Max Mark	a	b	c	d	e	u
H866	01 Introduction to quantitative reasoning	Raw	72	55	47	39	31	23	0
H866	02 Critical maths	Raw	60	47	41	35	29	23	0
		Overall	132	111	96	81	66	51	0

Level 3 Certificate Mathematics - Quantitive Problem Solving (MEI) (GQ Reform)

			Max Mark	a	b	c	d	e	u
H867	01 Introduction to quantitative reasoning	Raw	72	55	47	39	31	23	0
H867	02 Statistical problem solving	Raw	60	40	34	28	23	18	0
		Overall	132	103	88	73	59	45	0

Advanced Free Standing Mathematics Qualification (FSMQ)

			Max Mark	a	b	c	d	e	u
6993	01 Additional Mathematics	Raw	100	59	51	44	37	30	0

Intermediate Free Standing Mathematics Qualification (FSMQ)

			Max Mark	a	b	c	d	e	u
6989	01 Foundations of Advanced Mathematics (MEI)	Raw	40	35	30	25	20	16	0

Version	Details of change
1.1	Correction to Overall grade boundaries for H866
	Correction to Overall grade boundaries for H867

OCR
Oxford Cambridge and RSA

GCE Mathematics (MEI)

				Max Mark	a	b	c	d	e	u
4751	01	C1 – MEI Introduction to advanced mathematics (AS)	Raw	72	63	57	52	47	42	0
			UMS	100	80	70	60	50	40	0
4752	01	C2 – MEI Concepts for advanced mathematics (AS)	Raw	72	56	49	42	35	29	0
			UMS	100	80	70	60	50	40	0
4753	01	(C3) MEI Methods for Advanced Mathematics with Coursework: Written Paper	Raw	72	58	52	47	42	36	0
4753	02	(C3) MEI Methods for Advanced Mathematics with Coursework: Coursework	Raw	18	15	13	11	9	8	0
4753	82	(C3) MEI Methods for Advanced Mathematics with Coursework: Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
			UMS	100	80	70	60	50	40	0
4754	01	C4 – MEI Applications of advanced mathematics (A2)	Raw	90	64	57	51	45	39	0
			UMS	100	80	70	60	50	40	0
4755	01	FP1 – MEI Further concepts for advanced mathematics (AS)	Raw	72	59	53	48	43	38	0
			UMS	100	80	70	60	50	40	0
4756	01	FP2 – MEI Further methods for advanced mathematics (A2)	Raw	72	60	54	48	43	38	0
			UMS	100	80	70	60	50	40	0
4757	01	FP3 – MEI Further applications of advanced mathematics (A2)	Raw	72	60	54	49	44	39	0
			UMS	100	80	70	60	50	40	0
4758	01	(DE) MEI Differential Equations with Coursework: Written Paper	Raw	72	67	61	55	49	43	0
4758	02	(DE) MEI Differential Equations with Coursework: Coursework	Raw	18	15	13	11	9	8	0
4758	82	(DE) MEI Differential Equations with Coursework: Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
			UMS	100	80	70	60	50	40	0
4761	01	M1 – MEI Mechanics 1 (AS)	Raw	72	58	50	43	36	29	0
			UMS	100	80	70	60	50	40	0
4762	01	M2 – MEI Mechanics 2 (A2)	Raw	72	59	53	47	41	36	0
			UMS	100	80	70	60	50	40	0
4763	01	M3 – MEI Mechanics 3 (A2)	Raw	72	60	53	46	40	34	0
			UMS	100	80	70	60	50	40	0
4764	01	M4 – MEI Mechanics 4 (A2)	Raw	72	55	48	41	34	27	0
			UMS	100	80	70	60	50	40	0
4766	01	S1 – MEI Statistics 1 (AS)	Raw	72	59	52	46	40	34	0
			UMS	100	80	70	60	50	40	0
4767	01	S2 – MEI Statistics 2 (A2)	Raw	72	60	55	50	45	40	0
			UMS	100	80	70	60	50	40	0
4768	01	S3 – MEI Statistics 3 (A2)	Raw	72	60	54	48	42	37	0
			UMS	100	80	70	60	50	40	0
4769	01	S4 – MEI Statistics 4 (A2)	Raw	72	56	49	42	35	28	0
			UMS	100	80	70	60	50	40	0
4771	01	D1 – MEI Decision mathematics 1 (AS)	Raw	72	48	43	38	34	30	0
			UMS	100	80	70	60	50	40	0
4772	01	D2 – MEI Decision mathematics 2 (A2)	Raw	72	55	50	45	40	36	0
			UMS	100	80	70	60	50	40	0
4773	01	DC – MEI Decision mathematics computation (A2)	Raw	72	46	40	34	29	24	0
			UMS	100	80	70	60	50	40	0
4776	01	(NM) MEI Numerical Methods with Coursework: Written Paper	Raw	72	55	49	44	39	33	0
4776	02	(NM) MEI Numerical Methods with Coursework: Coursework	Raw	18	14	12	10	8	7	0
4776	82	(NM) MEI Numerical Methods with Coursework: Carried Forward Coursework Mark	Raw	18	14	12	10	8	7	0
			UMS	100	80	70	60	50	40	0
4777	01	NC – MEI Numerical computation (A2)	Raw	72	55	47	39	32	25	0
			UMS	100	80	70	60	50	40	0
4798	01	FPT - Further pure mathematics with technology (A2)	Raw	72	57	49	41	33	26	0

		UMS	100	80	70	60	50	40	0

GCE Statistics (MEI)

			Max Mark	a	b	c	d	e	u
G241	01 Statistics 1 MEI (Z1)	Raw	72	59	52	46	40	34	0
		UMS	100	80	70	60	50	40	0
G242	01 Statistics 2 MEI (Z2)	Raw	72	55	48	41	34	27	0
		UMS	100	80	70	60	50	40	0
G243	01 Statistics 3 MEI (Z3)	Raw	72	56	48	41	34	27	0
		UMS	100	80	70	60	50	40	0

GCE Quantitative Methods (MEI)

			Max Mark	a	b	c	d	e	u
G244	01 Introduction to Quantitative Methods MEI	Raw	72	58	50	43	36	28	0
G244	02 Introduction to Quantitative Methods MEI	Raw	18	14	12	10	8	7	0
		UMS	100	80	70	60	50	40	0
G245	01 Statistics 1 MEI	Raw	72	59	52	46	40	34	0
		UMS	100	80	70	60	50	40	0
G246	01 Decision 1 MEI	Raw	72	48	43	38	34	30	0
		UMS	100	80	70	60	50	40	0

Level 3 Certificate and FSMQ raw mark grade boundaries June 2016 series

For more information about results and grade calculations, see www.ocr.org.uk/ocr-for/learners-and-parents/getting-your-results

Level 3 Certificate Mathematics for Engineering

		Max Mark	a*	a	b	c	d	e	u
H860	01 Mathematics for Engineering	This unit has no entries in June 2016							
H860	02 Mathematics for Engineering								

Level 3 Certificate Mathematical Techniques and Applications for Engineers

			Max Mark	a*	a	b	c	d	e	u
H865	01 Component 1	Raw	60	48	42	36	30	24	18	0

Level 3 Certificate Mathematics - Quantitative Reasoning (MEI) (GQ Reform)

			Max Mark	a	b	c	d	e	u
H866	01 Introduction to quantitative reasoning	Raw	72	55	47	39	31	23	0
H866	02 Critical maths	Raw	60	47	41	35	29	23	0
		Overall	132	111	96	81	66	51	0

Level 3 Certificate Mathematics - Quantitive Problem Solving (MEI) (GQ Reform)

			Max Mark	a	b	c	d	e	u
H867	01 Introduction to quantitative reasoning	Raw	72	55	47	39	31	23	0
H867	02 Statistical problem solving	Raw	60	40	34	28	23	18	0
		Overall	132	103	88	73	59	45	0

Advanced Free Standing Mathematics Qualification (FSMQ)

			Max Mark	a	b	c	d	e	u
6993	01 Additional Mathematics	Raw	100	59	51	44	37	30	0

Intermediate Free Standing Mathematics Qualification (FSMQ)

			Max Mark	a	b	c	d	e	u
6989	01 Foundations of Advanced Mathematics (MEI)	Raw	40	35	30	25	20	16	0

Version	Details of change
1.1	Correction to Overall grade boundaries for H866
	Correction to Overall grade boundaries for H867