OCR
Oxford Cambridge and RSA

GCE

Mathematics

Unit **4724**: Core Mathematics 4

Advanced GCE

Mark Scheme for June 2017

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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	
1	i		$1 + 2x$ $\left(\frac{1}{4}\right)\times\left(-\frac{3}{4}\right)\times\frac{(8x)^2}{2!}$ oe soi $1 + 2x - 6x^2$ cao	**B1** **M1** **A1** **[3]**	allow bracket error	if **M0** allow **SC1** for $1+4x-8x^2$ ignore extra terms
1	ii		valid for $\lvert x\rvert < \frac{1}{8}$ oe	**B1** **[1]**		
2			Any two from $3+\lambda = -1-3\mu$ $\lambda = 8+\mu$ $2+3\lambda = 2-5\mu$ solve simultaneously to obtain a value of λ or μ $\lambda = 5$ or $\mu = -3$ (8, 5, 17) isw	**B1** **M1** **A1** **A1** **[4]**	may be in vector form allow vector form	

Question	Answer	Marks	Guidance	
3	$\frac{1}{4}e^{4x}$ soi	**B1**	from integration	
	$[16]x \times \frac{1}{4}e^{4x} - \int [16] \times \frac{1}{4}e^{4x} dx$ oe	**M1***	allow sign errors only	ignore limits at this stage
	$F[x] = \left[4xe^{4x} - e^{4x}\right]$	**A1**		
	$F[1] - F[0]$	**M1dep***	allow bracket errors, but substitution of limits must be shown	**NB** double negative may be implied by plus sign
	$= 3e^4 + 1$ **NB AG**	**A1**	convincing intermediate step needed eg $4e^4 - e^4 - \left(0 - e^0\right)$	no recovery from bracket errors for this mark
		[5]		
4	$\frac{A}{3+x} + \frac{B}{1-x} + \frac{C}{2x+1}$	**B1**	if not seen here, may be awarded at end	
	$\left[9x^2 + 43x + 8 \equiv\right]$ $A(1-x)(2x+1) + B(3+x)(2x+1) + C(3+x)(1-x)$ soi	**M1**	allow sign errors only	
	$A = 2$ $B = 5$ $C = -3$ isw	**A1** **A1** **A1**	$\frac{2}{3+x} + \frac{5}{1-x} - \frac{3}{2x+1}$	
		[5]		

Question			Answer	Marks	Guidance	
5	i		$3x^2$ seen in quotient and $\pm 6x^2$ seen as leading term in division quotient is $3x^2 - 3$ remainder is $x + 1$	**M1** **A1** **A1** **[3]**	if **M0**, **B2** for quotient and **B1** for remainder	the quotient and the remainder may be left embedded; but mark the final answer
5	ii		$\int\left(3x^2 - 3 + \frac{x+1}{2x^2+4x+1}\right)\mathrm{d}x$ $x^3 - 3x + \frac{1}{4}\ln(2x^2+4x+1)$ cao $18 + \frac{1}{4}\ln 31$ cao	**M1FT** **A1** **A1** **[3]**	their quadratic quotient and their linear remainder	

Question	Answer	Marks	Guidance	
6	$Ay^{-½} \times \frac{dy}{dx}$	**M1**	*A* is a constant	
	$Bxy + x^2 \frac{dy}{dx}$	**M1**	*B* is a constant	**NB** $\frac{-2xy}{x^2 + 2y^{-\frac{1}{2}}}$
	$4 \times \frac{1}{2} y^{-½} \times \frac{dy}{dx} + 2xy + x^2 \frac{dy}{dx} [= 0]$	**A1**		
	$x = \pm 2$	**B1**	both values	from $4\sqrt{1} + x^2 \times 1 - 8 = 0$
	substitution of (*their* 2, 1) *or* (*their* –2, 1) following differentiation	**M1**	may follow incorrect rearrangement	
	at (2, 1) $m = -⅔$	**A1**		association between point and gradient may be evidenced by substitution
	at (− 2, 1) $m = ⅔$	**A1**		
	Alternatively, marks for differentiation may be awarded as follows	**[7]**		
	$2x \frac{dx}{dy}$	**B1**		
	$2x \frac{dx}{dy} y + x^2 \times 1$	**M1**	use of Product Rule	
	$2x \frac{dx}{dy} y + x^2 + 2y^{-\frac{1}{2}} [= 0]$	**A1**		

Question			Answer	Marks	Guidance	
7	i		$\ln A - \ln(250 - A) = kt\ (+ c)$	**M1***	allow sign error	
			valid substitution of $t = 0$ and $A = 10$ to find c	**M1dep***	**NB** $\ln 10 - \ln 240 = 0 + c$	
			$c = -\ln 24$ oe	**A1**	allow to 3 sf or more	-3.17805383
			constructive log step	**A1**	eg $\ln\left(\frac{A}{250-A}\right) = kt - \ln 24$ oe	or $\ln\left(\frac{A}{250-A}\right) = kt - 3.178$
			taking exponentials correctly of both sides; FT their rearrangement and/or *their* numerical c	**M1dep***	eg $\left(\frac{24A}{250-A}\right) = e^{kt}$	or $\left(\frac{A}{250-A}\right) = e^{kt-3.178}$
			$[A] = \frac{250e^{kt}}{24 + e^{kt}}$ oe	**A1**		
			……	……	……	……
			Alternatively			
			$\ln A - \ln(250 - A) = kt\ (+ c)$	**M1***	allow sign error	
			constructive log step, may be awarded after taking exponentials	**A1**	eg $\ln\left(\frac{A}{250-A}\right) = kt + c$	
			taking exponentials correctly of both sides; FT their rearrangement	**M1dep***	eg $\frac{A}{250-A} = e^{kt+c}$	
			valid substitution of $t = 0$ and $A = 10$ to find c	**M1dep***	eg $\frac{10}{250-10} = e^{0+c}$	
			$\frac{A}{250-A} = e^{kt-\ln 24}$ oe	**A1**		
			$[A] = \frac{250e^{kt}}{24 + e^{kt}}$ oe	**A1**		
				[6]		

Question			Answer	Marks	Guidance	
7	ii		$k = 0.05$	**B1** **[1]**		
7	iii		$A = 250$ [m^2]	**B1** **[1]**	ignore commentary	
8	i		$\frac{\cos 4x \times 4\cos 4x - (1+\sin 4x) \times -4\sin 4x}{\cos^2 4x}$	**M1**	quotient rule; allow sign errors and/or one coefficient error	
			$\frac{4\cos^2 4x + 4\sin^2 4x + 4\sin 4x}{\cos^2 4x}$ oe	**A1**		
			$\frac{\cos 4x}{1+\sin 4x} \times their \frac{4(1+\sin 4x)}{\cos^2 4x}$	**M1**	use of chain rule; may be unsimplified	
			$= \frac{4}{\cos 4x}$ **NB AG**	**A1**		
			.....	.....	.....	
			Alternatively			
			$\frac{4\cos 4x}{1+\sin 4x} - \frac{-4\sin 4x}{\cos 4x}$	**M1**	chain rule; allow sign errors and/or one error in coefficient of cos 4*x* or sin4*x*	or use of product rule with (1+sin4*x*) and $(\cos 4x)^{-1}$ or sec4*x*
			$\frac{4\cos 4x \times \cos 4x + 4\sin 4x(1+\sin 4x)}{(1+\sin 4x)\cos 4x}$	**M1**	combine to a single fraction FT *their* chain rule	$(1+\sin 4x) \times -1(\cos 4x)^{-2} \times -4\sin 4x + \frac{4\cos 4x}{\cos 4x}$
			eg $\frac{4(\cos^2 4x + \sin^2 4x) + 4\sin 4x}{(1+\sin 4x)\cos 4x}$	**A1**	any equivalent correct step	
			$\frac{4}{\cos 4x}$	**A1**		

Question			Answer	Marks	Guidance	
			Alternatively $\frac{1}{\sec 4x + \tan 4x} \times \left(4\sec 4x \tan 4x + 4\sec^2 4x\right)$	**M1**	allow sign errors and/or one coefficient error	
			$\frac{4\sec 4x(\tan 4x + \sec 4x)}{\sec 4x + \tan 4x}$	**M1**	factorising – allow one coefficient slip	
			$4\sec 4x$	**A1**		
			$\frac{4}{\cos 4x}$	**A1**		
				[4]		
8	**ii**		$\frac{\cos 2x(\cos 2x - \sin 2x) + \sin 2x(\cos 2x + \sin 2x)}{(\cos 2x + \sin 2x)(\cos 2x - \sin 2x)}$ oe	**M1**	combine into a single fraction; allow sign errors	allow equivalent form with double angle formulae allow equivalent separate fractions with correct common denominator
			$\frac{\cos^2 2x - \cos 2x \sin 2x + \sin 2x \cos 2x + \sin^2 2x}{\left(\cos^2 2x - \sin^2 2x\right)}$	**A1**	or better	
			$\frac{1}{\cos 4x}$	**A1**		
			$\frac{1}{4}\ln\left(\frac{1+\sin 4x}{\cos 4x}\right) + c$ oe eg $\frac{1}{4}\ln(1+\sin 4x) + \frac{1}{4}\ln\sec 4x + c$	**A1**	**NB** $\frac{1}{4}\ln(\sec 4x + \tan 4x) + c$	
				[4]		

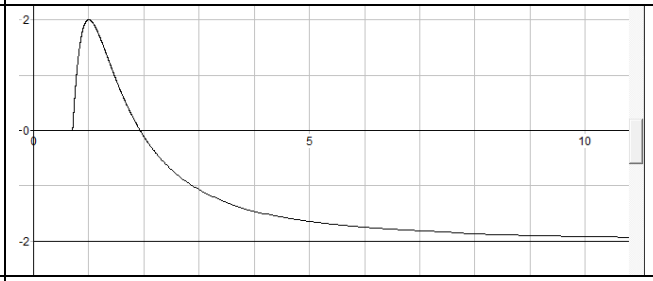
Question			Answer	Marks	Guidance	
9			$\frac{du}{dx} = 1 + \frac{1}{x}$	**B1**		
			$x + \ln x = \pm u \pm 1$ oe substituted into the numerator	**M1***	allow slip in substitution	
			dx replaced by *their* $\left(\frac{1}{1/x + 1}\right)$[d$u$] in integrand oe	**M1***		
			$\int\left(\frac{3(1-(u-1))}{u}\right)$[d$u$] oe	**A1**	may be simplified	$\int\left(\frac{6}{u} - 3\right)du$
			$A\ln u + Bu$ (+ c)	**M1dep***	following $\int\left(\frac{A}{u} + B\right)du$	
			$6\ln(1 + \ln x + x) - 3(1 + \ln x + x) + c$ oe isw	**A1**		if du and/or $\int$ and/or + c not seen at some stage, withhold the final **A1**
				[6]		
10	**i**		$r = \begin{pmatrix}5\\1\\9\end{pmatrix} + \lambda\begin{pmatrix}3\\6\\6\end{pmatrix}$ oe isw	**B1**	**NB** eg $r = \begin{pmatrix}8\\7\\15\end{pmatrix} + \lambda\begin{pmatrix}1\\2\\2\end{pmatrix}$	**B0** for just the RHS, must see "r =" oe
				[1]		
10	**ii**		$6\times3 - 3\times6 + 6\times6 = \sqrt{6^2 + (-3)^2 + 6^2} \times \sqrt{3^2 + 6^2 + 6^2}\cos A$	**M1**	allow sign errors and 1 algebraic slip eg omission of power	or $\cos A = \frac{9^2 + 9^2 - (their\sqrt{90})^2}{2\times9\times9}$
						$PB = 3\sqrt{10}$
			$36 = 81\cos A$ or $-36 = 81\cos A$ or better	**A1**		
			$A = 63.6°$ or 1.11 rad	**A1**	if obtuse angle found, clear explanation needed if acute angle stated as answer	$A = 63.6°$ or 1.11 rad
			eg $AB = \sqrt{3^2 + 6^2 + 6^2}$ and $AP = \sqrt{6^2 + (-3)^2 + 6^2}$ [so isosceles]	**B1**	**NB** AB = 9 and AP = 9 stated is sufficient **B0** if answer spoiled	**NB** 58.2° or $\cos\theta = \frac{\sqrt{10}}{6}$
				[4]		

Question			Answer	Marks	Guidance	
10	iii		$\overrightarrow{PD} = \begin{pmatrix} 5+3\lambda \\ 1+6\lambda \\ 9+6\lambda \end{pmatrix} - \begin{pmatrix} 11 \\ -2 \\ 15 \end{pmatrix}$ oe	**M1***		NB $\overrightarrow{PD} = \begin{pmatrix} 3\lambda - 6 \\ 3+6\lambda \\ 6\lambda - 6 \end{pmatrix}$
			$(3\lambda-6)^2 + (3+6\lambda)^2 + (6\lambda-6)^2 = 9^2$ oe	**M1dep***	allow one algebraic slip eg omission of one power	
			$\lambda = \frac{8}{9}$[or 0]	**A1**	**NB**	
			$\left(\frac{23}{3}, \frac{19}{3}, \frac{43}{3}\right)$	**A1**	$\lambda = \frac{8}{3}$ if direction vector is $\begin{pmatrix} 1 \\ 2 \\ 2 \end{pmatrix}$	
			…….	**[4]**	……..	
			Alternatively	…….		
			$AD^2 = 9^2 + 9^2 - 2\times9\times9\times\cos(180-2\times63.6)$	**M1***	**NB** AD = 8	
			$(3\lambda)^2 + (6\lambda)^2 + (6\lambda)^2 =$ their AD^2 oe	**M1dep***		
			$\lambda = \frac{8}{9}$	**A1**	$\lambda = \frac{8}{3}$ if direction vector is $\begin{pmatrix} 1 \\ 2 \\ 2 \end{pmatrix}$	
			$\left(\frac{23}{3}, \frac{19}{3}, \frac{43}{3}\right)$	**A1**		
				[4]		

Question			Answer	Marks	Guidance	
10	iii		*Alternatively* $\overrightarrow{PE} = \begin{pmatrix} 5+3\lambda-11 \\ 1+6\lambda--2 \\ 9+6\lambda-15 \end{pmatrix}$ $\overrightarrow{PE} \cdot \begin{pmatrix} 1 \\ 2 \\ 2 \end{pmatrix} = 0$ $\lambda = \frac{4}{9}$ $\left(\frac{23}{3}, \frac{19}{3}, \frac{43}{3}\right)$ …… *Alternatively* $\overrightarrow{PD}$ found as above $\overrightarrow{AP} \cdot \overrightarrow{AD} = \overrightarrow{DA} \cdot \overrightarrow{DP}$ oe $\lambda = \frac{8}{9}$ $\left(\frac{23}{3}, \frac{19}{3}, \frac{43}{3}\right)$	**M1** **M1** **A1** **A1** **[4]** **M1** **M1** **A1** **A1** **[4]**	E is the foot of the perpendicular from P to AB from $\overrightarrow{AD} = 2\overrightarrow{AE}$ eg $\begin{pmatrix} 6 \\ -3 \\ 6 \end{pmatrix} \cdot \begin{pmatrix} 3\lambda \\ 6\lambda \\ 6\lambda \end{pmatrix} = \begin{pmatrix} -3\lambda \\ -6\lambda \\ -6\lambda \end{pmatrix} \cdot \begin{pmatrix} 6-3\lambda \\ -3-6\lambda \\ 6-6\lambda \end{pmatrix}$	or $\begin{pmatrix} -2 \\ -6 \\ -6 \end{pmatrix} \cdot \begin{pmatrix} 6-3\lambda \\ -3-6\lambda \\ 6-6\lambda \end{pmatrix} = 36$ or $\begin{pmatrix} 6 \\ -3 \\ 6 \end{pmatrix} \cdot \begin{pmatrix} 3\lambda \\ 6\lambda \\ 6\lambda \end{pmatrix} = 32$

Question			Answer	Marks	Guidance	
11	i		$\left(\frac{dy}{dt}\right) = 3t^2 - 3$	B1		
			$\left(\frac{dx}{dt} =\right) k(2+t)^{-\frac{3}{2}}$	M1	$k \neq 0$	
			$\frac{dy}{dx} = \frac{3t^2 - 3}{-\frac{1}{2}(2+t)^{-\frac{3}{2}}}$ oe isw	A1	do not allow bracket errors in marked answer	
				[3]		
			Alternatively			
			$[y =](x^{-2} - 2)^3 - 3x^{-2} + 6$ oe	B1		
			$\left[\frac{dy}{dx} =\right] 3(x^{-2} - 2)^2 \times (-2x^{-3}) + 6x^{-3}$ oe	M1	allow sign errors and/or one coefficient error	
			$3\left[\left((2+t)^{-\frac{1}{2}}\right)^{-2} - 2\right]^2 \times -2\left((2+t)^{-\frac{1}{2}}\right)^{-3}$ $+6\left((2+t)^{-\frac{1}{2}}\right)^{-3}$ oe isw	A1		
				[3]		

Question			Answer	Marks	Guidance	
11	ii		their $\frac{dy}{dx} = 0$	M1	allow eg $3t^2 - 3 = 0$	allow one transcription error
			(1, 2) oe identified as only stationary point	A1	**NB** $t = -1$	
			eg $t = -0.5$, $x = \sqrt{⅔}$ **and** gradient = 8.27 eg $t = -1.5$, $x = \sqrt{2}$ **and** gradient = -2.65 **or** eg $t = -0.5$ and $y = 1.375$, $t = -1.5$ and $y = 1.125$	M1	consideration of gradient either side of *their* $x = 1$ **or** consideration of y-values either side of their $y = 2$	ignore work with other points for the last two marks
			hence maximum value at (1, 2)	A1		
			…….	…….	…….	…….
			Alternatively, for last two marks			ignore work with other points for the last two marks
			evaluation of second derivative at *their* $t = -1$ or *their* $x = 1$	M1		
			$\frac{d^2y}{dx^2} = -18x^{-4} + 24x^{-8} - 48x^{-6} + 18x^{-4}(x^{-2} - 2)^2$ or oe $6(2+t)^2(7t^2 + 8t - 3)$		second derivative must be obtained from correct method; allow sign errors	
			convincing justification that second derivative < 0 [NB – 24] so maximum	A1 [4]		
11	iii		$x \geq \frac{1}{\sqrt{2}}$	B1		
			$-2 < y \leq 2$	B1 [2]		

Question			Answer	Marks	Guidance	
11	iv			**B1** **[1]**	curve with maximum in 1st quadrant and horizontal asymptote in 4th quadrant drawn for $x \geq k$, where $k > 0$	

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