OCR
Oxford Cambridge and RSA

GCE

Mathematics

Unit **4724**: Core Mathematics 4

Advanced GCE

Mark Scheme for June 2018

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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.

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 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)	$\frac{3(x+1)}{(2x+1)(x+1)} - \frac{2(2x+1)}{(x+1)(2x+1)}$ oe	M1	for either fraction correct; may be embedded in single fraction	numerator and/or denominator may be expanded
	$\frac{1-x}{(2x+1)(x+1)}$ or $\frac{1-x}{(2x^2+3x+1)}$ oe	A1	mark the final answer	
		[2]		
1 (ii)	$3(2x + 1)$ soi	B1		
	$(x + 2)(x – 1)$ seen in denominator	M1	attempt to factorise denominator, allow sign errors only	
	$\frac{1-x}{(2x+1)(x+1)} \times \frac{3(2x+1)}{(x+2)(x-1)}$	M1	multiplication of given fraction and their result from part (i)	allow omission of brackets
	$\frac{-3}{(x+2)(x+1)}$ oe	A1	denominator may be expanded, but fraction must be in its lowest terms	allow recovery from omission of brackets
		[4]		
2 (i)	$(\lambda)\begin{pmatrix}4\\-11\\3\end{pmatrix} \neq k\begin{pmatrix}1\\4\\1\end{pmatrix}$ or equivalent in words as long as numerical values in direction vectors clearly identified	B1	allow eg $4 \times 1 = 4$ but $4 \times 4 \neq -11$	do not allow eg "the direction vectors are not multiples of each other"
		[1]		
2 (ii)	value for λ or μ obtained from $2 + \lambda = -4 + 4\mu$ $-3 + 4\lambda = 6 - 11\mu$	M1	or from $2 + \lambda = -4 + 4\mu$ $1 + \lambda = -2 + 3\mu$	or from $-3 + 4\lambda = 6 - 11\mu$ $1 + \lambda = -2 + 3\mu$ allow one sign and/or one coefficient error in equations
	$(\lambda =) -\frac{10}{9}$ or $(\mu =) \frac{11}{9}$	A1	$(\lambda =) 6$ or $(\mu =) 3$	$(\lambda =) -\frac{6}{23}$ or $(\mu =) \frac{21}{23}$

Question			Answer	Marks	Guidance	
			substitution of both in third equation $1-\frac{10}{9} \neq -2+3\times\frac{11}{9}$ oe (equations inconsistent) so lines are skew allow "do not intersect" isw	**M1** **A1** **[4]**	or substitution of one in third equation to find other parameter and then substitution of both in one of the original equations or $-3+4\times6 \neq 6-3\times11$ oe **A0** if answer spoiled by incorrect subsequent arithmetic do not allow eg $1-\frac{10}{9} = -2+3\times\frac{11}{9}$ so lines are skew	or obtains two values from a different pair of equations or $2-\frac{6}{23} \neq -4+4\times\frac{21}{23}$ oe two correct pairs of λ and μ obtained and correct conclusion made and justified
3	(i)		quotient is $2x + 1$ remainder is $3x + 1$	**B2** **B1** **[3]**	allow **B1** for $2x$ seen in quotient or from equating coefficients allow all 3 marks if not attributed or left embedded **B0** for eg remainder = $\frac{3x+1}{(1-x)^2}$	allow **B2** if quotient identified as $3x + 1$ and remainder identified as $2x + 1$ and all other working correct mark the final answer in each case

Question	Answer	Marks	Guidance	
3 (ii)	$(1-x)^2$ soi in denominator oe	B1	must be factorised	or **M1A1** for $1+(-1)(-2x+x^2)+(-1)(-2)\dfrac{(-2x+x^2)^2}{2!}$
	$1+(-2)(-x)+(-2)(-3)\dfrac{(-x)^2}{2!}$ soi	M1	allow sign errors only; must be at least three terms	
	$(3x+1)(1+2x+3x^2)$ expanded **FT** their remainder and their binomial expansion	M1FT	or expansion of $(1 + 2x + 3x^2) \times (2x^3 – 3x^2 + 3x + 2)$	or of $-3(1-x)^{-1} + 4(1-x)^{-2}$ from correct use of partial fractions if **B0M0** allow **B1** for $2 + 7x + kx^2$ from equating coefficients or **B2** for $2 + 7x + 9x^2$ or **B3** for $2 + 7x + 9x^2$ with explanation of rejection of terms in x^3 (and above) mark to benefit of candidate
	$2 + 7x + 9x^2$ cao	A1 [4]		
4 (i)	$x = 2\times\dfrac{2\tan t}{1-\tan^2 t}$ oe soi	B1		or $\dfrac{4\tan t}{(1+\tan t)(1-\tan t)}$
	$x = 2\times\dfrac{2(y\pm1)}{1\pm(y\pm1)^2}$ oe	M1		$\dfrac{4(y-1)}{y(2-y)}$
	at least one correct intermediate step seen and completion to $4y + xy^2 - 2xy = 4$ **AG** nfww	A1 [3]	eg $\left(2y-y^2\right)x = 4(y-1)$	must see $(y-1)^2$ or $y(2-y)$ expanded if **B1M0** allow **B1B1** for substitution for x and y in LHS of cartesian equation and obtaining 4 www

Question	Answer	Marks	Guidance	
4 (ii)	$4\frac{dy}{dx}$ seen in differentiation of $4y$	**B1**		**B1B1** for $\frac{dy}{dt} = \sec^2 t,\ \frac{dx}{dt} = 4\sec^2 2t$
	$y^2 + 2xy\frac{dy}{dx} - 2y - 2x\frac{dy}{dx}$	**M1**	Product rule used twice for $xy^2 - 2xy$; allow one sign and/or one coefficient error	**M1** for their $\frac{dy}{dt} \div$ their $\frac{dx}{dt}$
	$4\frac{dy}{dx} + y^2 + 2xy\frac{dy}{dx} - 2y - 2x\frac{dy}{dx}$ on LHS	**A1**	ignore RHS	**A1** for eg $\frac{1+(y-1)^2}{4+x^2}$ or $\frac{y^2-2y+2}{4+x^2}$
	$\left[\frac{dy}{dx} =\right] \frac{2y - y^2}{4 + 2xy - 2x}$ oe	**A1**	withhold **A1** if 4 left on RHS after differentiation	
		[4]		
	alternatively			
	4 from differentiation of $4y$	**B1**		if **B0M0** allow **B3** for $\frac{y^2(2-y)^2}{4(y^2-2y+2)}$ oe
	$2xy + 2y^2\frac{dx}{dy} - 2x - 2y\frac{dx}{dy}$	**M1**	Product rule used twice for $xy^2 - 2xy$; allow one sign and/or one coefficient error	from differentiation of $x = \frac{4(y-1)}{2y-y^2}$
	$4 + 2xy + y^2\frac{dx}{dy} - 2x - 2y\frac{dx}{dy}$ on LHS	**A1**	ignore RHS	
	$\left[\frac{dy}{dx} =\right] \frac{2y - y^2}{4 + 2xy - 2x}$ oe isw nfww	**A1**		
		[4]		
4 (iii)	intercept is (0, 1) soi	**B1**	allow $y = 1$	may be from substitution of $t = 0$ in parametric form or $x = 0$ in cartesian form
	$m = ¼$ or 0.25 cao	**B1**	allow **B2** for $m = ¼$ or 0.25 unsupported	**B0** if incorrect $\frac{dy}{dx}$ clearly used to obtain 0.25
		[2]		

Question	Answer	Marks	Guidance	
5 (i)	$\frac{1}{\cos x}$ soi $\frac{1}{\cos x} \times -\sin x$ isw	**M1** **A1** **[2]**	or $-\tan x$	eg **M1** implied by $\tan x$ seen
5 (ii)	$\pm k \sin 2x \ln\lvert\cos x\rvert \pm \int k \sin 2x \times -\frac{\sin x}{\cos x} \mathrm{d}x$	**M1***	integration by parts with functions correctly attributed; allow omission of one or both 2s in $\sin 2x$	**FT** from (i) if **M1** awarded in (i); allow brackets instead of modulus in natural log term throughout this question condone omission of brackets / modulus for log terms and dx throughout
	$\sin 2x \ln\lvert\cos x\rvert - \int \sin 2x \times \frac{-\sin x}{\cos x} \mathrm{d}x$	**A1**	or $\pm\frac{1}{2}\cos 2x \tan x \pm \int \frac{1}{2}\cos 2x \sec^2 x dx$	
	$\sin 2x = 2\sin x \cos x$ substituted in integrand NB $\sin 2x \ln\lvert\cos x\rvert + \int 2\sin^2 x \mathrm{d}x$	**M1dep***		
	$\pm 1 \pm \cos 2x$ seen in integrand $\sin 2x \ln\lvert\cos x\rvert + \int (1 - \cos 2x) \mathrm{d}x$	**M1dep***	substitution of $\cos 2x = 2\cos^2 x - 1$ in integrand	$-\frac{1}{2}\cos 2x \tan x + \frac{1}{2}\int \frac{2\cos^2 x - 1}{\cos^2 x} \mathrm{d}x$
	$\sin 2x \ln\lvert\cos x\rvert + x - \frac{1}{2}\sin 2x$ $(+c)$ isw	**A1** **[5]**	$\sin 2x \ln\lvert\cos x\rvert - \frac{1}{2}\cos 2x \tan x$ $+x - \frac{1}{2}\tan x (+c)$	allow recovery from omission of integral signs condone superfluous integral sign in answer

Question	Answer	Marks	Guidance	
6	$\frac{du}{dx} = kx^{-\frac{1}{2}}$	**M1***	or $\frac{dx}{du} = k(u-1)$	
	substitution of $\sqrt{x} = \frac{1}{2}(u-1)$ oe in numerator	**M1***	allow one sign error and/or one coefficient error	eg **M1** for substitution of $2(u + 1)$
	dx replaced by $k\sqrt{x}$ [du] or dx replaced by $k(u - 1)$ [du]	**M1***	$\sqrt{x}$ may be in terms of u	
	$\int \frac{\frac{1}{4}(u-1)^2}{u}[du]$ oe	**A1**		
	$\frac{1}{4}\int\left(u-2+\frac{1}{u}\right)[du]$	**M1dep***	**FT** expand brackets and divide by u	allow one slip eg two of three terms correct or omission of ¼; allow omission of integral sign for this mark
	$\frac{u^2}{8} - \frac{u}{2} + \frac{1}{4}\ln u (+c)$ oe	**A1**	allow ¼ln4u	
	$\frac{\left(1+2\sqrt{x}\right)^2}{8} - \frac{1+2\sqrt{x}}{2} + \frac{1}{4}\ln\left(1+2\sqrt{x}\right) + c$ oe isw	**A1**	must see + c at some point following integration for the final mark	or $-\frac{3}{8} - \frac{\sqrt{x}}{2} + \frac{x}{2} + \frac{1}{4}\ln(1+2\sqrt{x}) + c$ or $\frac{(1+2\sqrt{x})\left(5+2\sqrt{x}\right)}{8} + \frac{1}{4}\ln(1+2\sqrt{x}) + c$
		[7]	if full marks, but du not seen at least once in integrand and/or + c at some point, withhold final **A1**	

Question	Answer	Marks	Guidance	
7 (i)	$\frac{A}{1+x}+\frac{B}{1-2x}+\frac{C}{(1-2x)^2}$	**B1**	may be awarded later	NB if 6 is taken out as a common factor, $A = \frac{1}{3}$, $B = \frac{2}{3}$ and $C = 1$
	$12-6x = A(1-2x)^2 + B(1+x)(1-2x) + C(1+x)$	**M1**	allow sign errors only	
	$A = 2$	**A1**	NB $0 = 4A - 2B$ $-6 = -4A - B + C$	
	$B = 4$	**A1**	$12 = A + B + C$	
	$C = 6$	**A1** **[5]**	$\frac{2}{1+x}+\frac{4}{1-2x}+\frac{6}{(1-2x)^2}$	
7 (ii)	$\pm k\ln\lvert 1+x\rvert \pm l\ln\lvert 1-2x\rvert$ oe	**M1***	**FT** their three fractions from (i) for **M1M1**	condone use of brackets instead of modulus signs throughout; condone omission of brackets throughout if recovered later
	$\pm m(1-2x)^{-1}$	**M1**		
	$2\ln\lvert 1+x\rvert - 2\ln\lvert 1-2x\rvert + \frac{3}{1-2x}$	**A1**	all correct, may be unsimplified	
	F[2] – F[1]	**M1dep***	$2\ln3 - 2\ln\lvert -3\rvert - 1 - [2\ln2 - 2\ln\lvert -1\rvert - 3]$	
	$2 - \ln4$ cao	**A1** **[5]**	not from wrong working	allow eg $\ln(-3)^2 = \ln 9$ or $\ln\left(\frac{-3}{-1}\right) = \ln 3$
8 (i)	eg $\begin{pmatrix}1\\3\\1\end{pmatrix} + t\begin{pmatrix}3-1\\2-3\\4-1\end{pmatrix}$ oe soi	**M1**	any correct form with correct position vector	allow one sign error in direction vector
	$\boldsymbol{r} = \begin{pmatrix}1\\3\\1\end{pmatrix} + t\begin{pmatrix}2\\-1\\3\end{pmatrix}$ oe	**A1** **[2]**	must see "$\boldsymbol{r}$ =" or eg "$\boldsymbol{l}$ =" or appropriate column vector on LHS	do not allow eg "$\overrightarrow{AB} =$" on LHS

Question	Answer	Marks	Guidance	
8 (ii)	$\left(\overrightarrow{OQ}=\right)\begin{pmatrix}1+2t\\3-t\\1+3t\end{pmatrix}$ oe soi	**M1***	**FT** their equation; may be embedded; must be expressed as a single vector or point	may be awarded later
	$\left(\overrightarrow{PQ}=\right)\begin{pmatrix}1+2t\\3-t\\1+3t\end{pmatrix}-\begin{pmatrix}15\\4\\6\end{pmatrix}$ oe	**M1dep***	**FT** their equation; may be embedded	**M0** for $\overrightarrow{OQ}.\text{their}\begin{pmatrix}2\\-1\\3\end{pmatrix}=0$
	their $\overrightarrow{PQ}.\text{their}(t)\begin{pmatrix}2\\-1\\3\end{pmatrix}=0$ expanded; dependent on both previous **M** marks	**M1dep****	**NB** $4t - 28 + 1 + t + 9t - 15 = 0$ allow sign errors and slips in arithmetic for **M1**	***alternatively,*** use of Pythagoras: $14^2 + 1^2 + 5^2 = (2t)^2 + (-t)^2 + (3t)^2 + (2t - 14)^2 + (1 + t)^2 + (3t - 5)^2$
	$t = 3$ (or -3 if working with $\overrightarrow{QP}$)cao	**A1**		NB $t = \pm 2$ if working from point B
	Q is (7, 0, 10) cao	**A1**	allow if given as a column vector oe	if **M0M0M0** allow **B5** for (7, 0, 10) obtained not from wrong working
	alternatively	**[5]**		
	$\cos PAQ = \frac{42}{\sqrt{222}\sqrt{14}}$ from $\overrightarrow{AB}.\overrightarrow{AP}$	**M1***		
	$AQ = AP \times \cos PAQ$ oe	**M1dep***		or $\lvert AQ\rvert = AQ.AB \div \lvert AB\rvert$
	$AQ^2 = (2t)^2 + (-t)^2 + (3t)^2$	**M1dep***		or $AB = \sqrt{14}$ **and** $AQ = 3\sqrt{14}$
	$t = 3$ cao	**A1**	**NB** $t = 2$ if working from point B	
	Q is (7, 0, 10) cao	**A1**	allow if given as a position vector	

Question	Answer	Marks	Guidance	
8 (iii)	$PQ = \sqrt{((15-7)^2 + (4-0)^2 + (6-10)^2)}$ oe	**B1**		NB $\sqrt{96}$
	$AQ = \sqrt{((1-7)^2 + (3-0)^2 + (1-10)^2)}$ oe	**M1**	**FT** their calculated (7, 0, 10)	NB $\sqrt{126}$
	area = $12\sqrt{21}$ or 54.99091…rounded to 2 sf or more	**A1**		ignore units
	alternatively **M1** for AQ as above **B1** for angle $PAQ = \cos^{-1}(42/\sqrt{(222\times14)})$ **A1** for $12\sqrt{21}$ oe as above (from ½× AQ ×AP × sin PAQ)	**[3]**	**NB** 41.11678..° or 0.7176232...	
9 (i)	$\frac{dV}{dt} = k\,e^{-t}$ soi	**B1**	**B0** if x used as constant instead of k; **M** marks are still available	
	substitution of $\frac{dV}{dt} = 10$, $t = 2$	**M1**	**NB** $10 = k\,e^{-2}$ not from V	***alternatively, from connected rates of change*** $(x+1)^3 = -ke^{-t} + c$ from $\int ke^{-t}dt = \int 3(x+1)^2 dx$
	$V = -k\,e^{-t} + c$ oe	**M1***	from integration; allow omission of +c here; allow eg $V = l\,e^{-t} + c$	
	substitution of $t = 0$, $V = 0$ in their $V = -k\,e^{-t} + c$	**M1dep***	must see + c here; may be awarded before k found	substitution of $t = 0$, $x = 0$ (to obtain $c = 1 + k$)
	$V = 10e^2(1-e^{-t})$ **AG**	**A1**	correct completion to given result; **A0** if 73.89… used in working	
	$x = 3$ gives $V = 63$ soi	**B1**		
	t obtained from $63 = 10e^2(1-e^{-t})$	**M1**	**NB** 1.914688…unsupported to 3 or more sf implies **B1M1A1**	
	t = 1.9 to 1.915	**A1**		
		[8]		

Question			Answer	Marks	Guidance	
9	(ii)		as t becomes large, e^{-t} becomes very small soi	**M1**	need not be explicitly stated	may be implied by 73.890….to 3 or more sf
			x obtained from $10e^2 = (x+1)^3 - 1$	**M1**		**NB** 3.215111183 unsupported to 3 or more sf justifies award of **M1M1** if working not seen
			x = 3.22 cao	**A1**	allow **B3** for 3.22 unsupported	
				[3]		

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