OCR
RECOGNISING ACHIEVEMENT

GCE

Mathematics (MEI)

Advanced GCE

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

Mark Scheme for January 2012

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.

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Annotations

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.

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

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

Question			Answer	Marks	Guidance
1			$\frac{x+1}{x^2(2x-1)} = \frac{A}{x} + \frac{B}{x^2} + \frac{C}{2x-1} = \frac{Ax(2x-1)+B(2x-1)+Cx^2}{x^2(2x-1)}$	B1	correct partial fractions
			$\Rightarrow \quad x+1 = Ax(2x-1)+B(2x-1)+Cx^2$	M1	Using a correct method to find a coefficient (equating numerators and substituting oe or using cover-up) Condone omission of brackets only if brackets are implied by subsequent work. Must go as far as finding a coefficient. Not dependent on B1
			$x = 0$, $1 = -B \Rightarrow B = -1$	A1	$B = -1$ www
			$x = ½$, $1½ = C/4 \Rightarrow C = 6$	A1	$C = 6$ www
			x^2 coeffs: $0 = 2A + C \Rightarrow A = -3$ $\Rightarrow \quad \frac{x+1}{x^2(2x-1)} = -\frac{3}{x} - \frac{1}{x^2} + \frac{6}{2x-1}$	A1	$A = -3$ www isw for incorrect assembly of partial fractions following correct *A*,*B*,*C* SC $\frac{A}{x^2} + \frac{B}{2x-1}$ can get 2/5 max from B0 M1 A1 (for *B*=6) SC $\frac{Ax+B}{x^2} + \frac{C}{2x-1}$ can get B1 M1 A1 (*C*=6) and can continue for full marks if the first fraction is then split. SC $\frac{A}{x} + \frac{B}{x^2} + \frac{C+Dx}{2x-1}$ can get B1 M1 A1 A1 A1 (*C*=6, *D*=0)
				[5]	

Question			Answer	Marks	Guidance
2			$\cot 2\theta = 3$ $\Rightarrow$ $\tan 2\theta = 1/3$ $\Rightarrow$ $2\theta = 18.43°$ $\theta = 9.22°$ $2\theta = 198.43°$ $\theta = 99.22°$ or $(2\tan\theta)/(1 - \tan^2\theta) = 1/3$ $\Rightarrow$ $6\tan\theta = 1 - \tan^2\theta$ $\Rightarrow$ $\tan^2\theta + 6\tan\theta - 1 = 0$ $\Rightarrow$ $\tan\theta = [-6 \pm \sqrt{(36 + 4)}]/2 = 0.1623$ or -6.1623 $\Rightarrow$ $\theta = 9.22°, 99.22°$	M1 A1 M1 A1 M1 M1 A1 A1 **[4]**	tan=1/ cot **used** soi for first correct solution (9.22 or better eg 9.217) for method for second solution for θ. for second correct solution and no others in range (99.22 or better) or SC ft A1 for 90 +their first solution use of correct double angle formula rearranged to a quadratic = 0 and attempt to solve by formula oe first correct solution second correct solution and no others in the range (9.22, 99.22 or better) or SC ft A1 for 90 + their first solution -1 MR if radians used (0.16, 1.73 or better)
3			$3\sin x + 2\cos x = R\sin(x + \alpha) = R\sin x\cos\alpha + R\cos x\sin\alpha$ $\Rightarrow$ $R\cos\alpha = 3$, $R\sin\alpha = 2$ $\Rightarrow$ $R^2 = 3^2 + 2^2 = 13$, $R = \sqrt{13}$ $\tan\alpha = 2/3$, $\alpha = 0.588$ $\Rightarrow$ $3\sin x + 2\cos x = \sqrt{13}\sin(x + 0.588)$ maximum when $x + 0.588 = \pi/2$ $\Rightarrow$ $x = \pi/2 - 0.588 = 0.98$ rads $\Rightarrow$ $y = \sqrt{13} = 3.61$ So coords of max point are (0.98, 3.61)	M1 B1 M1 A1 M1 A1 B1 **[7]**	Correct pairs. Condone omission of R if used correctly. Condone sign error. or 3.6 or better, not $\pm\sqrt{13}$ unless $+\sqrt{13}$ chosen ft from first M1 0.588 or better (accept 0.59), with no errors seen in method for angle (allow 33.7° or better) any valid method eg differentiating 0.98 only. Do not accept degrees or multiples of π. condone $\sqrt{13}$, ft their R if ,say $=\sqrt{14}$

Question			Answer	Marks	Guidance
4	(i)		1, 0.6186, 0 $A \approx (\pi/16)\{1 + 0+2(0.9612+0.8409+0.6186)\}$ $= 1.147$ (3 dp)	B1 M1 A1 **[3]**	4dp (or more) ft their table. Need to see trapezium rule. cao
4	(ii)		The estimate will increase, because the trapezia will be below but closer to the curve, reducing the error.	B1 **[1]**	o.e., or an illustration using the curve full answer required
5			$\overrightarrow{AB}=\begin{pmatrix}-1\\2\\1\end{pmatrix}, \overrightarrow{AC}=\begin{pmatrix}-2\\-4\\0\end{pmatrix}$	M1	scalar product with any two directions in the plane (BC=$\begin{pmatrix}-1\\-6\\-1\end{pmatrix}$)
			$\mathbf{n}.\overrightarrow{AB}=\begin{pmatrix}2\\-1\\4\end{pmatrix}.\begin{pmatrix}-1\\2\\1\end{pmatrix}=2\times(-1)+(-1)\times 2+4\times 1=0$	B1	evaluation needed
			$\mathbf{n}.\overrightarrow{AC}=\begin{pmatrix}2\\-1\\4\end{pmatrix}.\begin{pmatrix}-2\\-4\\0\end{pmatrix}=2\times(-2)+(-1)\times(-4)+4\times 0=0$ $\Rightarrow$ **n** is perpendicular to plane.	B1	evaluation needed thus finding the scalar product with only one direction vector is M0 B1 B0. No marks for scalar product with position vectors. or SC finding direction of normal vector by using vector cross product, M1A1 eg 4*i*-2*j*+8*k* and showing this is a multiple of 2*i*-*j*+4*k*, A1
			Equation of plane is **r**.**n** = **a**.**n** $\Rightarrow \begin{pmatrix}x\\y\\z\end{pmatrix}.\begin{pmatrix}2\\-1\\4\end{pmatrix}=\begin{pmatrix}2\\0\\1\end{pmatrix}.\begin{pmatrix}2\\-1\\4\end{pmatrix}$	M1	For any complete method leading to the cartesian equation of the plane eg from vector form and eliminating parameters (there are many possibilities eg $r=\begin{pmatrix}2\\0\\1\end{pmatrix}+\mu\begin{pmatrix}-1\\2\\1\end{pmatrix}+\lambda\begin{pmatrix}-2\\-4\\0\end{pmatrix}$ $x=2-\mu-2\lambda, y=2\mu-4\lambda$, $z=1+\mu$, $2x-y=4-4\mu=4-4(z-1)=8-4z$, $2x-y+4z=8$ gets M1 once the parameters have been eliminated.
			$\Rightarrow \quad 2x - y + 4z = 8$	A1 **[5]**	oe **SC1** If they say the plane is of the form $2x$-y+$4z$=c and then show all points satisfy $2x$-y+$4z$=8 they can have M1 A1 for the first point and B2 for both the others. **SC2** If they omit verification and find equation from vector form without using normal as above and then state 2*i*-*j*+4*k* is perpendicular they can get M1A1B2

Question			Answer	Marks	Guidance
6			$(1 + qx)^p = 1 + pqx + ½ p(p - 1)q^2x^2 + \ldots$	B1 B1	(1)…+ pqx … + $½ p(p - 1)q^2x^2$
			$\Rightarrow$ $pq = -1$, $q = -1/p$ $½ p(p - 1)q^2 = 2$ $\Rightarrow$ $p(p - 1)/2p^2 = (p - 1)/2p = 2$	M1	eliminating q (or p) from simultaneous equations involving both variables oe $\frac{1}{2}\left(\frac{-1}{q}\right)\left(\frac{-1}{q}-1\right)q^2 = 2$, $-1(-1-q)=4$, $q=3$
			$\Rightarrow$ $p - 1 = 4p$, $p = -1/3$ $\Rightarrow$ $q = 3$	A1 A1ft	$p = -1/3$ www (or $q = 3$) $q = 3$ (or $p = -1/3$) for second value, ft their p or q eg -1/the other , provided only a single computational error in the method and correct initial equations
			Valid for $-1 < 3x < 1 \Rightarrow -1/3 < x < 1/3$	B1 **[6]**	or $\lvert x \rvert < 1/3$ www, allow $-1/3<\lvert x\rvert<1/3$ but not say, $x<1/3$ (actually $-1/3<x\leq 1/3$ is correct)
7			$\begin{pmatrix} 4+3\lambda \\ 2 \\ 4+\lambda \end{pmatrix} = \begin{pmatrix} -1-\mu \\ 4+\mu \\ 9+3\mu \end{pmatrix}$		
			$\Rightarrow$ $4 + 3\lambda = -1 - \mu$ (1) $2 = 4 + \mu$ (2) $4 + \lambda = 9 + 3\mu$ (3)	M1	equating components
			(2) $\Rightarrow \mu = -2$ (1) $\Rightarrow 4 + 3\lambda = -1 + 2 \Rightarrow \lambda = -1$ (3) $\Rightarrow 4 + (-1) = 9 + 3 \times (-2)$ so consistent Point of intersection is (1, 2, 3)	B1 A1 A1 A1 **[5]**	$\mu = -2$ $\lambda = -1$ checking third component dependent on all previous marks being obtained
8	(i)		$\frac{dy}{dx} = \frac{dy/dt}{dx/dt} = \frac{4}{4t} = \frac{1}{t}$ But gradient of tangent = tan θ * $\Rightarrow$ tan $\theta = 1/t$	M1 A1 A1 **[3]**	their dy/dt /dx/dt accept 4/4t here **ag** -need reference to gradient is tan θ

Question			Answer	Marks	Guidance
8	(ii)		Gradient of QP = $\frac{4t}{2t^2-2}=\frac{2t}{t^2-1}$	M1 A1	correct method for subtracting co-ordinates correct (does not need to be cancelled)
			$=\frac{2\frac{1}{\tan\theta}}{\frac{1}{\tan^2\theta}-1}$	M1	either substituting t=1/tanθ in above expression or substituting tanθ=1/t in double angle formula for tan2θ. (tan2θ=2tanθ/(1-tan²θ)=2/t/(1-1/t²)=2t/(t²-1)
			$=\frac{2\tan\theta}{1-\tan^2\theta}=\tan 2\theta$	A1	showing expressions are equal
			$\Rightarrow$ tan ϕ = tan 2θ		
			$\Rightarrow$ ϕ = 2θ *	A1	**ag**
			$\Rightarrow$ Angle QPR = 180 – 2θ	M1	supplementary angles oe
			$\Rightarrow$ ∠TPQ + 180 – 2θ + θ = 180	M1	angles on a straight line oe
			$\Rightarrow$ ∠TPQ = θ *	A1	**ag**
				[8]	
8	(iii)		$t = y/4$		
			$\Rightarrow$ $x = 2y^2/16 = y^2/8$	M1	eliminating t from parametric equation
			$\Rightarrow$ $y^2 = 8x$*	A1	**ag**
			When $t = \sqrt{2}$, $x = 2\times(\sqrt{2})^2 = 4$	B1	
			So $V=\int_0^4 \pi y^2\,dx=\int_0^4 8\pi x\,dx$	M1 A1	for M1 allow no limits or their limits need correct limits but they may appear later
			$=\left[4\pi x^2\right]_0^4$	B1	for 4πx² (ignore incorrect or missing limits)
			$= 64\pi$	A1 **[7]**	in terms of π only allow SC B1 for omission of π throughout integral but otherwise correct

Question			Answer	Marks	Guidance
9	(i)		$dV/dx = \pi(20x - x^2)$ $\Rightarrow \quad \frac{dV}{dt} = \frac{dV}{dx}.\frac{dx}{dt}$ $= \pi x(20-x).\frac{dx}{dt} = k(20-x)$ $\Rightarrow \quad \pi x \frac{dx}{dt} = k\,*$	B1 M1 A1 A1 **[4]**	 oe **ag**
9	(ii)		$\int \pi x\,dx = \int k\,dt$ $\Rightarrow \quad \frac{1}{2}\pi x^2 = kt + c$ When $t = 0$, $x = 0 \Rightarrow c = 0$ $\Rightarrow \quad \frac{1}{2}\pi x^2 = kt$ Full when $x = 10$, $t = T$ $\Rightarrow \quad 50\pi = kT$ $\Rightarrow \quad T = 50\pi/k\,*$	M1 A1 B1 M1 A1 **[5]**	separate variables and attempt integration of both sides condone absence of c c=0 www substitute t or T=50 π/k or x=10 and rearranging for the other (dependent on first M1) oe **ag,** need to have c=0
9	(iii)		$dV/dt = -kx$ $\Rightarrow \pi x(20-x).\frac{dx}{dt} = -kx$ $\Rightarrow \pi(20-x)\frac{dx}{dt} = -k\,*$	B1 M1 A1 **[3]**	correct $dV/dx.dx/dt = \pm kx$ ft **ag**

Question			Answer	Marks	Guidance
9	(iv)		$\int \pi(20-x)\,\mathrm{d}x = \int -k\,\mathrm{d}t$	M1	separate variables and intend to integrate both sides
			$\pi(20x - ½x^2) = -kt + c$	B1 A1	LHS (not dependent on M1) RHS ie $-kt + c$ (condone absence of c)
			When $t = 0$, $x = 10$ $\Rightarrow \pi(200 - 50) = c$ $\Rightarrow c = 150\pi$	A1	evaluation of c cao oe (x=10, t=0)
			$\Rightarrow \pi(20x - ½x^2) = 150\pi - kt$ $x = 0$ when $150\pi - kt = 0$	M1	substitute x=0 and rearrange for t -dependent on first M1 and non-zero c ,oe
			$\Rightarrow t = 150\pi/k = 3T$*	A1 **[6]**	**ag**

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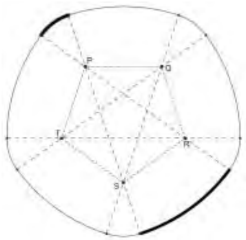
1			Each arc has to be centred on the opposite vertex but a polygon with an even number of sides does not have vertices opposite sides	B1 **[1]**	oe	
2	(i)			B1 **[1]**	must show both arcs and no others. if unclear, B0	
2	(ii)		$\pi l = 70$ $\Rightarrow \quad l = \dfrac{70}{\pi} = 22.3\text{cm (3.s.f.)}$	M1 A1 **[2]**	soi 22.3 only	
3			Reference to a tangent being perpendicular to AB or to AC. Evidence of further reasoning such as $90^o + 90^o - \text{BAC}$ 120°	M1 M1 A1 **[3]**	justification of 90^o not dependent on justification cao dep on at least second M1	 or SAB=30^o found, $60^o+2\text{x}30^o$ (could be on diagram)

Question			Answer	Marks	Guidance	
4	(i)		$3\times r\dfrac{\pi}{3}$	M1	3x$r\theta$ oe	or 3x $2\pi r\theta/360$ using degrees
			$+3\times(R+r)\dfrac{\pi}{3}$	M1	3x $(R+r)\theta$ oe	
			$=(R+2r)\pi=l\pi$ *	A1	**ag**	
				[3]		
4	(ii)		Substitute $R=\dfrac{l}{2}$ in $R^2\left(\dfrac{5\pi-2\sqrt{3}}{4}\right)$	M1	attempt to substitute $R=l/2$ in expression	oe using decimals eg in 3.060965 R^2
			Area is $l^2\left(\dfrac{5\pi-2\sqrt{3}}{16}\right)$	A1	correct	3.060965 $l^2/4$
			$\dfrac{5\pi-2\sqrt{3}}{16}\approx 0.765$ so in stated range	A1		must be correct, not just in range accept 0.76,0.77
				[3]		SC for those that change all expressions into functions of r, ie $R(\ldots)=r^2(5\pi-2\sqrt{3})=12.24r^2$ and $0.785l^2=16\text{x}0.785l^2=12.56r^2$, $0.705l^2=11.28r^2$ can score M1 A1 Similarly for those that change to functions of R and show that $2.82R^2<3.06097R^2<3.14R^2$ can score M1A1
5	(i)		$CE=AE-AC=l-l\cos 45^\circ$	M1	oe l-AC in terms of l	eg using $AC^2+CB^2=l^2$ for AC $2\,AC^2=l^2$ $AC=l/\sqrt{2}$
			$=l-l\dfrac{\sqrt{2}}{2}=\dfrac{l}{2}\left(2-\sqrt{2}\right)$ *	A1	**ag**	
				[2]		

Question			Answer	Marks	Guidance	
5	(ii)		$l-2CE$ $=l-\left(2-\sqrt{2}\right)l=\left(\sqrt{2}-1\right)l$ *	M1 A1 **[2]**	or AC-CE **ag**	
5	(iii)		$\left(\sqrt{2}-1\right)l=50 \Rightarrow \quad l=121\text{mm}$	B1 **[1]**		

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