OCR
RECOGNISING ACHIEVEMENT

GCE

Mathematics (MEI)

Advanced GCE

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

Mark Scheme for June 2011

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.

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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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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.

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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.

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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.

1 $\frac{1}{(2x+1)(x^2+1)} = \frac{A}{2x+1} + \frac{Bx+C}{x^2+1}$ $\Rightarrow$ $1 = A(x^2 + 1) + (Bx + C)(2x + 1)$ $x = -½$: $1 = 1¼ A \Rightarrow A = 4/5$ coeff of x^2: $0 = A + 2B \Rightarrow B = -2/5$ constants: $1 = A + C \Rightarrow C = 1/5$	M1 M1 B1 B1 B1 [5]	correct form of partial fractions mult up and equating or substituting oe soi www www www	for omission of B or C on numerator, M0, M1, then (x= -1/2, A= 4/5) B1, B0, B0 is possible. for $\frac{A+Dx}{2x+1} + \frac{Bx+C}{x^2+1}$, M1,M1 then B1 for both A=4/5 and D=0, B1, B1 is possible. isw for incorrect assembly of final partial fractions following correct A,B & C. condone omission of brackets for second M1 only if the brackets are implied by subsequent working.
2 $(1+3x)^{\frac{1}{3}} = 1 + \frac{1}{3}(3x) + \frac{\frac{1}{3}.(-\frac{2}{3})}{2!}(3x)^2 + \ldots$ $= 1 + x - x^2 + \ldots$ Valid for $-1 \le 3x \le 1$ $\Rightarrow$ $-1/3 \le x \le 1/3$	M1 A1 A1 M1 A1 [5]	correct binomial coefficients $1 + x \ldots$ $\ldots - x^2$ or $\lvert 3x \rvert \le 1$ oe or $\lvert x \rvert \le 1/3$ (correct final answer scores M1A1)	ie 1, 1/3, (1/3)(-2/3)/2 not nCr form simplified www in this part simplified www in this part, ignore subsequent terms using $(3x)^2$ as $3x^2$ can score M1B1B0 condone omission of brackets if $3x^2$ is used as $9x^2$ do not allow MR for power 3 or -1/3 or similar **condone inequality signs throughout** or say < at one end and ≤ at the other condone $-1/3 \le \lvert x \rvert \le 1/3$, $x \le 1/3$ is M0A0 the last two marks are not dependent on the first three
3 $2\sin\theta - 3\cos\theta = R\sin(\theta - \alpha)$ $= R\sin\theta\cos\alpha - R\cos\theta\sin\alpha$ $\Rightarrow$ $R\cos\alpha = 2$, $R\sin\alpha = 3$ $\Rightarrow$ $R^2 = 2^2 + 3^2 = 13$, $R = \sqrt{13}$ $\tan\alpha = 3/2$, $\Rightarrow$ $\alpha = 0.983$ minimum $1 - \sqrt{13}$, maximum $1 + \sqrt{13}$	M1 B1 M1 A1 B1 B1 [6]	correct pairs $R = \sqrt{13}$ or 3.61 or better 0.98 or better or –2.61, 4.61 or better	condone wrong sign at this stage correct division, ft from first M1 radians only accept multiples of π that round to 0.98 allow B1, B1ft for $1-\sqrt{R}$ and $1+\sqrt{R}$ for their R to 2dp or better

4(i) $x = 2\sin\theta$, $y = \cos 2\theta$ When $\theta = \pi/3$, $x = 2\sin \pi/3 = \sqrt{3}$ $y = \cos 2\pi/3 = -½$	B1 B1	$x = \sqrt{3}$ $y = -½$	exact only (isw all dec answers following exact ans)
EITHER $dx/d\theta = 2\cos\theta$, $dy/d\theta = -2\sin 2\theta$	M1	$dy/dx = (dy/d\theta) / (dx/d\theta)$ used	ft their derivatives if right way up (condone one further minor slip if intention clear) condone poor notation can isw if incorrect simplification
$\Rightarrow \dfrac{dy}{dx} = \dfrac{-\sin 2\theta}{\cos\theta}$	A1	any correct equivalent form	
$= \dfrac{-\sin 2\pi/3}{\cos \pi/3} = \dfrac{-\sqrt{3}/2}{1/2} = -\sqrt{3}$	A1	exact www	
…………………………………………………………...	……..	…………………………………………	
OR expressing y in terms of x, $y=1-x^2/2$ $\dfrac{dy}{dx} = -x$ or $-2\sin\theta$ $= -\sqrt{3}$	M1 A1 A1 [5]	exact www	
(ii) $y = 1 - 2\sin^2\theta = 1 - 2(x/2)^2 = 1 - ½ x^2$	M1A1 [2]	or reference to (i) if used there	for M1, need correct trig identity and attempt to substitute for x allow SC B1 for $y=\cos 2\arcsin(x/2)$ or equivalent

5 $\mathrm{cosec}^2\theta = 1 + \cot^2\theta$ $\Rightarrow\ 1 + \cot^2\theta = 1 + 2\cot\theta$ $\Rightarrow\ \cot^2\theta - 2\cot\theta = 0$ $\Rightarrow\ \cot\theta(\cot\theta - 2) = 0$ $\Rightarrow\ \cot\theta = 0$, **and** $\cot\theta = 2$, $\tan\theta = ½$ $\Rightarrow\ \theta = 26.6°, –153.4°, -90°, 90°$ …………………………………………………….. **OR** $\frac{1}{\sin^2\theta} = 1 + \frac{2\cos\theta}{\sin\theta} = \frac{\sin\theta + 2\cos\theta}{\sin\theta}$ $\Rightarrow \sin^2\theta + 2\sin\theta\cos\theta - 1 = 0$ $\Rightarrow 2\sin\theta\cos\theta - \cos^2\theta = 0$ $\Rightarrow \cos\theta\ (2\sin\theta - \cos\theta) = 0$ $\Rightarrow \cos\theta = 0$, **and** $\tan\theta = ½$ $\theta = 26.6°, –153.4°, –90°, 90°$	M1 M1 M1 B3,2,1,0 M1 M1 M1 B3,2,1,0 [6]	correct trig identity used factorising oe **both** needed and $\cot\theta = 1/\tan\theta$ soi –90°, 90°, 27°, –153° or better www …………………………………… correct trig equivalents and a one line equation (or common denominator) formed use of Pythagoras and factorising **both** needed and $\tan\theta = \sin\theta/\cos\theta$ oe soi accept 27º, -153º as above ……………………………………… answers, no working, award B3,2,1,0 (it is possible to score say M1 then B3 ow)	(use of 1-$\cot^2\theta$ could lead to M0 M1 M1 B1) allow if $\cot\theta$ =0 not seen (ie quadratic equation followed by $\cot\theta$-2=0 or $\cot\theta$=2) (omission of $\cot\theta$=0 could gain M1, M1, M0, B1) …………………………………………... as above allow if $\cos\theta$=0 not seen (as above) ……………………………………… **in both cases**, -1 if **extra** solutions in the range are given (dependent on at least B1 being scored)-not their incorrect solutions eg 26.6°,-153.4°, 0°,180°,-180° would obtain B1 -1 MR if answers given in radians (-π/2,π/2,0.464, -2.68 (-1.57.1.57) or multiples of π that round to these, or better) (dependent on at least B1 being scored) to lose both of these, at least B2 would need to be scored.
6 Vol = vol of rev of curve + vol of rev of line vol of rev of curve = $\int_0^2 \pi x^2\, dy$ $= \int_0^2 \pi \frac{y}{2}\, dy$ $= \pi\left[\frac{y^2}{4}\right]_0^2$ $= \pi$ height of cone = 3 – 2 = 1 so vol of cone = 1/3 π 1^2 x1 = π/3 so total vol = 4π/3	M1 M1 B1 A1 B1 B1 A1 [7]	(soi) at any stage substituting $x^2 = y/2$ $\left[\frac{y^2}{4}\right]$ h=1 soi www cao	 for M1 need π, substitution for x^2, (dy soi), intention to integrate and correct limits even if π missing or limits incorrect or missing cao OR $\pi\int_2^3 (3-y)^2 dy$ M1(even if expanded incorrectly) =π/3 A1 www

Section B

7(i) $\overrightarrow{AB} = \begin{pmatrix}-4\\0\\-2\end{pmatrix}, \overrightarrow{AC} = \begin{pmatrix}-2\\4\\1\end{pmatrix}$	B1B1		condone rows
$\cos BAC = \dfrac{\begin{pmatrix}-4\\0\\-2\end{pmatrix}.\begin{pmatrix}-2\\4\\1\end{pmatrix}}{AB.AC} = \dfrac{(-4).(-2)+0.4+(-2).1}{\sqrt{20}\sqrt{21}}$	M1 M1	dot product evaluated **cos** BAC= dot product / |AB|. |AC|	**substituted,** ft their vectors AB, AC for method only need to see method for modulae as far as √…
$= 0.293$	A1	0.293 or cos ABC=correct numerical expression as RHS above, or better	use of vectors BA and CA could obtain B0 B0 M1 M1 A1 A1
⇒ BAC = 73.0°	A1 [6]	or rounds to 73.0º (accept 73º www)	(or 1.27 radians)
(ii) A: $x + y - 2z + d = 2 - 6 + d = 0$ ⇒ $d = 4$ B: $-2 + 0 - 2\times1 + 4 = 0$ C: $0 + 4 - 2\times4 + 4 = 0$	M1 DM1 A1	substituting one point evaluating for other two points d = 4 www	alternatively, finding the equation of the plane using any valid method (eg from vector equation, M1 A1 for using valid equation and eliminating both parameters, A1 for required form, or using vector cross product to get x+y-2z =c oe M1 A1,finding c and required form, A1, or showing that two vectors in the plane are perpendicular to normal vector M1 A1 and finding d, A1) oe
Normal $\mathbf{n} = \begin{pmatrix}1\\1\\-2\end{pmatrix}$	B1	stated or used as normal anywhere in part (ii)	
$\mathbf{n}.\begin{pmatrix}0\\0\\1\end{pmatrix} = \dfrac{-2}{\sqrt{6}} = \cos\theta$	M1 A1	finding angle between normal vector and **k** allow ±2/√6 or 144.7º for A1	(may have deliberately made +ve to find acute angle)
⇒ θ = 144.7° ⇒ acute angle = 35.3°	A1 [7]	or rounds to 35.3º	do not need to find 144.7º explicitly (or 0.615 radians)
(iii) At D, $-2 + 4 - 2k + 4 = 0$ ⇒ $2k = 6$, $k = 3$ *	M1 A1	substituting into plane equation **AG**	
$\overrightarrow{CD} = \begin{pmatrix}-2\\0\\-1\end{pmatrix} = \frac{1}{2}\overrightarrow{AB}$	M1	$\overrightarrow{CD} = \begin{pmatrix}-2\\0\\-1\end{pmatrix}$	finding vector CD (or vector DC)
⇒ CD is parallel to AB	A1		or DC parallel to AB or BA oe (or hence two parallel sides, if clear which) but A0 if their vector CD is vector DC
CD : AB = 1 : 2	B1 [5]	mark final answer **www** allow CD:AB=1/2, √5:√20 oe, AB is twice CD oe	for B1 allow vector CD used as vector DC

8(i) $\frac{dV}{dt} = -kx$ $V = 1/3\, x^3 \Rightarrow dV/dx = x^2$ $\frac{dV}{dt} = \frac{dV}{dx}.\frac{dx}{dt} = x^2\frac{dx}{dt}$ $\Rightarrow \quad x^2\frac{dx}{dt} = -kx$ $\Rightarrow \quad x\frac{dx}{dt} = -k$ *	B1 M1 A1 [3]	oe eg $dx/dt=dx/dV \,.\, dV/dt = 1/x^2 . -kx = -k/x$ **AG**	
(ii) $x\frac{dx}{dt} = -k \quad \Rightarrow \quad \int x\,dx = \int -k\,dt$ $\Rightarrow \quad ½\, x^2 = -kt + c$ When $t = 0$, $x = 10 \Rightarrow 50 = c$ $\Rightarrow \quad ½\, x^2 = 50 - kt$ $\Rightarrow \quad x = \sqrt{(100 - 2kt)}$ *	M1 A1 B1 A1 [4]	separating variables and intention to integrate condone absence of c finding c correctly ft their integral of form $ax^2= bt+c$ where a,b non zero constants **AG**	
(iii) When $t = 50$, $x = 0$ $\Rightarrow \quad 0 = 100 - 100\,k \Rightarrow k = 1$	M1 A1 [2]		
(iv) $dV/dt = 1 - kx = 1 - x$ $\Rightarrow \quad x^2 dx/dt = 1 - x$ $\Rightarrow \quad \frac{dx}{dt} = \frac{1-x}{x^2}$ *	M1 A1 [2]	for $dV/dt= 1-kx$ or better **AG**	
(v) $\frac{1}{1-x} - x - 1 = \frac{1-(1-x)x-(1-x)}{1-x}$ $= \frac{1-x+x^2-1+x}{1-x} = \frac{x^2}{1-x}$ * $\int \frac{x^2}{1-x}dx = \int dt \Rightarrow \int (\frac{1}{1-x} - x - 1)dx = t + c$ $\Rightarrow \quad -\ln(1 - x) - ½\, x^2 - x = t + c$ When $t = 0$, $x = 0 \Rightarrow c = -\ln 1 - 0 - 0 = 0$ $\Rightarrow \quad t = \ln\left(\frac{1}{1-x}\right) - \frac{1}{2}x^2 - x$ *	M1 A1 M1 A1 B1 A1 [6]	combining to single fraction **AG** separating variables & subst for $x^2/(1-x)$ and intending to integrate condone absence of c finding c for equation of correct form eg $c = 0$, or ± ln1 (allow c=0 without evaluation here) cao **AG**	or long division or cross multiplying check signs need both sides of integral accept ln $(1/(1-x))$ as $-\ln(1-x)$ www ie $a\ln(1-x)+bx^2+dx=et+c$ a,b,d,e non zero constants do not allow if c=0 without evaluation
(vi) understanding that ln (1/0) or 1/0 is undefined oe	B1 [1]	www	ln (1/0) = ln 0, 1/0 = ∝ and ln (1/0) = ∝ are all B0

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

Mark Scheme for June 2011

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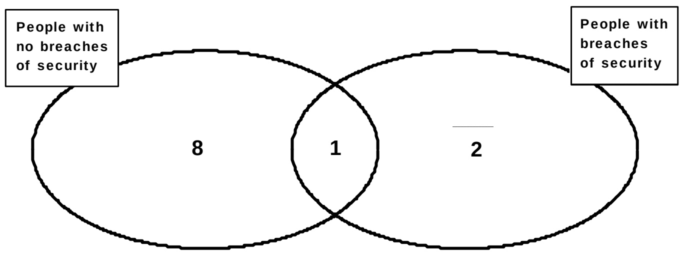
Question			Answer	Marks	Guidance	
1			$\frac{16}{250} = 6.4\%$ * or $\frac{16}{250}$ x 100 = 6.4*	B1 **[1]**	or $\frac{250-(64+170)}{250}$ =6.4% oe	need evaluation
2	(i)		The smallest possible PIN that does not begin with zero is 1000 and the largest is 9999, giving 9000. However the 9 numbers 1111, 2222, … 9999 are disallowed. The other disallowed numbers are 1234, 2345, … 6789 (6 numbers) And 9876, 8765, … 3210 (7 numbers). So, in all, there are 9000 – (9 + 6 + 7) = 8978 possible PINs	M1 M1 A1 **[3]**	from a correct starting point (eg 10,000 or 9000), clear attempt to eliminate (or not include) numbers starting with 0 clear attempt to eliminate **all** **three** of these categories (with approx correct values in each category) **if unclear, M0** M marks not dependent SC 8978 www B3	Alt1) for M1 (no 0 start), nos starting with 1,2,7,8,9 give 1000-2, nos starting with 3,4,5,6 give 1000-3 =5(1000-2)+4(1000-3)=8978 M1,A1 or2) eg starting with1, 1,not2,any,any+1,2,not3,any +1,2,3,not4 =900+90+9=999-(1111term)=998 can lead to 5(900+90+9-1)+4(900+90+9-2)=8978 oe
2	(ii)		$\frac{6\ 700\ 000\ 000}{8978} = 746\ 269$ The average is about 750 000.	M1 A1 **[2]**	ft from (i) ft	 accept 2sf (or 1sf) only for A1
3				M1 A1 **[2]**	numbers total 11 all correct	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th colspan="2">Guidance</th></tr>
<tr><td>4</td><td></td><td></td><td>100 000 transactions from 80 people over 3½ years with 365 days per year
$\frac{100\ 000}{(80\times 3.5\times 365)}(=0.978...)$
Approximately 1 transaction per person per day</td><td>M1
A1
[2]</td><td>

cao</td><td>allow approximate number of days in a year eg 360 for M1 A1</td></tr>
<tr><td>5</td><td></td><td></td><td>Allow any one of the following for 1 mark
An attack can happen without a breach of the card’s security.
The probabilities that a successful attack followed or did not follow a breach of card security are so close that a court would look for other evidence before reaching a decision.
In many cases of unauthorised withdrawals the banks refund the money.
The banks’ software does not detect all the attacks that occur.</td><td>B1
[1]</td><td>only accept versions of these statements</td><td></td></tr>
<tr><td>6</td><td>(i)</td><td></td><td><table><tr><th>Transactions</th><th>Authorised</th><th>Un-authorised</th><th>Total</th></tr><tr><td>Queried</td><td>480</td><td>20</td><td>500</td></tr><tr><td>Not queried</td><td>499 460</td><td>40</td><td>499 500</td></tr><tr><td>Total</td><td>499 940</td><td>60</td><td>500 000</td></tr></table></td><td>B1
B2
[3]</td><td>for top row 480, 20, 500
all five other entries correct</td><td>
(500 000 is given)
allow B1 for three or four correct from
499460,40,499500,499940,60</td></tr>
</table>

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th colspan="2">Guidance</th></tr>
<tr><td>6</td><td>(ii)</td><td></td><td>$\frac{480}{40} = 12$ or 12 to 1</td><td>B1

[1]</td><td>ft from (i)</td><td>their 480: their 40 isw
accept unsimplified answers</td></tr>
<tr><td>6</td><td>(iii)</td><td></td><td>
<table>
<tr><th>Transactions</th><th>Authorised</th><th>Un-authorised</th><th>Total</th></tr>
<tr><td>Queried</td><td>2 445</td><td>55</td><td>2 500</td></tr>
<tr><td>Not queried</td><td>497 495</td><td>5</td><td>497 500</td></tr>
<tr><td>Total</td><td>499 940</td><td>60</td><td>500 000</td></tr>
</table>

$\frac{2445}{5} = 489$ or 489 to 1</td><td>
M1

DM1

A1

[3]</td><td>
ft from (i)

cao</td><td>NB they are not required to complete the table.

{2500or 5xtheir 500}-(their 60-5) [=their 2445]

their 2445 ft from (i) :5</td></tr>
</table>

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