

Mathematics (MEI)

Advanced GCE

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

Mark Scheme for June 2011

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

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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.

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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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- 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.

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

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

<p>5 cosec²θ = 1 + cot² θ ⇒ 1 + cot² θ = 1 + 2cot θ ⇒ cot² θ - 2cot θ = 0 ⇒ cot θ (cot θ - 2) = 0 ⇒ cot θ = 0, and cot θ = 2, tan θ = 1/2 ⇒ θ = 26.6°, -153.4°, -90°, 90°</p> <p>.....</p> <p>OR $\frac{1}{\sin^2 \theta} = 1 + \frac{2 \cos \theta}{\sin \theta} = \frac{\sin \theta + 2 \cos \theta}{\sin \theta}$ ⇒ sin² θ + 2 sin θ cos θ - 1 = 0 ⇒ 2 sin θ cos θ - cos² θ = 0 ⇒ cos θ (2 sin θ - cos θ) = 0 ⇒ cos θ = 0, and tan θ = 1/2 θ = 26.6°, -153.4°, -90°, 90°</p>	<p>M1</p> <p>M1</p> <p>M1 B3,2,1,0</p> <p>M1</p> <p>M1 M1 B3,2,1,0</p> <p>[6]</p>	<p>correct trig identity used</p> <p>factorising oe</p> <p>both needed and cot θ = 1/tan θ soi -90°, 90°, 27°, -153° or better www </p> <p>correct trig equivalents and a one line equation (or common denominator) formed</p> <p>use of Pythagoras and factorising both needed and tan θ = sin θ / cos θ oe soi accept 27°, -153° as above</p> <p>.....</p> <p>answers, no working, award B3,2,1,0 (it is possible to score say M1 then B3 ow)</p>	<p>(use of 1-cot²θ could lead to M0 M1 M1 B1)</p> <p>allow if cot θ = 0 not seen (ie quadratic equation followed by cot θ - 2 = 0 or cot θ = 2)</p> <p>(omission of cot θ = 0 could gain M1, M1, M0, B1) </p> <p>as above</p> <p>allow if cos θ = 0 not seen (as above) </p> <p>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.</p>
<p>6 Vol = vol of rev of curve + vol of rev of line vol of rev of curve = $\int_0^2 \pi x^2 dy$ = $\int_0^2 \pi \frac{y}{2} dy$ = $\pi \left[\frac{y^2}{4} \right]_0^2$ = π</p> <p>height of cone = 3 - 2 = 1 so vol of cone = 1/3 π 1² x 1 = π/3</p> <p>so total vol = 4π/3</p>	<p>M1</p> <p>M1</p> <p>B1</p> <p>A1</p> <p>B1</p> <p>B1</p> <p>A1 [7]</p>	<p>(soi) at any stage</p> <p>substituting x² = y/2</p> <p>$\left[\frac{y^2}{4} \right]$</p> <p>h=1 soi</p> <p>www cao</p>	<p>for M1 need π, substitution for x², (dy soi), intention to integrate and correct limits</p> <p>even if π missing or limits incorrect or missing</p> <p>cao</p> <p>OR $\pi \int_2^3 (3-y)^2 dy$ M1 (even if expanded incorrectly) = π/3 A1 www</p>

Section B

<p>7(i) $\overline{AB} = \begin{pmatrix} -4 \\ 0 \\ -2 \end{pmatrix}, \overline{AC} = \begin{pmatrix} -2 \\ 4 \\ 1 \end{pmatrix}$</p> $\cos BAC = \frac{\begin{pmatrix} -4 \\ 0 \\ -2 \end{pmatrix} \cdot \begin{pmatrix} -2 \\ 4 \\ 1 \end{pmatrix}}{AB \cdot AC} = \frac{(-4)(-2) + 0 \cdot 4 + (-2) \cdot 1}{\sqrt{20}\sqrt{21}}$ $= 0.293$ <p>$\Rightarrow BAC = 73.0^\circ$</p>	<p>B1B1</p> <p>M1 M1</p> <p>A1</p> <p>A1 [6]</p>	<p>dot product evaluated cos BAC = dot product / AB . AC </p> <p>0.293 or cos ABC = correct numerical expression as RHS above, or better</p> <p>or rounds to 73.0° (accept 73° www)</p>	<p>condone rows</p> <p>substituted, ft their vectors AB, AC for method only need to see method for modulae as far as $\sqrt{\dots}$ use of vectors BA and CA could obtain B0 B0 M1 M1 A1 A1</p> <p>(or 1.27 radians)</p>
<p>(ii) A: $x + y - 2z + d = 2 - 6 + d = 0$ $\Rightarrow d = 4$ B: $-2 + 0 - 2 \times 1 + 4 = 0$ C: $0 + 4 - 2 \times 4 + 4 = 0$</p> <p>Normal $\mathbf{n} = \begin{pmatrix} 1 \\ 1 \\ -2 \end{pmatrix}$</p> $\mathbf{n} \cdot \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix} = \frac{-2}{\sqrt{6}} = \cos \theta$ <p>$\Rightarrow \theta = 144.7^\circ$ \Rightarrow acute angle = 35.3°</p>	<p>M1 DM1 A1</p> <p>B1</p> <p>M1 A1</p> <p>A1 [7]</p>	<p>substituting one point evaluating for other two points $d = 4$ www</p> <p>stated or used as normal anywhere in part (ii)</p> <p>finding angle between normal vector and \mathbf{k} allow $\pm 2/\sqrt{6}$ or 144.7° for A1</p> <p>or rounds to 35.3°</p>	<p>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</p> <p>(may have deliberately made +ve to find acute angle)</p> <p>do not need to find 144.7° explicitly (or 0.615 radians)</p>
<p>(iii) At D, $-2 + 4 - 2k + 4 = 0$ $\Rightarrow 2k = 6, k = 3$ *</p> $\overline{CD} = \begin{pmatrix} -2 \\ 0 \\ -1 \end{pmatrix} = \frac{1}{2} \overline{AB}$ <p>\Rightarrow CD is parallel to AB</p> <p>CD : AB = 1 : 2</p>	<p>M1 A1</p> <p>M1</p> <p>A1</p> <p>B1 [5]</p>	<p>substituting into plane equation AG</p> $\overline{CD} = \begin{pmatrix} -2 \\ 0 \\ -1 \end{pmatrix}$ <p>mark final answer www allow CD:AB=1/2, $\sqrt{5}:\sqrt{20}$ oe, AB is twice CD oe</p>	<p>finding vector CD (or vector DC)</p> <p>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 for B1 allow vector CD used as vector DC</p>

<p>8(i) $\frac{dV}{dt} = -kx$ $V = 1/3 x^3 \Rightarrow dV/dx = x^2$ $\frac{dV}{dt} = \frac{dV}{dx} \cdot \frac{dx}{dt} = x^2 \frac{dx}{dt}$ $\Rightarrow x^2 \frac{dx}{dt} = -kx$ $\Rightarrow x \frac{dx}{dt} = -k$ *</p>	<p>B1 M1 A1 [3]</p>	<p>oe eg $dx/dt = dx/dV \cdot dV/dt = 1/x^2 \cdot -kx = -k/x$</p> <p>AG</p>	
<p>(ii) $x \frac{dx}{dt} = -k \Rightarrow \int x dx = \int -k dt$ $\Rightarrow \frac{1}{2} x^2 = -kt + c$ When $t = 0, x = 10 \Rightarrow 50 = c$ $\Rightarrow \frac{1}{2} x^2 = 50 - kt$ $\Rightarrow x = \sqrt{(100 - 2kt)}$ *</p>	<p>M1 A1 B1 A1 [4]</p>	<p>separating variables and intention to integrate</p> <p>condone absence of c finding c correctly ft their integral of form $ax^2 = bt + c$ where a, b non zero constants</p> <p>AG</p>	
<p>(iii) When $t = 50, x = 0$ $\Rightarrow 0 = 100 - 100k \Rightarrow k = 1$</p>	<p>M1 A1 [2]</p>		
<p>(iv) $dV/dt = 1 - kx = 1 - x$ $\Rightarrow x^2 dx/dt = 1 - x$ $\Rightarrow \frac{dx}{dt} = \frac{1-x}{x^2}$ *</p>	<p>M1 A1 [2]</p>	<p>for $dV/dt = 1 - kx$ or better</p> <p>AG</p>	
<p>(v) $\frac{1}{1-x} - x - 1 = \frac{1 - (1-x)x - (1-x)}{1-x}$ $= \frac{1-x+x^2-1+x}{1-x} = \frac{x^2}{1-x}$ *</p> <p>$\int \frac{x^2}{1-x} dx = \int dt \Rightarrow \int (\frac{1}{1-x} - x - 1) dx = t + c$ $\Rightarrow -\ln(1-x) - \frac{1}{2} x^2 - x = t + c$ When $t = 0, x = 0 \Rightarrow c = -\ln 1 - 0 - 0 = 0$ $\Rightarrow t = \ln\left(\frac{1}{1-x}\right) - \frac{1}{2} x^2 - x$ *</p>	<p>M1 A1 M1 A1 B1 A1 [6]</p>	<p>combining to single fraction</p> <p>AG</p> <p>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 $\pm \ln 1$ (allow $c=0$ without evaluation here) cao AG</p>	<p>or long division or cross multiplying</p> <p>check signs</p> <p>need both sides of integral</p> <p>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</p>
<p>(vi) understanding that $\ln(1/0)$ or $1/0$ is undefined oe</p>	<p>B1 [1]</p>	<p>www</p>	<p>$\ln(1/0) = \ln 0, 1/0 = \infty$ and $\ln(1/0) = \infty$ are all B0</p>

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- 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

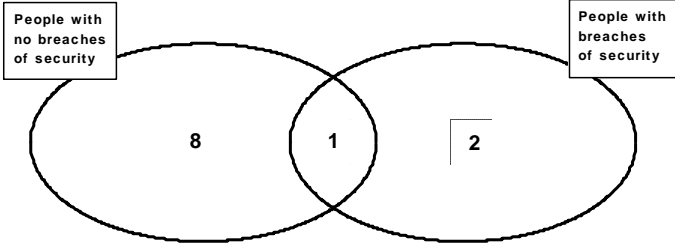
If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests.

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	$\frac{16}{250} = 6.4\% \text{ * or } \frac{16}{250} \times 100 = 6.4\%$	B1 [1]	or $\frac{250-(64+170)}{250} = 6.4\%$ oe need evaluation
2 (i)	<p>The smallest possible PIN that does not begin with zero is 1000 and the largest is 9999, giving 9000.</p> <p>However the 9 numbers 1111, 2222, ... 9999 are disallowed.</p> <p>The other disallowed numbers are 1234, 2345, ... 6789 (6 numbers)</p> <p>And 9876, 8765, ... 3210 (7 numbers).</p> <p>So, in all, there are $9000 - (9 + 6 + 7) = 8978$ possible PINs</p>	M1 M1 A1 [3]	<p>from a correct starting point (eg 10,000 or 9000), clear attempt to eliminate (or not include) numbers starting with 0</p> <p>clear attempt to eliminate all three of these categories (with approx correct values in each category)</p> <p>if unclear, M0 M marks not dependent SC 8978 www B3</p> <p>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 with 1, 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</p>
2 (ii)	$\frac{6\ 700\ 000\ 000}{8978} = 746\ 269$ <p>The average is about 750 000.</p>	M1 A1 [2]	<p>ft from (i)</p> <p>ft</p> <p>accept 2sf (or 1sf) only for A1</p>
3		M1 A1 [2]	<p>numbers total 11</p> <p>all correct</p>

Question	Answer	Marks	Guidance																	
4	<p>100 000 transactions from 80 people over 3½ years with 365 days per year</p> $\frac{100\,000}{(80 \times 3.5 \times 365)} (= 0.978\dots)$ <p>Approximately 1 transaction per person per day</p>	<p>M1 A1 [2]</p>	<p>cao</p>	<p>allow approximate number of days in a year eg 360 for M1 A1</p>																
5	<p>Allow any one of the following for 1 mark</p> <p>An attack can happen without a breach of the card's security.</p> <p>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.</p> <p>In many cases of unauthorised withdrawals the banks refund the money.</p> <p>The banks' software does not detect all the attacks that occur.</p>	<p>B1 [1]</p>	<p>only accept versions of these statements</p>																	
6 (i)	<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th data-bbox="365 895 573 1007">Transactions</th> <th data-bbox="573 895 768 1007">Authorised</th> <th data-bbox="768 895 938 1007">Un- authorised</th> <th data-bbox="938 895 1106 1007">Total</th> </tr> </thead> <tbody> <tr> <td data-bbox="365 1007 573 1090">Queried</td> <td data-bbox="573 1007 768 1090" style="text-align: center;">480</td> <td data-bbox="768 1007 938 1090" style="text-align: center;">20</td> <td data-bbox="938 1007 1106 1090" style="text-align: center;">500</td> </tr> <tr> <td data-bbox="365 1090 573 1173">Not queried</td> <td data-bbox="573 1090 768 1173" style="text-align: center;">499 460</td> <td data-bbox="768 1090 938 1173" style="text-align: center;">40</td> <td data-bbox="938 1090 1106 1173" style="text-align: center;">499 500</td> </tr> <tr> <td data-bbox="365 1173 573 1256">Total</td> <td data-bbox="573 1173 768 1256" style="text-align: center;">499 940</td> <td data-bbox="768 1173 938 1256" style="text-align: center;">60</td> <td data-bbox="938 1173 1106 1256" style="text-align: center;">500 000</td> </tr> </tbody> </table>	Transactions	Authorised	Un- authorised	Total	Queried	480	20	500	Not queried	499 460	40	499 500	Total	499 940	60	500 000	<p>B1 B2 [3]</p>	<p>for top row 480, 20, 500</p> <p>all five other entries correct</p>	<p>(500 000 is given) allow B1 for three or four correct from 499460,40,499500,499940,60</p>
Transactions	Authorised	Un- authorised	Total																	
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Question	Answer	Marks	Guidance																
6 (ii)	$\frac{480}{40} = 12 \text{ or } 12 \text{ to } 1$	B1 [1]	ft from (i) their 480: their 40 isw accept unsimplified answers																
6 (iii)	<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Transactions</th> <th>Authorised</th> <th>Un- authorised</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Queried</td> <td style="text-align: right;">2 445</td> <td style="text-align: right;">55</td> <td style="text-align: right;">2 500</td> </tr> <tr> <td>Not queried</td> <td style="text-align: right;">497 495</td> <td style="text-align: right;">5</td> <td style="text-align: right;">497 500</td> </tr> <tr> <td>Total</td> <td style="text-align: right;">499 940</td> <td style="text-align: right;">60</td> <td style="text-align: right;">500 000</td> </tr> </tbody> </table> $\frac{2445}{5} = 489 \text{ or } 489 \text{ to } 1$	Transactions	Authorised	Un- authorised	Total	Queried	2 445	55	2 500	Not queried	497 495	5	497 500	Total	499 940	60	500 000	M1 DM1 A1 [3]	ft from (i) cao NB they are not required to complete the table. {2500or 5xtheir 500}-(their 60-5) [=their 2445] their 2445 ft from (i) :5
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