GCE

Mathematics (MEI)

Unit **4757**: Further Applications of Advanced Mathematics

Advanced GCE

Mark Scheme for June 2016

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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.

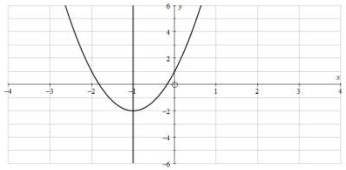
Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

Question			Answer	Marks	Guidance	
1	(i)		$\begin{pmatrix}3\\4\\8\end{pmatrix}\times\begin{pmatrix}2\\1\\0\end{pmatrix}=\begin{pmatrix}-8\\16\\-5\end{pmatrix}$	M1 A1	Appropriate vector product Correctly evaluated	
			Distance is $\dfrac{\sqrt{8^2+16^2+5^2}}{\sqrt{2^2+1^2+0^2}}=\dfrac{\sqrt{345}}{\sqrt{5}}$ $=\sqrt{69}\quad(\approx 8.31)\ \text{(km)}$	A1 A1	Dividing by $\sqrt{2^2+1^2+0^2}$	*Sign error in vector product can earn M1A0A1A1*
		OR	$\begin{pmatrix}3+2\lambda\\4+\lambda\\8\end{pmatrix}$ is perpendicular to $\begin{pmatrix}2\\1\\0\end{pmatrix}$		M1	
			$2(3+2\lambda)+(4+\lambda)=0$		A1	
			$\lambda=-2$; shortest vector is $\begin{pmatrix}-1\\2\\8\end{pmatrix}$		A1	
			Distance is $\sqrt{1^2+2^2+8^2}=\sqrt{69}$		A1	
				[4]		
	(ii)		$\begin{pmatrix}2\\1\\0\end{pmatrix}\times\begin{pmatrix}-8\\-4\\-1\end{pmatrix}=\begin{pmatrix}-1\\2\\0\end{pmatrix}$	M1 A1	Vector product of directions Correctly evaluated	
			$\begin{pmatrix}77\\36\\2\end{pmatrix}.\begin{pmatrix}-1\\2\\0\end{pmatrix}=-5\qquad\left[\text{ or }\begin{pmatrix}3\\4\\8\end{pmatrix}.\begin{pmatrix}-1\\2\\0\end{pmatrix}\right]$	M1 A1	Appropriate scalar product For (−) 5	*Dependent on previous M1*
			Distance is $\dfrac{5}{\sqrt{1^2+2^2+0^2}}$	M1	Dividing by $\sqrt{1^2+2^2+0^2}$	*Dependent on M1M1*
			$=\dfrac{5}{\sqrt{5}}=\sqrt{5}=2.236\ldots=2.24$ (km) (correct to 3 sf)	E1		
				[6]		

Question			Answer	Marks	Guidance	
	(iii)		$\overrightarrow{AB}=\begin{pmatrix}80-8\mu\\40-4\mu\\10-\mu\end{pmatrix}-\begin{pmatrix}3+2\lambda\\4+\lambda\\8\end{pmatrix}\quad\left[=\begin{pmatrix}77-2\lambda-8\mu\\36-\lambda-4\mu\\2-\mu\end{pmatrix}\right]$	B1		
			$\overrightarrow{AB}.\begin{pmatrix}2\\1\\0\end{pmatrix}=0$ and $\overrightarrow{AB}.\begin{pmatrix}-8\\-4\\-1\end{pmatrix}=0$ $2(77-2\lambda-8\mu)+(36-\lambda-4\mu)=0$ $-8(77-2\lambda-8\mu)-4(36-\lambda-4\mu)-(2-\mu)=0$ $5\lambda+20\mu=190$ $20\lambda+81\mu=762$ and hence $\lambda=30,\ \mu=2$	M1 A1 A1		
		OR	$\overrightarrow{AB}$ is parallel to $\begin{pmatrix}-1\\2\\0\end{pmatrix}$ $36-\lambda-4\mu=-2(77-2\lambda-8\mu)$ $2-\mu=0$ $5\lambda+20\mu=190$ $2-\mu=0$ and hence $\lambda=30,\ \mu=2$		M1 A1 A1	
		OR	$\overrightarrow{AB}=(\pm)\begin{pmatrix}1\\-2\\0\end{pmatrix}$ $77-2\lambda-8\mu=1$ $36-\lambda-4\mu=-2$ $2-\mu=0$ $\lambda=30,\ \mu=2$		M1 A1 A1	

Question			Answer	Marks	Guidance	
			Closest points are A(63, 34, 8) and B(64, 32, 8)	A1		
			P is at A at time $t_1=\dfrac{\sqrt{5}\lambda}{900}\left[\text{or } \dfrac{\sqrt{60^2+30^2+0^2}}{900}=\dfrac{\sqrt{4500}}{900}\right]=\dfrac{\sqrt{5}}{30}$	M1	Method for finding time	
			Q is at B at time $t_2=\dfrac{9\mu}{270}\left[\text{or } \dfrac{\sqrt{16^2+8^2+2^2}}{270}=\dfrac{18}{270}\right]=\dfrac{2}{30}$ These times are different, so the planes are never this close	E1	Both times correct, and conclusion	
				[7]		

Question			Answer	Marks	Guidance	
	(iv)		$\mathbf{q}=\begin{pmatrix}80\\40\\10\end{pmatrix}+\frac{270t}{9}\begin{pmatrix}-8\\-4\\-1\end{pmatrix}\quad\left[=\begin{pmatrix}80-240t\\40-120t\\10-30t\end{pmatrix}\right]$	M1 A1	Speed and unit direction vectors	
			$\mathbf{r}=\begin{pmatrix}29\\19\\5.5\end{pmatrix}+\frac{285t}{19}\begin{pmatrix}18\\6\\1\end{pmatrix}\quad\left[=\begin{pmatrix}29+270t\\19+90t\\5.5+15t\end{pmatrix}\right]$	A1		
			Q, R will collide if $\begin{aligned}80-240t&=29+270t\\40-120t&=19+90t\\10-30t&=5.5+15t\end{aligned}$	M1	One equation sufficient for M1	
			All three equations have solution $t=0.1$ Planes would collide; so R must alter course or speed	A1 A1 E1	For $t=0.1$ obtained Shown to satisfy all three Correctly shown	Point of collision is (56, 28, 7)
		OR	Paths intersect if $\begin{aligned}80-8\mu&=29+18\nu\\40-4\mu&=19+6\nu\\10-\mu&=5.5+\nu\end{aligned}$		M1 OR A1 Two correct equations	$\Delta=\begin{pmatrix}-51\\-21\\-4.5\end{pmatrix}.\left[\begin{pmatrix}-8\\-4\\-1\end{pmatrix}\times\begin{pmatrix}18\\6\\1\end{pmatrix}\right]$
			$\mu=3,\quad \nu=1.5$		A1	$\begin{pmatrix}-8\\-4\\-1\end{pmatrix}\times\begin{pmatrix}18\\6\\1\end{pmatrix}=\begin{pmatrix}2\\-10\\24\end{pmatrix}$
			All equations are satisfied, so paths intersect [at X (56, 28, 7)]		A1 *Must check third equation*	$\Delta=0$, so the paths intersect
			Q is at X at time $t=\frac{9\mu}{270}\left[\text{or } \frac{\sqrt{24^2+12^2+3^2}}{270}=\frac{27}{270}\right]=0.1$ R is at X at time $t=\frac{19\nu}{285}\left[\text{or } \frac{\sqrt{27^2+9^2+1.5^2}}{285}=\frac{28.5}{285}\right]=0.1$		M1 Method for finding time A1 For $t=0.1$	
			Planes would collide; so R must alter course or speed		E1 Correctly shown	*Dependent on all previous marks*
				[7]		

Question			Answer	Marks	Guidance	
2	(i)			B1	Correct shape	
				B1	Minimum in third quadrant and positive intercept on *z*-axis	
			$y=1 \Rightarrow z=3x^2+6x+1 \quad [=3(x+1)^2-2]$	B1		
			So line of symmetry is $\mathbf{r}=\begin{pmatrix}-1\\1\\-2\end{pmatrix}+\lambda\begin{pmatrix}0\\0\\1\end{pmatrix}$	B1B1	For $\begin{pmatrix}-1\\1\\.\end{pmatrix}$ and $\lambda\begin{pmatrix}0\\0\\1\end{pmatrix}$	
				[5]		
2	(ii)		We require $\frac{\partial z}{\partial x}=\frac{\partial z}{\partial y}=0$	M1		
			$\frac{\partial z}{\partial x}=6x+6y=0 \quad [\Rightarrow y=-x]$	A1	For either equation	
			$\frac{\partial z}{\partial y}=6x+3y^2=0$ and hence $y^2=2y$	A1	Correct equation in *y* or *x*	Or $6x+3x^2=0$
			$y=0,2;\ x=0,-2;\ z=0,-4$ Stationary points are $(0,0,0)$ and $(-2,2,-4)$	E1	*Some working required for -4*	
				[4]		

Question			Answer	Marks	Guidance	
	(iii)		For $x=-2+h,\ y=2+k,\ z=\lambda$ $\lambda=3(-2+h)^2+6(-2+h)(2+k)+(2+k)^3$ $=12-12h+3h^2+6hk+12h-12k-24$ $+8+12k+6k^2+k^3$ $=-4+3h^2+6hk+6k^2+k^3$ $=-4+3(h+k)^2+k^3+3k^2$ $=-4+3(h+k)^2+k^2(k+3)$ Since $3(h+k)^2>0$ and $k^2(k+3)>0$ for small k $\lambda>-4$ for all small values of h and k so P is a minimum.	M1 A1 E1 M1 E1	Substitution *M0 for numerical work* Must mention small k or $k>-3$	
				[5]		
	(iv)		For small x and y, z can be positive or negative If $x=0$ and $y>0$, then $z>0$ If $x=0$ and $y<0$, then $z<0$ Hence O is neither a maximum nor a minimum	M1 A1 E1	(Numerical demonstration can earn M1A0E0) Correct argument which applies arbitrarily close to O Correctly shown	When $x=0,\ z=y^3$ which has a point of inflection
				[3]		
	(v)		We require $\dfrac{\partial z}{\partial x}=18,\ \dfrac{\partial z}{\partial y}=18$ $6x+6y=18,\ 6x+3y^2=18$ $2(3-y)+y^2=6$ Points are $(3, 0, 27)$ and $(1, 2, 23)$ $18x+18y-z=d$ So $d=27, 31$	M1 M1 A1 M1 A1 M1 A1	Allow -18 for M1 Obtaining equation for y or x or $2x+(3-x)^2=6$ Obtaining values of x, y, z	
				[7]		

Question			Answer	Marks	Guidance	
3	(i)		When $x=0,\ \ t=0,\pm\dfrac{1}{\sqrt{3}}$	E1		
			$y=1,\ \ y=2$	B1	For both	
				[2]		
	(ii)		$\dot{x}=1-9t^2,\ \dot{y}=6t \qquad \ddot{x}=-18t,\ \ddot{y}=6$	B1	All 4 soi	$\dot{x}=-2,\ \dot{y}=\dfrac{6}{\sqrt{3}} \qquad \ddot{x}=-\dfrac{18}{\sqrt{3}},\ \ddot{y}=6$
			$\rho=\dfrac{\left(\left(1-9t^2\right)^2+36t^2\right)^{3/2}}{6(1-9t^2)+108t^2}=\dfrac{\left(1+9t^2\right)^3}{6\left(1+9t^2\right)}=\dfrac{\left(1+9t^2\right)^2}{6}$	M1 A1	Use of formula for ρ or κ Unsimplified	$\rho=\dfrac{\left(4+12\right)^{3/2}}{-12+36}$
			When $t=\dfrac{1}{\sqrt{3}},\ \rho=\dfrac{16}{6}=\dfrac{8}{3}$	A1		
			$\tan\psi=\dfrac{\mathrm{d}y}{\mathrm{d}x}=\dfrac{6t}{1-9t^2}$	M1 A1		$\tan\psi=\dfrac{\mathrm{d}y}{\mathrm{d}x}=-\sqrt{3}$
			$\sin\psi=\dfrac{6t}{1+9t^2},\ \ \cos\psi=\dfrac{1-9t^2}{1+9t^2}$	M1 A1	or unit normal is $\begin{pmatrix}\dfrac{\sqrt{3}}{2}\\ \dfrac{1}{2}\end{pmatrix}$	$\sin\psi=\dfrac{\sqrt{3}}{2},\ \ \cos\psi=-\dfrac{1}{2}$
			Centre of curvature is at $\left(0-\dfrac{8}{3}\times\dfrac{\sqrt{3}}{2},\ 2-\dfrac{8}{3}\times\dfrac{1}{2}\right)$	M1		
			i.e. $\left(-\dfrac{4\sqrt{3}}{3},\ \dfrac{2}{3}\right)$	A1A1		
				[11]		
	(iii)		$\dot{x}^2+\dot{y}^2=\left(1-9t^2\right)^2+\left(6t\right)^2=\left(1+9t^2\right)^2$	M1A1	Soi	
			$s=\displaystyle\int_0^{1/\sqrt{3}}\left(1+9t^2\right)\mathrm{d}t$	M1	*Limits not required*	
			$=\left[t+3t^3\right]_0^{1/\sqrt{3}}$	A1	*Including limits*	
			$=\dfrac{2}{\sqrt{3}}=\dfrac{2}{3}\sqrt{3}$	A1		
				[5]		

Question			Answer	Marks	Guidance	
	(iv)		$S = 2\pi \int_0^{1/\sqrt{3}} x \, \mathrm{d}s = 2\pi \int_0^{1/\sqrt{3}} \left(t - 3t^3\right)\left(1 + 9t^2\right)\mathrm{d}t$	M1 M1 A1	Correct formula Integral in terms of t *Including limits*	
			$= 2\pi \int_0^{1/\sqrt{3}} \left(t + 6t^3 - 27t^5\right)\mathrm{d}t = 2\pi\left[\frac{t^2}{2} + \frac{3}{2}t^4 - \frac{9}{2}t^6\right]_0^{1/\sqrt{3}}$	M1 A1	Expand and integrate *Including limits*	
			$= 2\pi\left(\frac{1}{6} + \frac{1}{6} - \frac{1}{6}\right) = \frac{\pi}{3}$	E1	*Intermediate step required*	
				[6]		

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th colspan="2">Guidance</th></tr>
<tr><td>4</td><td>(a)</td><td>(i)</td><td>3*(9*11) = 3*3 = 9
(3*9)*11 = 11*11 = 9

Construction of group table (or otherwise):

It shows closure,
the identity is 1
each element has an inverse
$3^{-1}=11,\ 9^{-1}=9, 11^{-1}=3, 1^{-1}=1$</td><td>B1
B1

B1

B1
B1

B1</td><td></td><td>Group table
is: $\begin{array}{c|c} & \begin{matrix}1 & 3 & 9 & 11\end{matrix} \\ \begin{matrix}1\\3\\9\\11\end{matrix} & \begin{pmatrix}1 & 3 & 9 & 11\\ 3 & 9 & 11 & 1\\ 9 & 11 & 1 & 3\\ 11 & 1 & 3 & 9\end{pmatrix}\end{array}$</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[6]</td><td></td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td>

Element	1	3	9	11
Order	1	4	2	4

</td><td>B2</td><td>−1 each error</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td>[2]</td><td></td><td></td></tr>
<tr><td></td><td></td><td>(iii)</td><td>{1} {1,9} {1,3,9,11}</td><td>B1</td><td>Condone omission of trivial subgroups</td><td>B0 if any extras</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[1]</td><td></td><td></td></tr>
<tr><td></td><td></td><td>(iv)</td><td>e.g. $3^2 = 9,\ 3^3 = 11, 3^4 = 1$
3 generates the group and so it is cyclic</td><td>E1</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td>[1]</td><td></td><td></td></tr>
<tr><td></td><td>(b)</td><td></td><td>Composition table:
$\begin{array}{c|c} & \begin{matrix}e & a & b & ab\end{matrix} \\ \begin{matrix}e\\a\\b\\ab\end{matrix} & \begin{pmatrix}e & a & b & ab\\ a & e & ab & b\\ b & ab & e & a\\ ab & b & a & e\end{pmatrix}\end{array}$
All elements are self-inverse, and so no element generates the group</td><td>B3

E1</td><td>−1 each error</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td>[4]</td><td></td><td></td></tr>
</table>

Question			Answer	Marks	Guidance	
	(c)		In group G all elements are self-inverse i.e. $X^2 = I$, $Y^2 = I$ and $Z^2 = I$ So this group is isomorphic to the group in (b) e.g. $\mathbf{I} \leftrightarrow e \quad \mathbf{X} \leftrightarrow a \quad \mathbf{Y} \leftrightarrow b \quad \mathbf{Z} \leftrightarrow ab$	M1 A1A1 A1 B1B1	 Correctly shown	
				[6]		
	(d)		One of the elements needs to be the identity element. It is neither p nor q for otherwise $p \circ q = p$ (or q) It is neither r nor s, for otherwise $p \circ q = q \circ p = r$ (or s) So there is no identity element and so not a group	M1 A1 A1 E1		
				[4]		

Question			Answer	Marks	Guidance	
5	(i)		$\begin{pmatrix} 0.75 & 0 & p \\ 0.125 & 0.5 & \frac{1-p}{2} \\ 0.125 & 0.5 & \frac{1-p}{2} \end{pmatrix}$	B1 M1 A1	1st two columns Making 3rd column sum to 1	
				[3]		
	(ii)		$\begin{pmatrix} 0.75 & 0 & p \\ 0.125 & 0.5 & \frac{1-p}{2} \\ 0.125 & 0.5 & \frac{1-p}{2} \end{pmatrix}\begin{pmatrix} \frac{1}{3} \\ \frac{1}{3} \\ \frac{1}{3} \end{pmatrix} = \begin{pmatrix} \frac{1}{3} \\ \frac{1}{3} \\ \frac{1}{3} \end{pmatrix}$ $0.75 + p = 1$ $p = 0.25$	M1 A1 A1 A1	Equilibrium probs Equation *Correct equation implies M1A1A1* *Just answer: B4*	
				[4]		
	(iii)		$\text{P(A on day 5)} = \begin{pmatrix} 0.75 & 0 & 0.25 \\ 0.125 & 0.5 & 0.375 \\ 0.125 & 0.5 & 0.375 \end{pmatrix}^4 \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$ $= \begin{pmatrix} 0.435059 & ..... & ..... \\ ..... & ..... & ..... \\ ..... & ..... & ..... \end{pmatrix}$ $= 0.435$	M1 A1 A1	For power 4 At least one right, soi *Just answer: B3*	
				[3]		

Question			Answer	Marks	Guidance	
	(iv)		$\mathbf{P}=\begin{pmatrix}0.75 & 0 & 0.4\\ 0.125 & 0.5 & 0.3\\ 0.125 & 0.5 & 0.3\end{pmatrix}$, $\mathbf{P}^3=\begin{pmatrix}0.536875 & 0.31 & 0.431\\ 0.231563 & 0.345 & 0.2845\\ 0.231563 & 0.345 & 0.2845\end{pmatrix}$	M1	For using P^3	
			$\mathbf{P}^3\begin{pmatrix}1\\0\\0\end{pmatrix}=\begin{pmatrix}0.536875\\0.231563\\0.231563\end{pmatrix}$	M1 A1	First column of P^3	
			$p=0.536875\times0.536875+0.345\times0.2315625+0.2845\times0.2315625$ $=0.434(003)...$	M1 A1		
				[5]		
	(v)		P(from A to A) = 0.75 so $\alpha=0.75$ Expected number is $\dfrac{\alpha}{1-\alpha}=\dfrac{0.75}{0.25}=3$	B1 M1 A1	Using $\dfrac{\alpha}{1-\alpha}$	
				[3]		
	(vi)		$\begin{pmatrix}0 & 0.5 & 0.5\\ 0 & 0 & 0.5\\ 1 & 0.5 & 0\end{pmatrix}\begin{pmatrix}x\\y\\z\end{pmatrix}=\begin{pmatrix}x\\y\\z\end{pmatrix}$	B1	New transition matrix	
			$0.5y+0.5z=x,\quad 0.5z=y,\quad x+0.5y=z$	M1 A1		
			$x+y+z=1$	M1		
			$x=\dfrac{1}{3},\ y=\dfrac{2}{9},\ z=\dfrac{4}{9}$	A2	−1 each error	
		OR	New transition matrix Considering a high power (at least 20) P(A) = 0.333, P(B) = 0.222, P(C) = 0.444		B1 M2 Give M1 for at least 10 A1A1A1	
				[6]		

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

Education and Learning
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

For staff training purposes and as part of our quality assurance programme your call may be recorded or monitored

PART OF THE CAMBRIDGE ASSESSMENT GROUP

OCR (Oxford Cambridge and RSA Examinations)
Head office
Telephone: 01223 552552
Facsimile: 01223 552553