OCR
RECOGNISING ACHIEVEMENT

Thursday 31 May 2012 – Morning

A2 GCE MATHEMATICS (MEI)

4763 Mechanics 3

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:
- Printed Answer Book 4763
- MEI Examination Formulae and Tables (MF2)

Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

These instructions are the same on the Printed Answer Book and the Question Paper.

- The Question Paper will be found in the centre of the Printed Answer Book.
- Write your name, centre number and candidate number in the spaces provided on the Printed Answer Book. Please write clearly and in capital letters.
- **Write your answer to each question in the space provided in the Printed Answer Book**. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- You are permitted to use a scientific or graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.
- The acceleration due to gravity is denoted by $g\,\text{m}\,\text{s}^{-2}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

INFORMATION FOR CANDIDATES

This information is the same on the Printed Answer Book and the Question Paper.

- The number of marks is given in brackets **[ ]** at the end of each question or part question on the Question Paper.
- You are advised that an answer may receive **no marks** unless you show sufficient detail of the working to indicate that a correct method is being used.
- The total number of marks for this paper is **72**.
- The Printed Answer Book consists of **12** pages. The Question Paper consists of **8** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER / INVIGILATOR

- Do not send this Question Paper for marking; it should be retained in the centre or recycled. Please contact OCR Copyright should you wish to re-use this document.

1 The fixed point A is at a height $4b$ above a smooth horizontal surface, and C is the point on the surface which is vertically below A. A light elastic string, of natural length $3b$ and modulus of elasticity λ, has one end attached to A and the other end attached to a block of mass m. The block is released from rest at a point B on the surface where $BC = 3b$, as shown in Fig. 1. You are given that the block remains on the surface and moves along the line BC.

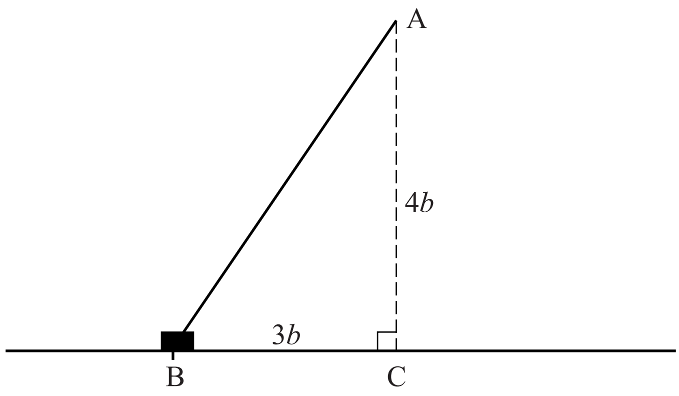


Fig. 1

(i) Show that immediately after release the acceleration of the block is $\frac{2\lambda}{5m}$. **[4]**

(ii) Show that, when the block reaches C, its speed v is given by $v^2 = \frac{\lambda b}{m}$. **[4]**

(iii) Show that the equation $v^2 = \frac{\lambda b}{m}$ is dimensionally consistent. **[3]**

The time taken for the block to move from B to C is given by $km^{\alpha}b^{\beta}\lambda^{\gamma}$, where k is a dimensionless constant.

(iv) Use dimensional analysis to find α, β and γ. **[4]**

When the string has natural length 1.2 m and modulus of elasticity 125 N, and the block has mass 8 kg, the time taken for the block to move from B to C is 0.718 s.

(v) Find the time taken for the block to move from B to C when the string has natural length 9 m and modulus of elasticity 20 N, and the block has mass 75 kg. **[3]**

2 **(a)** Fig. 2 shows a car of mass 800 kg moving at constant speed in a horizontal circle with centre C and radius 45 m, on a road which is banked at an angle of 18° to the horizontal. The forces shown are the weight W of the car, the normal reaction, R, of the road on the car and the frictional force F.

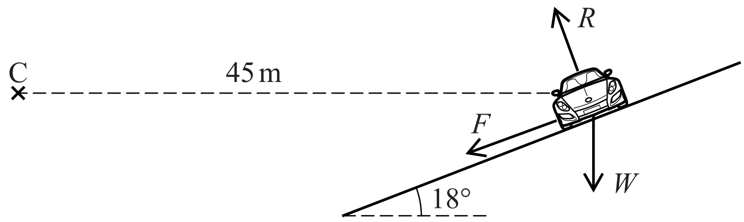


Fig. 2

(i) Given that the frictional force is zero, find the speed of the car. **[4]**

(ii) Given instead that the speed of the car is $15\,\mathrm{m\,s^{-1}}$, find the frictional force and the normal reaction. **[7]**

(b) One end of a light inextensible string is attached to a fixed point O, and the other end is attached to a particle P of mass m kg. Starting with the string taut and P vertically below O, P is set in motion with a horizontal velocity of $7\,\mathrm{m\,s^{-1}}$. It then moves in part of a vertical circle with centre O. The string becomes slack when the speed of P is $2.8\,\mathrm{m\,s^{-1}}$.

Find the length of the string. Find also the angle that OP makes with the upward vertical at the instant when the string becomes slack. **[7]**

3 A particle Q is performing simple harmonic motion in a vertical line. Its height, x metres, above a fixed level at time t seconds is given by

$$x = c + A\cos(\omega t - \phi)$$

where c, A, ω and ϕ are constants.

(i) Show that $\ddot{x} = -\omega^2(x - c)$. **[3]**

Fig. 3 shows the displacement-time graph of Q for $0 \leqslant t \leqslant 14$.

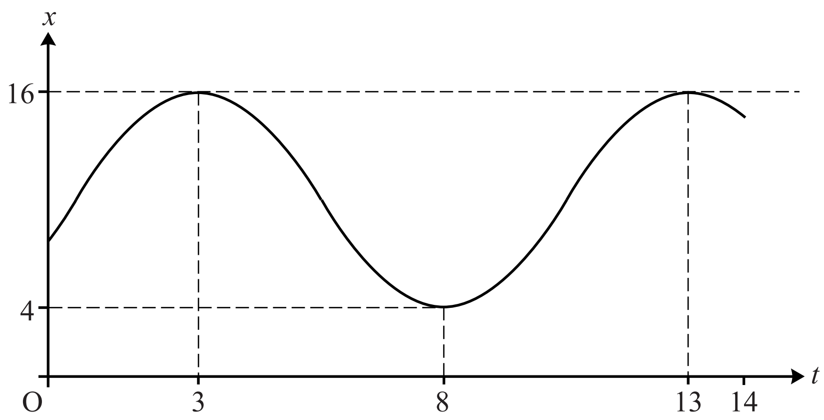


Fig. 3

(ii) Find exact values for c, A, ω and ϕ. **[6]**

(iii) Find the maximum speed of Q. **[2]**

(iv) Find the height and the velocity of Q when $t = 0$. **[3]**

(v) Find the distance travelled by Q between $t = 0$ and $t = 14$. **[4]**

4 **(a)** A uniform lamina occupies the region bounded by the x-axis, the y-axis and the curve $y = 3 - \sqrt{x}$ for $0 \leqslant x \leqslant 9$. Find the coordinates of the centre of mass of this lamina. **[9]**

(b) Fig. 4.1 shows the region bounded by the line $x = 2$ and the part of the circle $y^2 = 25 - x^2$ for which $2 \leqslant x \leqslant 5$. This region is rotated about the x-axis to form a uniform solid of revolution S.

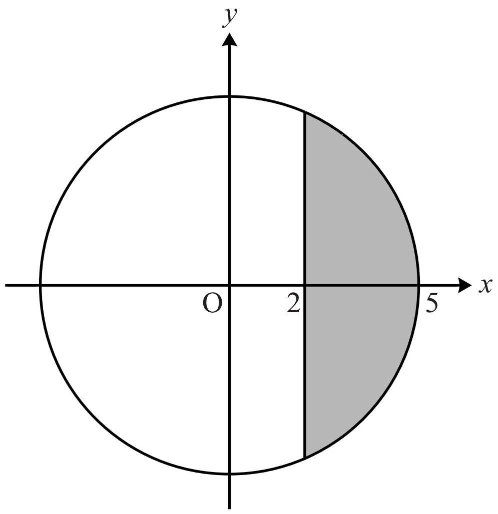


Fig. 4.1

(i) Find the x-coordinate of the centre of mass of S. **[5]**

The solid S rests in equilibrium with its curved surface in contact with a rough plane inclined at 25° to the horizontal. Fig. 4.2 shows a vertical section containing AB, which is a diameter and also a line of greatest slope of the flat surface of S. This section also contains XY, which is a line of greatest slope of the plane.

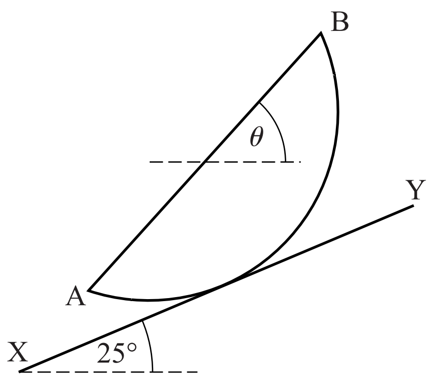


Fig. 4.2

(ii) Find the angle θ that AB makes with the horizontal. **[4]**

BLANK PAGE

BLANK PAGE

OCR
RECOGNISING ACHIEVEMENT

Thursday 31 May 2012 – Morning

A2 GCE MATHEMATICS (MEI)

4763 Mechanics 3

PRINTED ANSWER BOOK

Candidates answer on this Printed Answer Book.

OCR supplied materials:
- Question Paper 4763 (inserted)
- MEI Examination Formulae and Tables (MF2)

Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

These instructions are the same on the Printed Answer Book and the Question Paper.

- The Question Paper will be found in the centre of the Printed Answer Book.
- Write your name, centre number and candidate number in the spaces provided on the Printed Answer Book. Please write clearly and in capital letters.
- **Write your answer to each question in the space provided in the Printed Answer Book.** Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- You are permitted to use a scientific or graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.
- The acceleration due to gravity is denoted by $g\,\mathrm{m\,s^{-2}}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

INFORMATION FOR CANDIDATES

This information is the same on the Printed Answer Book and the Question Paper.

- The number of marks is given in brackets **[ ]** at the end of each question or part question on the Question Paper.
- You are advised that an answer may receive **no marks** unless you show sufficient detail of the working to indicate that a correct method is being used.
- The total number of marks for this paper is **72.**
- The Printed Answer Book consists of **12** pages. The Question Paper consists of **8** pages. Any blank pages are indicated.

1 (i)	
1 (ii)	

1 (iii)	
1 (iv)	

1 (v)	
2 (a) (i)	

2 (a) (ii)

2 (b)	

3 (i)	
3 (ii)	

3 (iii)	
3 (iv)	
3 (v)	

4 (a)

(answer space continued overleaf)

4 (a)	**(continued)**
4 (b) (i)	
	(answer space continued on next page)

4 (b) (i)	**(continued)**
4 (b) (ii)	
	(answer space continued overleaf)

4 (b) (ii)	(continued)

GCE

Mathematics (MEI)

Advanced GCE

Unit **4763:** Mechanics 3

Mark Scheme for June 2012

Oxford Cambridge and RSA Examinations

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.

Any enquiries about publications should be addressed to:

OCR Publications
PO Box 5050
Annesley
NOTTINGHAM
NG15 0DL

Telephone: 0870 770 6622
Facsimile: 01223 552610
E-mail: publications@ocr.org.uk

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) Mechanics 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 Unless units are specifically requested, there is no penalty for wrong or missing units as long as the answer is numerically correct and expressed either in SI or in the units of the question. (e.g. lengths will be assumed to be in metres unless in a particular question all the lengths are in km, when this would be assumed to be the unspecified unit.)

We are usually quite flexible about the accuracy to which the final answer is expressed and we do not penalise over-specification.

When a value is given in the paper
Only accept an answer correct to at least as many significant figures as the given value. This rule should be applied to each case.

When a value is not given in the paper
Accept any answer that agrees with the correct value to 2 s.f.

ft should be used so that only one mark is lost for each distinct accuracy error, except for errors due to premature approximation which should be penalised only once in the examination.

There is no penalty for using a wrong value for *g*. E marks will be lost except when results agree to the accuracy required in the question.

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.

Marks designated as cao may be awarded as long as there are no other errors. E marks are lost unless, by chance, the given results are established by equivalent working.

'Fresh starts' will not affect an earlier decision about a misread.

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

i If a graphical calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers (provided, of course, that there is nothing in the wording of the question specifying that analytical methods are required). Where an answer is wrong but there is some evidence of method, allow appropriate method marks. Wrong answers with no supporting method score zero. If in doubt, consult your Team Leader.

j If in any case the scheme operates with considerable unfairness consult your Team Leader.

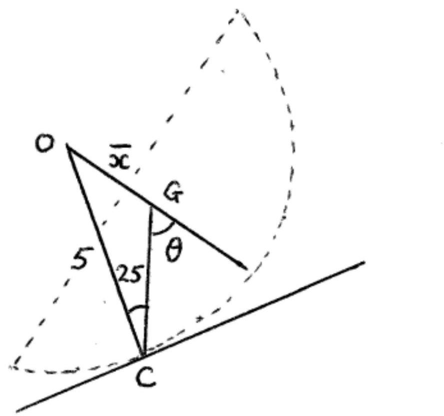
Question			Answer	Marks	Guidance	
1	(i)			M1	For use of $\frac{\lambda x}{l}$	
			$\text{AB} = 5b$, so $T = \frac{\lambda(2b)}{3b}$ $\left(= \frac{2}{3}\lambda\right)$	A1		
			Horizontal component is $T\cos\theta = \frac{3}{5}T$ where $\theta = \angle ABC$	B1	For $\frac{3}{5}T$ or $T\cos 53.1°$	
			Acceleration is $\frac{\frac{3}{5}(\frac{2}{3}\lambda)}{m} = \frac{2\lambda}{5m}$	E1	*Allow use of* $\cos 53.1°$	
				[4]		
1	(ii)			B1B1	For $\frac{\lambda(2b)^2}{2(3b)}$ and $\frac{\lambda b^2}{2(3b)}$	$\left(\frac{2}{3}\lambda b \text{ and } \frac{1}{6}\lambda b\right)$
			$\frac{1}{2}mv^2 = \frac{\lambda(2b)^2}{2(3b)} - \frac{\lambda b^2}{2(3b)}$	M1	Equation involving KE and EE	
			$\frac{1}{2}mv^2 = \frac{\lambda b}{2}$			
			$v^2 = \frac{\lambda b}{m}$	E1		
				[4]		
1	(iii)		$[\lambda] = \text{M L T}^{-2}$	B1	*Can be implied from part (iv)*	
			$[\text{RHS}] = \frac{(\text{M L T}^{-2})(\text{L})}{\text{M}} = \text{L}^2\text{T}^{-2}$	M1	Obtaining dimensions of RHS	Must see dimensions of λ, b, m and simplification
			$[\text{LHS}] = (\text{L T}^{-1})^2$, so it is dimensionally consistent	E1	Correctly shown	
				[3]		

Question			Answer	Marks	Guidance	
1	(iv)		$\mathrm{T} = \mathrm{M}^{\alpha}\,\mathrm{L}^{\beta}\,(\mathrm{M\,L\,T}^{-2})^{\gamma}$ $\gamma = -\frac{1}{2}$ $\alpha + \gamma = 0, \quad \beta + \gamma = 0$ $\alpha = \frac{1}{2}, \quad \beta = \frac{1}{2}$	 B1 M1 A1A1 **[4]**	 CAO Considering powers of M or L FT $\alpha = -\gamma,\ \beta = -\gamma$ (provided non-zero)	
1	(v)		$0.718 = k(8)^{\frac{1}{2}}(0.4)^{\frac{1}{2}}(125)^{-\frac{1}{2}}$ $k = 4.4875$ $t = (4.4875)(75)^{\frac{1}{2}}(3)^{\frac{1}{2}}(20)^{-\frac{1}{2}}$ New time is 15.1 s (3 sf)	M1 M1 A1 **[3]**	Obtaining equation for k Obtaining expression for new time CAO *No penalty for using* $b = 1.2$ *and* $b = 9$	Or using ratio and powers Or $\times\left(\frac{75}{8}\right)^{\frac{1}{2}}\times\left(\frac{3}{0.4}\right)^{\frac{1}{2}}\times\left(\frac{20}{125}\right)^{-\frac{1}{2}}$
2	(a)	(i)	$R\cos 18° = 800\times 9.8$ ($R = 8243$) $R\sin 18° = 800\times\frac{v^2}{45}$ $\tan 18° = \frac{v^2}{45\times 9.8}$ Speed is $12.0\ \mathrm{m\,s^{-1}}$ (3 sf)	M1 M1 A1 A1 **[4]**	Resolving vertically Horizontal equation of motion	Might also include F Might also include F
2	(a)	(ii)	 $R\cos 18° = F\sin 18° + 800\times 9.8$ $R\sin 18° + F\cos 18° = 800\times\frac{15^2}{45}$ Frictional force is 1380 N (3 sf) Normal reaction is 8690 N (3 sf)	M1 A1 M1 A1 M1 A1 A1 **[7]**	Resolving vertically (three terms) Horizontal equation (three terms) Obtaining a value for F or R	 *Dependent on previous M1M1*

Question			Answer	Marks	Guidance	
2	(b)			M1	Equation involving KE and PE	$h=2.1$ implies M1 a is length of the string
			$\frac{1}{2}m(7^2-2.8^2)=mg(a+a\cos\theta)$	A1	Correct equation involving a and θ	(Might use angle with downward vertical or horizontal)
			$a(1+\cos\theta)=2.1$			
				M1	Radial equation of motion	Might also involve T
			$mg\cos\theta=m\times\dfrac{2.8^2}{a}$	A1	Correct equation involving a and θ	
			$a\cos\theta=0.8$			
				M1	Eliminating θ or a	*Dependent on previous M1M1*
			Length of string is 1.3 m	A1		
			Angle with upward vertical is 52.0° (3 sf)	A1		A0 for 128° or 38°
				[7]		
3	(i)		$\dot{x}=-A\omega\sin(\omega t-\phi)$	B1		
			$\ddot{x}=-A\omega^2\cos(\omega t-\phi)$	M1	Obtaining second derivative	*Allow one error*
			$\ddot{x}=-\omega^2(x-c)$	E1	Correctly shown	
				[3]		
3	(ii)		$c=10$	B1		
			$A=6$	B1	Accept $A=-6$	
			$\dfrac{2\pi}{\omega}=10$	M1	Using $\dfrac{2\pi}{\omega}$	*Or other complete method for finding ω*
			$\omega=\dfrac{\pi}{5}$	A1	Accept $\omega=-\dfrac{\pi}{5}$	*Allow* $\dfrac{2\pi}{10}$ *etc*
			$x=16$ when $t=3 \Rightarrow 3\omega-\phi=0$	M1	Obtaining simple relationship between ϕ and ω. *NB $\phi=3$ is M0*	Or $x=10+6\cos\{\frac{\pi}{5}(t-3)\}$
			$\phi=\dfrac{3\pi}{5}$	A1	NB other values possible *If exact values not seen, give A0A1 for both $\omega=0.63$ and $\phi=1.9$*	e.g. $\phi=-\dfrac{7\pi}{5}$, $\phi=\dfrac{13\pi}{5}$, $x=10-6\cos(\frac{\pi}{5}t-\frac{8\pi}{5})$ etc
				[6]	*Max 5/6 if values are not consistent*	

Question			Answer	Marks	Guidance	
3	(iii)		Maximum speed is $A\omega$	M1	Or e.g. evaluating $\dot{x}$ when $t = 5.5$	
			Maximum speed is $\frac{6\pi}{5}$ or $3.77\ \mathrm{m\,s^{-1}}$ (3 sf)	A1	FT is $\lvert A\omega \rvert$ (must be positive)	
				[2]		
3	(iv)		When $t = 0$, height is 8.15 m (3 sf)	B1	FT is $c + A\cos\phi$ (provided $4 < x < 16$)	Must use radians
			$v = -\frac{6\pi}{5}\sin(\frac{\pi t}{5} - \frac{3\pi}{5})$	M1	Or $v^2 = \left(\frac{\pi}{5}\right)^2 (6^2 - 1.854^2)$	*Allow one error in differentiation*
			When $t = 0$, velocity is $3.59\ \mathrm{m\,s^{-1}}$ (3 sf)	A1	FT is $A\omega\sin\phi$ (must be positive)	($\phi = 3$ gives $x = 4.06$, $v = 0.532$)
				[3]		
3	(v)		When $t = 0$, $x = 8.146$			
			When $t = 14$, $x = 14.854$	M1	Finding x when $t = 14$	Correct (FT) value, or evidence of substitution, required ($\phi = 3$ gives $x = 15.3$)
				M1	$(16 - 14.854)$ used	Requires $4 < x(14) < 16$
			$(16 - 8.146) + 12 + 12 + (16 - 14.854)$	M1	Fully correct strategy	Also requires $4 < x(0) < 16$
			Distance is 33 m	A1	CAO	
				[4]		

Question			Answer	Marks	Guidance	
4	(a)		$A=\int_0^9 (3-\sqrt{x})\,dx$	M1		
			$=\left[\,3x-\frac{2}{3}x^{\frac{3}{2}}\,\right]_0^9 \quad (=9)$	A1	For $3x-\frac{2}{3}x^{\frac{3}{2}}$	
			$A\bar{x}=\int xy\,dx=\int_0^9 x(3-\sqrt{x})\,dx$	M1	For $\int xy\,dx$	
			$=\left[\,\frac{3}{2}x^2-\frac{2}{5}x^{\frac{5}{2}}\,\right]_0^9 \quad (=24.3)$	A1	For $\frac{3}{2}x^2-\frac{2}{5}x^{\frac{5}{2}}$	
			$\bar{x}=\frac{24.3}{9}=2.7$	A1		
			$A\bar{y}=\int \frac{1}{2}y^2\,dx=\int_0^9 \frac{1}{2}(3-\sqrt{x})^2\,dx$	M1	For $\int \ldots y^2\,dx$	Or $\int_{(0)}^{(3)} (3-y)^2\,y\,dy$
				M1	Expanding (three terms) and integrating *(allow one error)*	
			$=\left[\,\frac{9}{2}x-2x^{\frac{3}{2}}+\frac{1}{4}x^2\,\right]_0^9 \quad (=6.75)$	A1	For $\frac{9}{2}x-2x^{\frac{3}{2}}+\frac{1}{4}x^2$	Or $\frac{9}{2}y^2-2y^3+\frac{1}{4}y^4$
			$\bar{y}=\frac{6.75}{9}=0.75$	A1		
				[9]		

Question			Answer	Marks	Guidance	
4	(b)	(i)	$V = \int_2^5 \pi(25 - x^2)\,\mathrm{d}x$	M1	For $\int \ldots(25 - x^2)\,\mathrm{d}x$	
			$= \pi\left[\, 25x - \frac{1}{3}x^3 \,\right]_2^5 \quad (= 36\pi\,)$	A1	For $25x - \frac{1}{3}x^3$	
			$V\bar{x} = \int \pi x y^2\,\mathrm{d}x = \int_2^5 \pi x(25 - x^2)\,\mathrm{d}x$	M1	For $\int xy^2\,\mathrm{d}x$	
			$= \pi\left[\, \frac{25}{2}x^2 - \frac{1}{4}x^4 \,\right]_2^5 \quad \left(= \frac{441\pi}{4}\right)$	A1	For $\frac{25}{2}x^2 - \frac{1}{4}x^4$	
			$\bar{x} = \frac{\frac{441}{4}\pi}{36\pi} = \frac{49}{16} \quad (= 3.0625)$	A1	Accept 3.1 from correct working	
				[5]		
4	(b)	(ii)				
				M1	CG is vertical *(may be implied)*	Lenient, if CG drawn. Needs to be quite accurate if CG not drawn
				M1	Using triangle OGC *or equivalent*	
			$\frac{\sin\theta}{5} = \frac{\sin 25°}{\bar{x}}$	M1		
			$\theta = 43.6°$	A1	Accept art 43° or 44° from correct work FT is $\sin^{-1}\left(\frac{2.113}{\bar{x}}\right)$	Provided $2.113 < \bar{x} < 5$
				[4]		

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

4763 Mechanics 3

General Comments

Most candidates answered this paper very well, demonstrating a sound understanding of the mechanical and mathematical principles involved, and presenting their working clearly. They were particularly competent at applying the techniques accurately in questions involving dimensional analysis and centres of mass; and slightly less competent in questions involving simple harmonic motion and motion in a circle.

Comments on Individual Questions

1) In part (i) candidates needed to use Hooke's law to obtain the tension in the string, and then resolve the tension in the horizontal direction. As the answer is given on the question paper it was important to show the two separate steps clearly, and most candidates did so convincingly.

   Again in part (ii) there is a given answer so the working had to be clearly shown, and most candidates obtained the changes in kinetic and elastic energy correctly. Common errors included omitting the elastic energy stored in the string when the block was at C, and using constant acceleration formulae.

   In part (iii) most candidates demonstrated the dimensional consistency by clearly identifying the dimensions of each term in the equation.

   In part (iv) the dimensional method for finding unknown indices in an equation was very well understood, and was applied accurately by most candidates. The numerical application in part (v) was also done very well.

2) In part (a)(i), the horizontal equation of motion was almost always formed correctly. Most candidates realised that the vertical direction is the only one where the forces balance, and used this to find the normal reaction correctly. A very common error here was to resolve perpendicular to the slope, obtaining R=Wcos18 instead of the correct Rcos18=W.

   In part (a)(ii) most candidates obtained two equations by considering horizontal and vertical forces, then solved these simultaneously to find F and R. Common errors included resolving perpendicular (and sometimes parallel) to the slope without taking account of the acceleration in that direction. Some candidates solved the problem very efficiently by resolving the acceleration parallel and perpendicular to the slope, then finding F and R directly without needing to solve simultaneous equations.

   In part (b) candidates needed to use conservation of energy and radial acceleration to obtain two equations involving the length of the string and the angle between the string and the vertical. About half the candidates found these equations correctly. There was quite often confusion about whether the angle used in the equations was measured from the upward vertical, the downward vertical or the horizontal, especially when no clear diagram was drawn. Another fairly common error was to resolve vertically as if the system were in equilibrium.

3) Most candidates derived the given result in part (i) convincingly.
Part (ii) required the candidates to identify parameters in the SHM equation to fit the given graph, and most gave all the values correctly. The most common error was to give ϕ as 3 instead of 3ω.

Most candidates then used their equation successfully to find the maximum speed in part (iii) and the height and velocity in part (iv). For the velocity, those who differentiated the height equation were much more likely to obtain the correct answer than those who used the standard SHM equation relating velocity to displacement from the centre (which was very often confused with the height x).

In part (v) most candidates made a good attempt to find the distance travelled, and about half obtained the correct answer.

4) In part (a) almost all candidates knew how to find the centre of mass of a lamina, and most carried out the calculations accurately. The only common error was the loss of a factor ½ in the y-coordinate at some stage in the process.

In part (b)(i) the centre of mass of the solid of revolution was almost always found correctly.

In part (b)(ii) about half the candidates earned the first mark for indicating clearly that the centre of mass was vertically above the point of contact. The next step, drawing the normal at the point of contact to pass through O (the centre of the 'sphere') was found to be very challenging.

GCE Mathematics (MEI)											
			Max Mark	90% cp	a	b	c	d	e	u
4753/01	(C3) MEI Methods for Advanced Mathematics with Coursework: Written Paper	Raw	72	66	60	53	47	41	34	0
4753/02	(C3) MEI Methods for Advanced Mathematics with Coursework: Coursework	Raw	18	16	15	13	11	9	8	0
4753/82	(C3) MEI Methods for Advanced Mathematics with Coursework: Carried Forward Coursework Mark	Raw	18	16	15	13	11	9	8	0
4753	(C3) MEI Methods for Advanced Mathematics with Coursework	UMS	100	90	80	70	60	50	40	0
4754/01	(C4) MEI Applications of Advanced Mathematics	Raw	90	73	65	57	50	43	36	0
		UMS	100	90	80	70	60	50	40	0
4756/01	(FP2) MEI Further Methods for Advanced Mathematics	Raw	72	66	61	53	46	39	32	0
		UMS	100	90	80	70	60	50	40	0
4757/01	(FP3) MEI Further Applications of Advanced Mathematics	Raw	72	61	54	47	40	34	28	0
		UMS	100	90	80	70	60	50	40	0

4758/01	(DE) MEI Differential Equations with Coursework: Written Paper	Raw	72	68	63	57	51	45	39	0
4758/02	(DE) MEI Differential Equations with Coursework: Coursework	Raw	18	16	15	13	11	9	8	0
4758/82	(DE) MEI Differential Equations with Coursework: Carried Forward Coursework Mark	Raw	18	16	15	13	11	9	8	0
4758	(DE) MEI Differential Equations with Coursework	UMS	100	90	80	70	60	50	40	0
4762/01	(M2) MEI Mechanics 2	Raw	72	65	58	51	44	38	32	0
		UMS	100	90	80	70	60	50	40	0
4763/01	(M3) MEI Mechanics 3	Raw	72	67	63	56	50	44	38	0
		UMS	100	90	80	70	60	50	40	0
4764/01	(M4) MEI Mechanics 4	Raw	72	63	56	49	42	35	29	0
		UMS	100	90	80	70	60	50	40	0
4767/01	(S2) MEI Statistics 2	Raw	72	66	61	55	49	43	38	0
		UMS	100	90	80	70	60	50	40	0
4768/01	(S3) MEI Statistics 3	Raw	72	65	58	51	44	38	32	0
		UMS	100	90	80	70	60	50	40	0
4769/01	(S4) MEI Statistics 4	Raw	72	63	56	49	42	35	28	0
		UMS	100	90	80	70	60	50	40	0
4772/01	(D2) MEI Decision Mathematics 2	Raw	72	62	56	50	44	39	34	0
		UMS	100	90	80	70	60	50	40	0
4773/01	(DC) MEI Decision Mathematics Computation	Raw	72	52	46	40	34	29	24	0
		UMS	100	90	80	70	60	50	40	0
4777/01	(NC) MEI Numerical Computation	Raw	72	63	55	47	39	32	25	0
		UMS	100	90	80	70	60	50	40	0