OCR
RECOGNISING ACHIEVEMENT

Thursday 6 June 2013 – Morning

A2 GCE MATHEMATICS (MEI)

4763/01 Mechanics 3

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:
- Printed Answer Book 4763/01
- MEI Examination Formulae and Tables (MF2)

Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

4715810613

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

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- 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 **16** 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 **(a)** A particle P of mass 1.5 kg is connected to a fixed point by a light inextensible string of length 3.2 m. The particle P is moving as a conical pendulum in a horizontal circle at a constant angular speed of $2.5\,\text{rad}\,\text{s}^{-1}$.

(i) Find the tension in the string. **[4]**

(ii) Find the angle that the string makes with the vertical. **[2]**

(b) A particle Q of mass m moves on a smooth horizontal surface, and is connected to a fixed point on the surface by a light elastic string of natural length d and stiffness k. With the string at its natural length, Q is set in motion with initial speed u perpendicular to the string. In the subsequent motion, the maximum length of the string is $2d$, and the string first returns to its natural length after time t.

You are given that $u = \sqrt{\dfrac{4kd^2}{3m}}$ and $t = Ak^{\alpha}d^{\beta}m^{\gamma}$, where A is a dimensionless constant.

(i) Show that the dimensions of k are MT^{-2}. **[1]**

(ii) Show that the equation $u = \sqrt{\dfrac{4kd^2}{3m}}$ is dimensionally consistent. **[2]**

(iii) Find α, β and γ. **[4]**

You are now given that Q has mass 5 kg, and the string has natural length 0.7 m and stiffness $60\,\text{N}\,\text{m}^{-1}$.

(iv) Find the initial speed u, and use conservation of energy to find the speed of Q at the instant when the length of the string is double its natural length. **[5]**

2 A particle P of mass 0.25 kg is connected to a fixed point O by a light inextensible string of length a metres, and is moving in a vertical circle with centre O and radius a metres. When P is vertically below O, its speed is $8.4\,\text{m s}^{-1}$. When OP makes an angle θ with the downward vertical, and the string is still taut, P has speed $v\,\text{m s}^{-1}$ and the tension in the string is T N, as shown in Fig. 2.

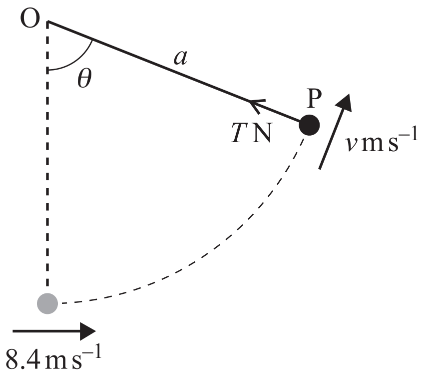

Fig. 2

(i) Find an expression for v^2 in terms of a and θ, and show that

$$T = \frac{17.64}{a} + 7.35\cos\theta - 4.9.$$ **[7]**

(ii) Given that $a = 0.9$, show that P moves in a complete circle. Find the maximum and minimum magnitudes of the tension in the string. **[4]**

(iii) Find the largest value of a for which P moves in a complete circle. **[3]**

(iv) Given that $a = 1.6$, find the speed of P at the instant when the string first becomes slack. **[4]**

3 A light spring, with modulus of elasticity 686 N, has one end attached to a fixed point A. The other end is attached to a particle P of mass 18 kg which hangs in equilibrium when it is 2.2 m vertically below A.

(i) Find the natural length of the spring AP. **[2]**

Another light spring has natural length 2.5 m and modulus of elasticity 145 N. One end of this spring is now attached to the particle P, and the other end is attached to a fixed point B which is 2.5 m vertically below P (so leaving the equilibrium position of P unchanged). While in its equilibrium position, P is set in motion with initial velocity $3.4\,\mathrm{m\,s^{-1}}$ vertically downwards, as shown in Fig. 3. It now executes simple harmonic motion along part of the vertical line AB.

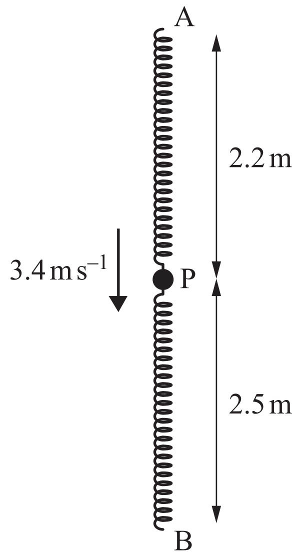

Fig. 3

At time t seconds after it is set in motion, P is x metres below its equilibrium position.

(ii) Show that the tension in the spring AP is $(176.4 + 392x)$ N, and write down an expression for the thrust in the spring BP. **[3]**

(iii) Show that $\dfrac{\mathrm{d}^2x}{\mathrm{d}t^2} = -25x$. **[3]**

(iv) Find the period and the amplitude of the motion. **[3]**

(v) Find the magnitude and direction of the velocity of P when $t = 2.4$. **[3]**

(vi) Find the total distance travelled by P during the first 2.4 seconds of its motion. **[4]**

4 **(a)** A uniform solid of revolution S is formed by rotating the region enclosed between the x-axis and the curve $y = x\sqrt{4-x}$ for $0 \leqslant x \leqslant 4$ through 2π radians about the x-axis, as shown in Fig. 4.1. O is the origin and the end A of the solid is at the point $(4, 0)$.

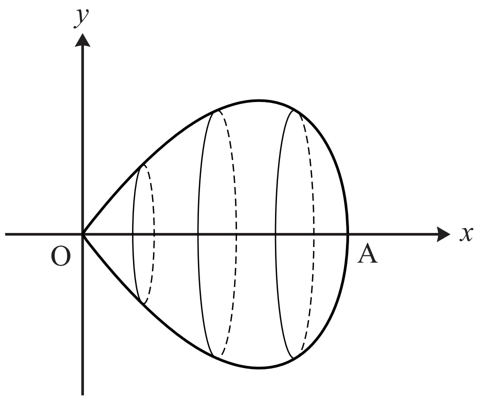

Fig. 4.1

(i) Find the x-coordinate of the centre of mass of the solid S. **[6]**

The solid S has weight W, and it is freely hinged to a fixed point at O. A horizontal force, of magnitude W acting in the vertical plane containing OA, is applied at the point A, as shown in Fig. 4.2. S is in equilibrium.

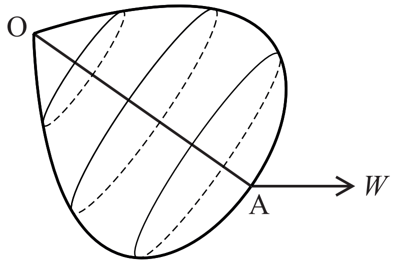

Fig. 4.2

(ii) Find the angle that OA makes with the vertical. **[3]**

[Question 4(b) is printed overleaf]

(b) Fig. 4.3 shows the region bounded by the x-axis, the y-axis, the line $y = 8$ and the curve $y = (x-2)^3$ for $0 \leqslant y \leqslant 8$.

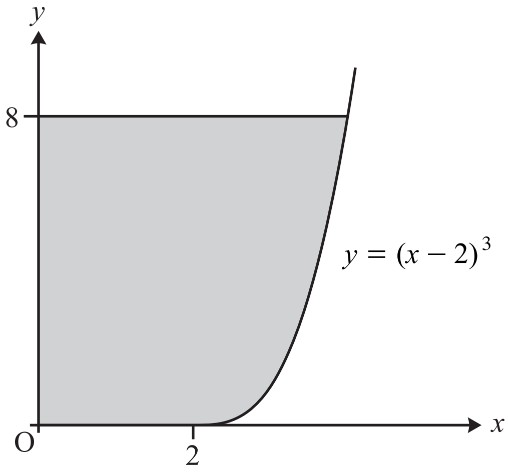

Fig. 4.3

Find the coordinates of the centre of mass of a uniform lamina occupying this region. **[9]**

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4763/01 Mechanics 3

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Centre number						Candidate number				

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1 (a) (i)	
1 (a) (ii)	

1 (b) (i)	
1 (b) (ii)	

1 (b) (iii)	

1 (b) (iv)	

2 (i)	
	(answer space continued on next page)

2 (i)	**(continued)**
2 (ii)	

2 (iii)	
2 (iv)	

3 (i)	
3 (ii)	

3 (iii)	
3 (iv)	

3 (v)	
3 (vi)	

4 (a) (i)	

4 (a) (ii)	

4 (b)	
	(answer space continued on next page)

4 (b)	(continued)

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RECOGNISING ACHIEVEMENT

GCE

Mathematics (MEI)

Advanced GCE

Unit **4763:** Mechanics 3

Mark Scheme for June 2013

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.

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

12. **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	**(a)**	**(i)**	$T\sin\theta = mr\omega^2$	M1	Equation involving $r\omega^2$ or $l\omega^2$	*All marks in (a) can be earned anywhere in (i) or (ii)*
			$r = 3.2\sin\theta$	B1		
			$T\sin\theta = (1.5)(3.2\sin\theta)(2.5)^2$	A1	$T = (1.5)(3.2)(2.5)^2$ *with no wrong working* earns M1B1A1	
			Tension is 30 N	A1 **[4]**		
1	**(a)**	**(ii)**	$T\cos\theta = mg$	M1	Resolving vertically	
			$30\cos\theta = 1.5\times 9.8$			
			Angle is 60.7° (3 sf)	A1 **[2]**	or 1.06 rad	
1	**(b)**	**(i)**	$[\,k\,] = (\mathrm{M\,L\,T^{-2}})\mathrm{L^{-1}} = \mathrm{M\,T^{-2}}$	E1 **[1]**	Can use $u = \sqrt{\dfrac{4kd^2}{3m}}$ or $k = \dfrac{\lambda}{l}$	
1	**(b)**	**(ii)**	$\left[\sqrt{\dfrac{4kd^2}{3m}}\right] = \left(\dfrac{\mathrm{M\,T^{-2}\,L^2}}{\mathrm{M}}\right)^{\frac{1}{2}} = \mathrm{L\,T^{-1}}$	M1	Obtaining dimensions of RHS	
			$[\,u\,] = \mathrm{L\,T^{-1}}$, so eqn is dimensionally consistent	E1 **[2]**	Condone circular argument	
1	**(b)**	**(iii)**	$\mathrm{T} = (\mathrm{M\,T^{-2}})^{\alpha}\,\mathrm{L}^{\beta}\,\mathrm{M}^{\gamma}$			
			$\alpha = -\frac{1}{2}$	B1		
			$\beta = 0$	B1		
			$\alpha + \gamma = 0$	M1	Considering powers of M	
			$\gamma = \frac{1}{2}$	A1 **[4]**	FT from wrong non-zero α	

Question			Answer	Marks	Guidance	
1	(b)	(iv)	$u = \sqrt{\dfrac{4\times 60\times 0.7^2}{3\times 5}} = 2.8\ \text{m s}^{-1}$	B1		
			Elastic energy is $\frac{1}{2}\times 60\times 0.7^2 \quad (=14.7)$	M1A1	M1A0 if one error	
			$\frac{1}{2}(5)(2.8)^2 - \frac{1}{2}(5)v^2 = 14.7$	M1	Equation involving initial KE, final KE and EE	
			Speed is $1.4\ \text{m s}^{-1}$	A1		*No FT in any part of Q1 except (iii)*
				[5]		
2	(i)			M1	Equation involving initial KE, final KE and PE	
			$\frac{1}{2}m(8.4)^2 - \frac{1}{2}mv^2 = mg(a - a\cos\theta)$	A1		$(m = 0.25)$
			$v^2 = 70.56 - 19.6a(1-\cos\theta)$	A1		
				M1	Using acceleration $\dfrac{v^2}{a}$	
			$T - mg\cos\theta = m\dfrac{v^2}{a}$	A1		
			$T - 2.45\cos\theta = 0.25(\dfrac{70.56}{a} - 19.6 + 19.6\cos\theta)$	M1	Equation relating *T, a, θ*	*Dependent on previous M1M1*
			$T - 2.45\cos\theta = \dfrac{17.64}{a} - 4.9 + 4.9\cos\theta$			
			$T = \dfrac{17.64}{a} + 7.35\cos\theta - 4.9$	E1		
				[7]		
2	(ii)		If $a = 0.9,\quad T = 14.7 + 7.35\cos\theta$	M1	Expression for T when $a = 0.9$	In terms of θ or when $\theta = \pi$
			$T > 0$ for all θ, so P moves in a complete circle	E1	Any correct explanation	
				M1	Using $\theta = 0$ or $\theta = \pi$	
			Maximum tension is $14.7 + 7.35 = 22.05$ N Minimum tension is $14.7 - 7.35 = 7.35$ N	A1	Both correct	
				[4]		

Question			Answer	Marks	Guidance	
2	(iii)		If P just completes the circle, $T=0$ when $\theta=\pi$	M1		
			$\frac{17.64}{a}-7.35-4.9=0$	A1		
			$a=1.44$	A1 **[3]**	For 1.44	Condone $a<1.44$ etc
2	(iv)		If $a=1.6$, $T=6.125+7.35\cos\theta$	M1	Using expression for T when $a=1.6$	
			String becomes slack when $T=0$	M1		
			$\cos\theta=-\frac{6.125}{7.35}=-\frac{5}{6}$ [$\theta=2.56$ rad or $146°$]			
			$v^2=70.56-19.6\times1.6(1+\frac{5}{6})$	M1	Obtaining an equation for v Or $-mg(-\frac{5}{6})=m\frac{v^2}{1.6}$	*Dependent on previous M1M1*
			Speed is 3.61 m s^{-1} (3 sf)	A1 **[4]**		*No FT in any part of Q2*
3	(i)		$\frac{686(2.2-l)}{l}=18\times9.8$	M1	Using Hooke's law	
			Natural length is 1.75 m	A1 **[2]**		
3	(ii)		Tension in AP is $\frac{686}{1.75}(0.45+x)$	M1		
			$=176.4+392x$	E1		
			Thrust in BP is $\frac{145}{2.5}x$ $(=58x)$	B1 **[3]**	Allow $-58x$	Condone thrust / tension confusion

Question			Answer	Marks	Guidance	
3	(iii)		$18\times9.8-(176.4+392x)-58x=18\frac{d^2x}{dt^2}$ $176.4-176.4-450x=18\frac{d^2x}{dt^2}$ $\frac{d^2x}{dt^2}=-25x$	M1 A1 E1 **[3]**	Equation of motion Correct LHS equated to $\pm18a$ Fully correct derivation	2 forces from (ii), *mg* and *ma* *No FT*
3	(iv)		Period is $\frac{2\pi}{5}=1.26$ s (3 sf) $A\omega=3.4$ Amplitude ($A=\frac{3.4}{5}$) is 0.68 m	B1 M1 A1 **[3]**	Allow $\frac{2\pi}{5}$	
3	(v)		$v=3.4\cos5t$ When $t=2.4$, $v=2.87$ Magnitude of velocity is $2.87\ \text{m s}^{-1}$ (3 sf) Since $v>0$ the direction is downwards	M1 A1 A1 **[3]**	Using $\cos\omega t$ or $\sin\omega t$ *Dependent on M1A1*	$\cos\frac{2}{5}\pi t$ is M0 'Downwards' is sufficient
		OR	When $t=2.4$, $x=-0.3649$ $v^2=25(0.68^2-0.3649^2)$ Magnitude of velocity is $2.87\ \text{m s}^{-1}$ (3 sf) Between 1¾ and 2 periods; hence downwards		M1 Using $v^2=\omega^2(A^2-x^2)$ A1 A1 *Dependent on M1A1*	Earns B1M1 from (vi) *No FT* Must be justified
3	(vi)		$x=0.68\sin5t$ When $t=2.4$, $x=-0.3649$ 2.4 s is $\frac{2.4}{1.26}=1.91$ periods (between 1¾ and 2) Distance is $8\times0.68-0.3649$ Distance is 5.08 m (3 sf)	B1 M1 M1 A1 **[4]**	FT (from wrong amplitude) $8A+x_{t=2.4}$ with $x_{t=2.4}<0$ FT is 7.463*A*	B1M1 can be earned in (v) Strictly, only for this

Question			Answer	Marks	Guidance	
4	(a)	(i)	$V=\int_0^4 \pi x^2(4-x)\,\mathrm{d}x$	M1	For $\int \left(x\sqrt{4-x}\right)^2 \mathrm{d}x$	π may be omitted throughout
			$=\pi\left[\frac{4}{3}x^3-\frac{1}{4}x^4\right]_0^4 \quad (=\frac{64\pi}{3})$	A1	For $\frac{4}{3}x^3-\frac{1}{4}x^4$	
			$V\bar{x}=\int \pi xy^2\,\mathrm{d}x=\int_0^4 \pi x^3(4-x)\,\mathrm{d}x$	M1	For $\int xy^2\,\mathrm{d}x$	
			$=\pi\left[x^4-\frac{1}{5}x^5\right]_0^4 \quad (=51.2\pi)$	A1	For $x^4-\frac{1}{5}x^5$	
			$\bar{x}=\frac{51.2\pi}{\frac{64}{3}\pi}$	M1	*Dependent on previous M1M1*	
			$=2.4$	A1 **[6]**		
4	(a)	(ii)		M1	Taking moments	
			$W(2.4\sin\theta)=W(4\cos\theta)$	A1	FT Correct equation for required angle	$W(2.4\cos\phi)=W(4\sin\phi)$ is A0 unless $\theta=90°-\phi$ also appears
			$\tan\theta=\frac{4}{2.4}=\frac{5}{3}$			
			$\theta=59.0°$ (3 sf)	A1	FT is $\tan^{-1}\frac{4}{\bar{x}}$	FT requires $\bar{x}<4$
				[3]		

Question			Answer	Marks	Guidance	
4	(b)		$x = 2 + y^{\frac{1}{3}}$	B1		
			$A = \int_0^8 (2 + y^{\frac{1}{3}})\,dy \quad = \left[\; 2y + \frac{3}{4} y^{\frac{4}{3}} \;\right]_0^8 \quad (= 28)$	B1	FT	Or $32 - \left[\; \frac{1}{4}(x-2)^4 \;\right]_2^4$
			$A\bar{x} = \int \frac{1}{2} x^2\,dy = \int_0^8 \frac{1}{2}\left(4 + 4y^{\frac{1}{3}} + y^{\frac{2}{3}}\right)dy$	M1	For $\int x^2\,dy$	Or $32 \times 2 - \int_2^4 xy\,dx$
			$= \left[\; 2y + \frac{3}{2} y^{\frac{4}{3}} + \frac{3}{10} y^{\frac{5}{3}} \;\right]_0^8 \quad (= 49.6)$	B2	FT for $2y + \frac{3}{2} y^{\frac{4}{3}} + \frac{3}{10} y^{\frac{5}{3}}$ Give B1 for one minor slip in integration, or if ½ omitted	Or $\frac{1}{5}(x-2)^5 + \frac{1}{2}(x-2)^4$ Or $\frac{1}{4}x(x-2)^4 - \frac{1}{20}(x-2)^5$ Or $\frac{1}{5}x^5 - \frac{3}{2}x^4 + 4x^3 - 4x^2$
			$\bar{x} = \frac{49.6}{28} = \frac{62}{35} = 1.77 \quad$ (3 sf)	A1	CAO	*Must be* $\bar{x}$
			$A\bar{y} = \int xy\,dy = \int_0^8 \left(2y + y^{\frac{4}{3}}\right)dy$	M1	For $\int xy\,dy$	Or $32 \times 4 - \int_2^4 (\frac{1}{2}) y^2\,dx$
			$= \left[\; y^2 + \frac{3}{7} y^{\frac{7}{3}} \;\right]_0^8 \quad (= \frac{832}{7})$	A1	FT for $y^2 + \frac{3}{7} y^{\frac{7}{3}}$	Or B2 for $\frac{1}{14}(x-2)^7$ Give B1 for one minor slip in integration, or if ½ omitted
			$\bar{y} = \frac{\frac{832}{7}}{28} = \frac{208}{49} = 4.24 \quad$ (3 sf)	A1	CAO	*Must be* $\bar{y}$
				[9]		
		OR	Region under curve has CM $(3.6,\ \frac{16}{7})$		B2B2	For integrals, as above
			$28\bar{x} + 4 \times 3.6 = 32 \times 2$		B1 (for 28) M1	
			$\bar{x} = 1.77$		A1	
			$28\bar{y} + 4 \times \frac{16}{7} = 32 \times 4$		M1	
			$\bar{y} = 4.24$		A1	

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RECOGNISING ACHIEVEMENT

GCE

Mathematics (MEI)

Advanced GCE **A2 7895-8**

Advanced Subsidiary GCE **AS 3895-8**

OCR Report to Centres

June 2013

4763 Mechanics 3

General Comments

The work on this question paper was generally of a very high standard, with most candidates demonstrating a sound understanding of the topics being examined. The questions on dimensional analysis and centre of mass of a solid of revolution were particularly well answered; but the questions on circular motion and simple harmonic motion did present difficulties for a significant number of candidates. Almost all candidates appeared to have sufficient time in which to complete the question paper.

Comments on Individual Questions

1) In part (a), many candidates were unable to solve this problem about a conical pendulum. The difficulty lay in the horizontal equation of motion, where the length of the string (3.2 m) was often taken to be the radius of the circle. Some candidates confused angular speed with speed. Almost all candidates resolved vertically, but those who had not found the tension were then also unable to calculate the angle.

   Part (b), on dimensional analysis, was answered extremely well, with candidates applying the techniques accurately and confidently. About half the candidates used the given equation for *u* to establish the dimensions of *k*, rather than the much simpler (force)/(length), so they did essentially the same work in parts (b) (i) and (b) (ii). Hardly any mistakes were made; there were just a few sign errors, in the calculation of the powers in part (b) (iii), and especially in the energy equation in part (b) (iv).

2) In part (i), the majority of candidates used conservation of energy to find an expression for v^2, and then used the radial equation of motion to obtain the given equation for *T*. The potential energy term was sometimes incorrect, and the weight was often omitted or wrongly resolved in the radial equation. A few attempts did not involve any consideration of energy, and some candidates tried to resolve vertically.

   In part (ii), the maximum and minimum tensions were usually found correctly, although some did use $\theta = \pi/2$ to find one of the extremes. It was fairly common for proof of motion in a complete circle to be based on positive kinetic energy at the highest point rather than positive tension.

   Again, in part (iii), many candidates assumed that the velocity would be zero at the highest point.

   In part (iv), most candidates realised that the string becomes slack when $T = 0$, and were able to use their previous results to find the speed of P at this point.

3) This was found to be the most difficult question, but even so, about one quarter of the candidates scored full marks on it.

   In part (i), almost every candidate used Hooke's law to find the natural length correctly.

   In part (ii), many candidates stated that the tension in AP is $mg + (\lambda/l)x$, which clearly yields the given result. Some did explain this satisfactorily, as (tension in equilibrium position) plus (stiffness) times (*extra* extension), but as the answer is given it is much more convincing to say (stiffness) times (total extension $0.45 + x$). The thrust in BP was usually given correctly, although some candidates added an *mg* term to this.

In part (iii), most candidates realised that they were expected to set up an equation of motion using the results from part (ii). The terms and signs usually appeared correctly, possibly helped by the displayed result.

In part (iv), the great majority of candidates recognised that this was simple harmonic motion, and gave the period correctly. The amplitude caused some difficulty, with many candidates appearing not to realise that 3.4 ms^{-1} is the maximum speed in the motion. Some candidates became confused between ω and the period, in this and the subsequent parts.

In part (v), those candidates who used $v = 3.4 \cos 5t$ were usually successful, although some then assumed that the positive direction was upwards. Those who found the displacement and then used $v^2 = \omega^2(A^2 - x^2)$ were very rarely able to determine the direction.

In part (vi), most candidates found the displacement when $t = 2.4$, but using this to obtain the actual distance travelled presented a considerable challenge.

4) In part (a) (i) the techniques for finding the centre of mass of a solid of revolution were very well understood, and usually applied accurately.

However, part (a) (ii) was often omitted or poorly attempted, even though it is a simple application of moments using the centre of mass found in the previous part.

In part (b), most candidates treated this as a lamina between a curve and the *y*-axis, using appropriate formulae and integrating with respect to *y*, and this was very often carried out correctly. A common error was expanding $(2 + y^{1/3})^2$ as $4 + 2y^{1/3} + y^{2/3}$, and the factor ½ was sometimes missing from the *x*-coordinate. Many candidates integrated with respect to *x* instead; some of these did not appear to realise that they had found the centre of mass of the wrong lamina, but others went on to apply the composite body formulae correctly.

For a description of how UMS marks are calculated see:
www.ocr.org.uk/learners/ums_results.html

Unit level raw mark and UMS grade boundaries June 2013 series

AS GCE / Advanced GCE / AS GCE Double Award / Advanced GCE Double Award

GCE Mathematics (MEI)

		Max Mark	a	b	c	d	e	u
4751/01 (C1) MEI Introduction to Advanced Mathematics	Raw	72	62	56	51	46	41	0
	UMS	100	80	70	60	50	40	0
4752/01 (C2) MEI Concepts for Advanced Mathematics	Raw	72	54	48	43	38	33	0
	UMS	100	80	70	60	50	40	0
4753/01 (C3) MEI Methods for Advanced Mathematics with Coursework: Written Paper	Raw	72	58	52	46	40	33	0
4753/02 (C3) MEI Methods for Advanced Mathematics with Coursework: Coursework	Raw	18	15	13	11	9	8	0
4753/82 (C3) MEI Methods for Advanced Mathematics with Coursework: Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
4753 (C3) MEI Methods for Advanced Mathematics with Coursework	UMS	100	80	70	60	50	40	0
4754/01 (C4) MEI Applications of Advanced Mathematics	Raw	90	66	59	53	47	41	0
	UMS	100	80	70	60	50	40	0
4755/01 (FP1) MEI Further Concepts for Advanced Mathematics	Raw	72	63	57	51	45	40	0
	UMS	100	80	70	60	50	40	0
4756/01 (FP2) MEI Further Methods for Advanced Mathematics	Raw	72	61	54	48	42	36	0
	UMS	100	80	70	60	50	40	0
4757/01 (FP3) MEI Further Applications of Advanced Mathematics	Raw	72	60	52	44	36	28	0
	UMS	100	80	70	60	50	40	0
4758/01 (DE) MEI Differential Equations with Coursework: Written Paper	Raw	72	62	56	51	46	40	0
4758/02 (DE) MEI Differential Equations with Coursework: Coursework	Raw	18	15	13	11	9	8	0
4758/82 (DE) MEI Differential Equations with Coursework: Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
4758 (DE) MEI Differential Equations with Coursework	UMS	100	80	70	60	50	40	0
4761/01 (M1) MEI Mechanics 1	Raw	72	57	49	41	33	25	0
	UMS	100	80	70	60	50	40	0
4762/01 (M2) MEI Mechanics 2	Raw	72	50	43	36	29	22	0
	UMS	100	80	70	60	50	40	0
4763/01 (M3) MEI Mechanics 3	Raw	72	64	56	48	41	34	0
	UMS	100	80	70	60	50	40	0
4764/01 (M4) MEI Mechanics 4	Raw	72	56	49	42	35	29	0
	UMS	100	80	70	60	50	40	0
4766/01 (S1) MEI Statistics 1	Raw	72	55	48	41	35	29	0
	UMS	100	80	70	60	50	40	0
4767/01 (S2) MEI Statistics 2	Raw	72	58	52	46	41	36	0
	UMS	100	80	70	60	50	40	0
4768/01 (S3) MEI Statistics 3	Raw	72	61	55	49	44	39	0
	UMS	100	80	70	60	50	40	0
4769/01 (S4) MEI Statistics 4	Raw	72	56	49	42	35	28	0
	UMS	100	80	70	60	50	40	0
4771/01 (D1) MEI Decision Mathematics 1	Raw	72	58	52	46	40	35	0
	UMS	100	80	70	60	50	40	0
4772/01 (D2) MEI Decision Mathematics 2	Raw	72	58	52	46	41	36	0
	UMS	100	80	70	60	50	40	0
4773/01 (DC) MEI Decision Mathematics Computation	Raw	72	46	40	34	29	24	0
	UMS	100	80	70	60	50	40	0
4776/01 (NM) MEI Numerical Methods with Coursework: Written Paper	Raw	72	56	50	44	38	31	0
4776/02 (NM) MEI Numerical Methods with Coursework: Coursework	Raw	18	14	12	10	8	7	0
4776/82 (NM) MEI Numerical Methods with Coursework: Carried Forward Coursework Mark	Raw	18	14	12	10	8	7	0
4776 (NM) MEI Numerical Methods with Coursework	UMS	100	80	70	60	50	40	0
4777/01 (NC) MEI Numerical Computation	Raw	72	55	47	39	32	25	0
	UMS	100	80	70	60	50	40	0
4798/01 (FPT) Further Pure Mathematics with Technology	Raw	72	57	49	41	33	26	0
	UMS	100	80	70	60	50	40	0

GCE Statistics (MEI)

		Max Mark	a	b	c	d	e	u
G241/01 (Z1) Statistics 1	Raw	72	55	48	41	35	29	0
	UMS	100	80	70	60	50	40	0
G242/01 (Z2) Statistics 2	Raw	72	55	48	41	34	27	0
	UMS	100	80	70	60	50	40	0
G243/01 (Z3) Statistics 3	Raw	72	56	48	41	34	27	0
	UMS	100	80	70	60	50	40	0