OCR
Oxford Cambridge and RSA

Wednesday 25 May 2016 – Morning

A2 GCE MATHEMATICS (MEI)

4763/01 Mechanics 3

QUESTION PAPER

6369660419

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

INSTRUCTIONS TO CANDIDATES

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

- The Question Paper will be found inside 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.

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)** In an investigation, small spheres are dropped into a long column of a viscous liquid and their terminal speeds measured. It is thought that the terminal speed V of a sphere depends on a product of powers of its radius r, its weight mg and the viscosity η of the liquid, and is given by

$$V = kr^{\alpha}(mg)^{\beta}\eta^{\gamma},$$

where k is a dimensionless constant.

(i) Given that the dimensions of viscosity are $\mathrm{ML^{-1}T^{-1}}$ find α, β and γ. **[6]**

A sphere of mass 0.03 grams and radius 0.2 cm has a terminal speed of $6\,\mathrm{m\,s^{-1}}$ when falling through a liquid with viscosity η. A second sphere of radius 0.25 cm falling through the same liquid has a terminal speed of $8\,\mathrm{m\,s^{-1}}$.

(ii) Find the mass of the second sphere. **[4]**

(b) A manufacturer is testing different types of light elastic ropes to be used in bungee jumping. You may assume that air resistance is negligible.

A bungee jumper of mass 80 kg is connected to a fixed point A by one of these elastic ropes. The natural length of this rope is 25 m and its modulus of elasticity is 1600 N. At one instant, the jumper is 30 m directly below A and he is moving vertically upwards at $15\,\mathrm{m\,s^{-1}}$. He comes to instantaneous rest at a point B, with the rope slack.

(i) Find the distance AB. **[5]**

The same bungee jumper now tests a second rope, also of natural length 25 m. He falls from rest at A. It is found that he first comes instantaneously to rest at a distance 54 m directly below A.

(ii) Find the modulus of elasticity of this second rope. **[4]**

2

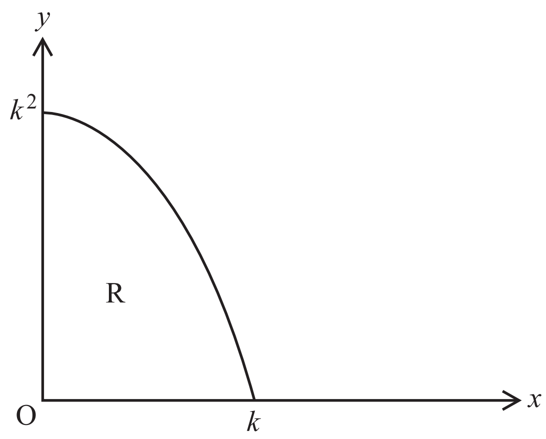

Fig. 2.1

The region R shown in Fig. 2.1 is bounded by the curve $y = k^2 - x^2$, for $0 \leqslant x \leqslant k$, and the coordinate axes. The x-coordinate of the centre of mass of a uniform lamina occupying the region R is 0.75.

(i) Show that $k = 2$. **[4]**

A uniform solid S is formed by rotating the region R through 2π radians about the x-axis.

(ii) Show that the centre of mass of S is at (0.625, 0). **[7]**

Fig. 2.2 shows a solid T made by attaching the solid S to the base of a uniform solid circular cone C. The cone C is made of the same material as S and has height 8 cm and base radius 4 cm.

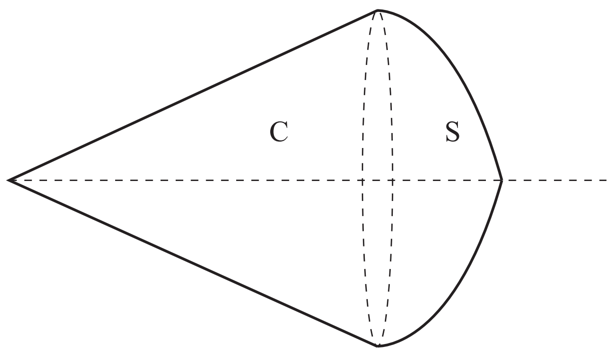

Fig. 2.2

(iii) Show that the centre of mass of T is at a distance of 6.75 cm from the vertex of the cone. [You may quote the standard results that the volume of a cone is $\frac{1}{3}\pi r^2 h$ and its centre of mass is $\frac{3}{4}h$ from its vertex.] **[4]**

(iv) The solid T is suspended from a point P on the circumference of the base of C. Find the acute angle between the axis of symmetry of T and the vertical. **[3]**

3

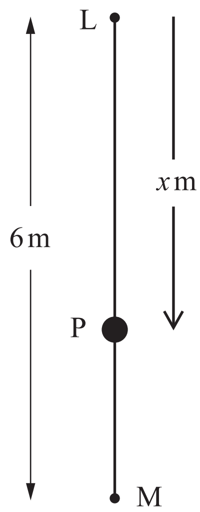

Fig. 3

One end of a light elastic string, of natural length 2.7 m and modulus of elasticity 54 N, is attached to a fixed point L. The other end of the string is attached to a particle P of mass 2.5 kg. One end of a second light elastic string, of natural length 1.7 m and modulus of elasticity 8.5 N, is attached to P. The other end of this second string is attached to a fixed point M, which is 6 m vertically below L. This situation is shown in Fig. 3.

The particle P is released from rest when it is 4.2 m below L. Both strings remain taut throughout the subsequent motion. At time t s after P is released from rest, its displacement below L is x m.

(i) Show that $\frac{d^2x}{dt^2} = -10(x-4)$. **[7]**

(ii) Write down the value of x when P is at the centre of its motion. **[1]**

(iii) Find the amplitude and the period of the oscillations. **[4]**

(iv) Find the velocity of P when $t = 1.2$. **[5]**

4 A particle P of mass m is attached to one end of a light inextensible string of length a. The other end of the string is attached to a fixed point O. Particle P is projected so that it moves in complete vertical circles with centre O; there is no air resistance. A and B are two points on the circle, situated on opposite sides of the vertical through O. The lines OA and OB make angles α and β with the upward vertical as shown in Fig. 4.

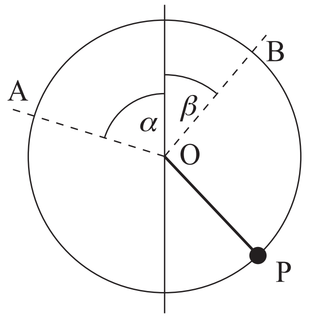

Fig. 4

The speed of P at A is $\sqrt{\frac{17ag}{3}}$. The speed of P at B is $\sqrt{5ag}$ and $\cos\beta = \frac{2}{3}$.

(i) Show that $\cos\alpha = \frac{1}{3}$. **[3]**

On one occasion, when P is at its lowest point and moving in a clockwise direction, it collides with a stationary particle Q. The two particles coalesce and the combined particle continues to move in the same vertical circle. When this combined particle reaches the point A, the string becomes slack.

(ii) Show that when the string becomes slack, the speed of the combined particle is $\sqrt{\frac{ag}{3}}$. **[2]**

The mass of the particle Q is km.

(iii) Find the value of k. **[9]**

(iv) Find, in terms of m and g, the instantaneous change in the tension in the string as a result of the collision. **[4]**

END OF QUESTION PAPER

BLANK PAGE

BLANK PAGE

OCR
Oxford Cambridge and RSA

Wednesday 25 May 2016 – Morning

A2 GCE MATHEMATICS (MEI)

4763/01 Mechanics 3

PRINTED ANSWER BOOK

Candidates answer on this Printed Answer Book.

OCR supplied materials:
- Question Paper 4763/01 (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 inside 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 (a) (i)

1 (a) (ii)

1 (b) (i)	

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

4 (ii)	
4 (iii)	
	(answer space continued on next page)

4 (iii)	**(continued)**

4 (iv)	

OCR
Oxford Cambridge and RSA

GCE

Mathematics (MEI)

Unit **4763**: Mechanics 3 (M3)

Advanced GCE

Mark Scheme for June 2016

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.

1. **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

2. 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 error made in the accuracy to which working is done or an answer given. Refer cases to your Team Leader where the same type of error (e.g. errors due to premature approximation leading to error) has been made in different questions or parts of questions.

There are some mistakes that might be repeated throughout a paper. If a candidate makes such a mistake, (eg uses a calculator in wrong angle mode) then you will need to check the candidate's script for repetitions of the mistake and consult your Team Leader about what penalty should be given.

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.

1	**(a)**	**(i)**	Units of weight are MLT^{-2}	B1		
			$LT^{-1} = L^{\alpha}\left(MLT^{-2}\right)^{\beta}\left(ML^{-1}T^{-1}\right)^{\gamma}$	M1		
			Compare powers for at least one dimension	M1		
			$0 = \beta + \gamma$ $1 = \alpha + \beta - \gamma$ $-1 = -2\beta - \gamma$	A1 A1	One equation correct Another equation correct	
			$\alpha = -1,\ \beta = 1,\ \gamma = -1$	A1 **[6]**	All correct	
		(ii)	**EITHER:** $V = \frac{kmg}{r\eta}$: $600 = \frac{0.03kg}{0.2\eta}$	M1	Put m = 0.(000)03, r = 0.(00)2, V = 6(00) into equation *Allow one error*	
			$\frac{kg}{\eta} = 4000$	A1	FT correct substitution *Condone m / cm mix*	
			Use V = 800 and r = 0.25	M1	Put r = 0.(00)25, V = 8(00) into equation *Allow one error*	
			Mass is 0.05 (grams) [0.000 05 kg]	A1 **[4]**	CAO *Correct answer implies full marks A0 for 0.05 kg*	
			OR: $0.03 \times \frac{800}{600}$	M1 A1	Use of $(8/6)^{1/\beta}$ or $(6/8)^{1/\beta}$ FT for $0.03 \times (8/6)^{1/\beta}$ or $0.03 \times (0.25/0.2)^{-\alpha/\beta}$	
			$\times \frac{0.25}{0.2}$	M1	Use of $(0.25/0.2)^{-\alpha/\beta}$ or $(0.2/0.25)^{-\alpha/\beta}$	
			Mass is 0.05	A1 **[4]**	CAO	
	(b)	**(i)**	Loss in KE + loss in EPE = Gain in GPE	M1	Equation involving KE, EPE and GPE	
			KE = $\frac{1}{2}.80.15^2 = 9000$ and GPE = $80gH$	B1		
			EPE = $\frac{1}{2} \times \frac{1600}{25} \times (30 - 25)^2 = 800$	B1		
			$9000 + 800 = 80gH$	A1		
			$AB = 30 - H = 17.5\ m$	A1 **[5]**		

		(ii)	Loss in GPE = $80g \times 54$ (= 42336) Gain in EPE = $\frac{1}{2} \times \frac{\lambda}{25} \times (54-25)^2$ (= 16.82λ) Modulus of elasticity is 2517 N (to 4 s.f.)	B1 B1 M1 A1 [4]	 Equate and solve to obtain a value of λ	
2	(i)		$A\bar{x} = \int_0^k x(k^2 - x^2)\,dx = \left[\frac{1}{2}k^2x^2 - \frac{1}{4}x^4\right]_0^k$ $= \frac{1}{4}k^4$ $A = \int_0^k (k^2 - x^2)\,dx = \left[k^2x - \frac{1}{3}x^3\right]_0^k = \frac{2}{3}k^3$ $\bar{x} = 0.375k$ and hence $k = 2$	M1 A1 B1 E1 [4]	For $\int_0^k x(k^2 - x^2)\,dx$ [or $\int_0^{k^2} \frac{1}{2}(k^2 - y)\,dy$] Correctly shown	
	(ii)		$V = \pi\int_0^2 (4 - x^2)^2\,dx =$ $= \pi\int_0^2 (16 - 8x^2 + x^4)dx = \pi\left[16x - \frac{8}{3}x^3 + \frac{1}{5}x^5\right]_0^2$ $= \frac{256}{15}\pi$ $\left[\text{ or } \frac{8k^5}{15}\pi\right]$ $V\bar{x} = \pi\int_0^2 x(16 - 8x^2 + x^4)dx = \pi\left[8x^2 - 2x^4 + \frac{1}{6}x^6\right]_0^2$ $= \frac{32}{3}\pi$ $\left[\text{ or } \frac{k^6}{6}\pi\right]$ $\bar{x} = 0.625$ $\bar{y} = 0$ by symmetry	 M1 A1 M1 M1 A1 E1 E1 [7]	 Integrate expression to obtain volume For $\int_0^k x(k^2 - x^2)^2\,dx$ Integrate Correctly shown *Accept 'com is on the axis'*	

Question			Answer	Marks	Guidance	
	(iii)		<table><tr><td></td><td>C</td><td>S</td><td>T</td></tr><tr><td>Volume</td><td>$\frac{128}{3}\pi$</td><td>$\frac{256}{15}\pi$</td><td>$\frac{896}{15}\pi$</td></tr><tr><td>Dist of com from vertex</td><td>6</td><td>$8+0.625=\frac{69}{8}$</td><td>$\bar{x}$</td></tr></table>	B1 B1	FT Volume of T is $\frac{1}{3}\pi\times4^2\times8+\frac{256}{15}\pi$ com of C and S relative to the same origin	
			$\frac{896}{15}\pi\bar{x}=\frac{128}{3}\pi\times6+\frac{256}{15}\pi\times\frac{69}{8}$	M1	Take moments	
			$\bar{x}=\frac{27}{4}=6.75$	E1 **[4]**	Correctly shown	
	(iv)		Identify required angle	B1		
			$\tan\theta=\frac{4}{8-6.75}$	M1	Correct trigonometry in the relevant triangle	
			$\theta=72.6^\circ$ (to 3 s.f.)	A1 **[3]**	*If working unclear, give B3 for 72.6 or B1 for 17.4*	
3	(i)		Tension in LP = $\frac{54}{2.7}(x-2.7)$ [= $20(x-2.7)$]	M1 A1	Use Hooke's law	
			Tension in MP = $\frac{8.5}{1.7}(6-x-1.7)$ [= $5(4.3-x)$]	A1		
				M1 A1	N2L with at least 3 terms For $mg+T_{MP}-T_{LP}=(\pm)ma$	
			$2.5\ddot{x}=5(4.3-x)+2.5g-20(x-2.7)$ $=100-25x$	A1	*Must have $\ddot{x}$ here or in final answer*	
			$\ddot{x}=40-10x=-10(x-4)$	E1 **[7]**	Correctly shown	
	(ii)		$x=4$	B1 **[1]**		
	(iii)			M1	Amplitude is 4.2 – answer to (ii)	
			Amplitude is $4.2-4=0.2$ m	A1	CAO	
			$\omega=\sqrt{10}$	B1		
			Period is $\frac{2\pi}{\omega}=1.99$ s (to 3.s.f.)	B1 **[4]**	CAO *Accept* $\frac{2\pi}{\sqrt{10}}$ *o.e.*	

	(iv)		**EITHER:** $x = 4 + 0.2\cos\omega t$ $v = -0.2\omega\sin\omega t$ When $t = 1.2$, $v = 0.3844...$, speed is 0.384 m s^{-1} Moving downwards (since $v > 0$)	B1 M1 M1 A1** A1 **[5]**	FT For $0.2\cos\sqrt{10}t$ Differentiate Substituting $t = 1.2$ CAO *Dep A1***	
			OR: $x = 4 + 0.2\cos\omega t$ [or $y = 0.2\cos\omega t$] When $t = 1.2$, $x = 3.84(12)$ Use $v^2 = \omega^2(a^2 - y^2)$: $v^2 = 10(0.2^2 - (4 - 3.84)^2)$ $v^2 = 0.148$ Speed is 0.384 m s^{-1} Moving downwards	B1 M1 M1 A1** A1 **[5]**	FT For $0.2\cos\sqrt{10}t$ Substituting $t = 1.2$ *M0 if 3.84 used for y in formula* CAO *Dep A1*** Must be justified, by e.g. 1/2 period < 1.2 < period	
4	**(i)**		$\frac{1}{2}m\left(\frac{17ag}{3} - 5ag\right) = mga(\cos\beta - \cos\alpha)$ $\cos\alpha = \frac{1}{3}$	M1 A1 E1 **[3]**	Energy equation A to B Correctly shown	
	(ii)		V is speed of combined particle after collision; u is speed when string goes slack; v is speed of P before collision , T is the tension in the string When string goes slack at A: Use $T = 0$ $Mg\cos\alpha = \frac{Mu^2}{a}$ and so $u = \sqrt{\frac{ag}{3}}$	M1 E1 **[2]**	*May be implied* Correctly shown (N2L at A) *Condone use of m or km for M (= (k + 1)m)*	

	(iii)		$\frac{1}{2}m\left(v^2-5ag\right)=mg\frac{5a}{3}$	M1*	Energy equation B (or A) to lowest point	
			$v^2=\frac{25ag}{3}$	A1		
				M1*	Energy equation: lowest point to when string goes slack at A	
			$\frac{1}{2}M\left(V^2-u^2\right)=Mg\frac{4a}{3}$	A1	*Condone use of m or km for M (= (k + 1)m)*	
			$V^2=\frac{8ag}{3}+\frac{ag}{3}=3ag$	A1	*The first 5 marks can be earned in (iv)* *SC B2 for* $V^2=3ag$ *seen (or clearly implied) after M0*	
			$(k+1)mV=mv$	M1* A1	PCLM at collision	
			$(k+1)\sqrt{3ag}=\sqrt{\frac{25ag}{3}}$	M1	*Dep M3** Substitute into momentum equation	
			$(k+1)^2=\frac{25}{9}$			
			$k=\frac{2}{3}$	A1	Must be positive	
				[9]		
	(iv)		$T_1-mg=\frac{mv^2}{a}$	M1	N2L at lowest point before collision	
			$T_1=\frac{28}{3}mg$	A1		
			$T_2-(k+1)mg=\frac{m(k+1)V^2}{a}$	M1	N2L at lowest point immediately after collision *Must use (k + 1)m in both terms*	
			$T_2=\frac{20}{3}mg$			
			Change in tension is $\frac{8}{3}mg$	A1	CAO	
				[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

Oxford Cambridge and RSA Examinations
is a Company Limited by Guarantee
Registered in England
Registered Office; 1 Hills Road, Cambridge, CB1 2EU
Registered Company Number: 3484466
OCR is an exempt Charity

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

PART OF THE CAMBRIDGE ASSESSMENT GROUP

4763 Mechanics 3

General Comments:

Most candidates were able to demonstrate a good working knowledge of the topics being examined. The first three questions (on dimensional analysis, elasticity, centres of mass and simple harmonic motion) were well answered; but the last two items on the paper, Q.4(iii) and Q.4(iv), were found to be considerably more challenging.

Comments on Individual Questions:

Q.1(a)(i) The method for finding powers in a formula was very well understood; although some candidates started with the wrong dimensions for velocity or weight. There were a few slips in solving the equations.

Q.1(a)(ii) Most candidates used the first set of values to obtain an expression for k, then used this with the new values of V and r to calculate the mass. This was very often carried out accurately; but careless errors such as forgetting to change one of the variables, or omitting g from the final equation, were fairly common. The answer was sometimes given as 0.05 kg instead of 0.05 grams. The more efficient approach, noting that m is proportional to Vr, was adopted by some candidates.

Q.1(b)(i) This application of the conservation of energy was well answered, although many candidates gave the distance travelled (12.5 m) instead of the required AB (17.5 m).

Q.1(b)(ii) This was also answered well, using conservation of energy. Just a few candidates assumed that the jumper was in equilibrium at the lowest point.

Q.2(i)-(ii) The use of integration to find centres of mass was well understood, and most candidates obtained the given results correctly.

Q.2(iii) Most candidates knew how to find the centre of mass of the composite body. A very common error was to take the distance of the centre of mass of S from the vertex to be 0.625 cm instead of 8.625 cm.

Q.2(iv) Most candidates realised that the centre of mass was vertically below the point of suspension, although very many found the complementary angle (17.4° instead of 72.6°).

Q.3(i) Candidates were expected to show explicit expressions for the tension in each string and to form the equation of motion. This was quite well done and the given result was very often obtained convincingly.

Q.3(ii)-(iii) These parts were usually answered correctly.

Q.3(iv) Most candidates formed a displacement-time equation. Many used x to represent a different quantity in this part (such as the displacement upwards from the centre of motion); this in itself was not penalised, although it is of course not a practice to be recommended. A fairly common error was to put ω equal to the period (even when $\omega = \sqrt{10}$ had been used correctly in the previous part). Those who differentiated their equation to obtain the velocity were usually able to find the speed and direction of motion correctly. Those who calculated the displacement first and then used $v^2 = \omega^2(A^2 - y^2)$ often failed to determine the direction of motion.

Q.4(i) Most candidates used the conservation of energy correctly in this part.

Q.4(ii) Most candidates formed a radial equation of motion, with zero tension in the string, and obtained the given result correctly.

Q.4(iii) There were three stages to consider: using conservation of energy to find the speed immediately before the collision; using the result from part (ii) and conservation of energy to find the speed immediately after the collision; using conservation of linear momentum in the collision. Unfortunately this was rarely seen. A very common strategy was to use conservation of energy from the single particle at A (or B) to the combined particle at A, in effect assuming that energy was conserved in the collision. Most candidates scored 2 marks or fewer (out of 9) in this part.

Q.4(iv) This was omitted altogether by about one fifth of the candidates, and most scored 2 marks or fewer (out of 4). The tension in the string immediately before the collision was quite often found correctly, but previous errors usually prevented a successful conclusion.

OCR
Oxford Cambridge and RSA

GCE Mathematics (MEI)

				Max Mark	a	b	c	d	e	u
4751	01	C1 – MEI Introduction to advanced mathematics (AS)	Raw	72	63	57	52	47	42	0
			UMS	100	80	70	60	50	40	0
4752	01	C2 – MEI Concepts for advanced mathematics (AS)	Raw	72	56	49	42	35	29	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	47	42	36	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
			UMS	100	80	70	60	50	40	0
4754	01	C4 – MEI Applications of advanced mathematics (A2)	Raw	90	64	57	51	45	39	0
			UMS	100	80	70	60	50	40	0
4755	01	FP1 – MEI Further concepts for advanced mathematics (AS)	Raw	72	59	53	48	43	38	0
			UMS	100	80	70	60	50	40	0
4756	01	FP2 – MEI Further methods for advanced mathematics (A2)	Raw	72	60	54	48	43	38	0
			UMS	100	80	70	60	50	40	0
4757	01	FP3 – MEI Further applications of advanced mathematics (A2)	Raw	72	60	54	49	44	39	0
			UMS	100	80	70	60	50	40	0
4758	01	(DE) MEI Differential Equations with Coursework: Written Paper	Raw	72	67	61	55	49	43	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
			UMS	100	80	70	60	50	40	0
4761	01	M1 – MEI Mechanics 1 (AS)	Raw	72	58	50	43	36	29	0
			UMS	100	80	70	60	50	40	0
4762	01	M2 – MEI Mechanics 2 (A2)	Raw	72	59	53	47	41	36	0
			UMS	100	80	70	60	50	40	0
4763	01	M3 – MEI Mechanics 3 (A2)	Raw	72	60	53	46	40	34	0
			UMS	100	80	70	60	50	40	0
4764	01	M4 – MEI Mechanics 4 (A2)	Raw	72	55	48	41	34	27	0
			UMS	100	80	70	60	50	40	0
4766	01	S1 – MEI Statistics 1 (AS)	Raw	72	59	52	46	40	34	0
			UMS	100	80	70	60	50	40	0
4767	01	S2 – MEI Statistics 2 (A2)	Raw	72	60	55	50	45	40	0
			UMS	100	80	70	60	50	40	0
4768	01	S3 – MEI Statistics 3 (A2)	Raw	72	60	54	48	42	37	0
			UMS	100	80	70	60	50	40	0
4769	01	S4 – MEI Statistics 4 (A2)	Raw	72	56	49	42	35	28	0
			UMS	100	80	70	60	50	40	0
4771	01	D1 – MEI Decision mathematics 1 (AS)	Raw	72	48	43	38	34	30	0
			UMS	100	80	70	60	50	40	0
4772	01	D2 – MEI Decision mathematics 2 (A2)	Raw	72	55	50	45	40	36	0
			UMS	100	80	70	60	50	40	0
4773	01	DC – MEI Decision mathematics computation (A2)	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	55	49	44	39	33	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
			UMS	100	80	70	60	50	40	0
4777	01	NC – MEI Numerical computation (A2)	Raw	72	55	47	39	32	25	0
			UMS	100	80	70	60	50	40	0
4798	01	FPT - Further pure mathematics with technology (A2)	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 Statistics 1 MEI (Z1)	Raw	72	59	52	46	40	34	0
		UMS	100	80	70	60	50	40	0
G242	01 Statistics 2 MEI (Z2)	Raw	72	55	48	41	34	27	0
		UMS	100	80	70	60	50	40	0
G243	01 Statistics 3 MEI (Z3)	Raw	72	56	48	41	34	27	0
		UMS	100	80	70	60	50	40	0

GCE Quantitative Methods (MEI)

			Max Mark	a	b	c	d	e	u
G244	01 Introduction to Quantitative Methods MEI	Raw	72	58	50	43	36	28	0
G244	02 Introduction to Quantitative Methods MEI	Raw	18	14	12	10	8	7	0
		UMS	100	80	70	60	50	40	0
G245	01 Statistics 1 MEI	Raw	72	59	52	46	40	34	0
		UMS	100	80	70	60	50	40	0
G246	01 Decision 1 MEI	Raw	72	48	43	38	34	30	0
		UMS	100	80	70	60	50	40	0

Level 3 Certificate and FSMQ raw mark grade boundaries June 2016 series

For more information about results and grade calculations, see www.ocr.org.uk/ocr-for/learners-and-parents/getting-your-results

Level 3 Certificate Mathematics for Engineering

			Max Mark	a*	a	b	c	d	e	u
H860	01 Mathematics for Engineering		This unit has no entries in June 2016							
H860	02 Mathematics for Engineering									

Level 3 Certificate Mathematical Techniques and Applications for Engineers

			Max Mark	a*	a	b	c	d	e	u
H865	01 Component 1	Raw	60	48	42	36	30	24	18	0

Level 3 Certificate Mathematics - Quantitative Reasoning (MEI) (GQ Reform)

			Max Mark	a	b	c	d	e	u
H866	01 Introduction to quantitative reasoning	Raw	72	55	47	39	31	23	0
H866	02 Critical maths	Raw	60	47	41	35	29	23	0
		Overall	132	111	96	81	66	51	0

Level 3 Certificate Mathematics - Quantitive Problem Solving (MEI) (GQ Reform)

			Max Mark	a	b	c	d	e	u
H867	01 Introduction to quantitative reasoning	Raw	72	55	47	39	31	23	0
H867	02 Statistical problem solving	Raw	60	40	34	28	23	18	0
		Overall	132	103	88	73	59	45	0

Advanced Free Standing Mathematics Qualification (FSMQ)

			Max Mark	a	b	c	d	e	u
6993	01 Additional Mathematics	Raw	100	59	51	44	37	30	0

Intermediate Free Standing Mathematics Qualification (FSMQ)

			Max Mark	a	b	c	d	e	u
6989	01 Foundations of Advanced Mathematics (MEI)	Raw	40	35	30	25	20	16	0

Version	Details of change
1.1	Correction to Overall grade boundaries for H866
	Correction to Overall grade boundaries for H867