

**Monday 28 January 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



**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  $g \text{ m s}^{-2}$ . 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 **16** pages. The Question Paper consists of **4** 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 is executing simple harmonic motion, and the centre of the oscillations is at the point O. The maximum speed of P during the motion is  $5.1 \text{ m s}^{-1}$ . When P is 6 m from O, its speed is  $4.5 \text{ m s}^{-1}$ . Find the period and the amplitude of the motion. [6]

- (b) The force  $F$  of gravitational attraction between two objects of masses  $m_1$  and  $m_2$  at a distance  $d$  apart is given by  $F = \frac{Gm_1m_2}{d^2}$ , where  $G$  is the universal gravitational constant.

- (i) Find the dimensions of  $G$ . [3]

Three objects, each of mass  $m$ , are moving in deep space under mutual gravitational attraction. They move round a single circle with constant angular speed  $\omega$ , and are always at the three vertices of an equilateral triangle of side  $R$ . You are given that  $\omega = kG^\alpha m^\beta R^\gamma$ , where  $k$  is a dimensionless constant.

- (ii) Find  $\alpha$ ,  $\beta$  and  $\gamma$ . [5]

For three objects of mass 2500 kg at the vertices of an equilateral triangle of side 50 m, the angular speed is  $2.0 \times 10^{-6} \text{ rad s}^{-1}$ .

- (iii) Find the angular speed for three objects of mass  $4.86 \times 10^{14} \text{ kg}$  at the vertices of an equilateral triangle of side 30 000 m. [4]

- 2 (a) A fixed solid sphere with a smooth surface has centre O and radius 0.8 m. A particle P is given a horizontal velocity of  $1.2 \text{ m s}^{-1}$  at the highest point on the sphere, and it moves on the surface of the sphere in part of a vertical circle of radius 0.8 m.

- (i) Find the radial and tangential components of the acceleration of P at the instant when OP makes an angle  $\frac{1}{6}\pi$  radians with the upward vertical. (You may assume that P is still in contact with the sphere.) [5]

- (ii) Find the speed of P at the instant when it leaves the surface of the sphere. [6]

- (b) Two fixed points R and S are 2.5 m apart with S vertically below R. A particle Q of mass 0.9 kg is connected to R and to S by two light inextensible strings; Q is moving in a horizontal circle at a constant speed of  $5 \text{ m s}^{-1}$  with both strings taut. The radius of the circle is 2.4 m and the centre C of the circle is 0.7 m vertically below S, as shown in Fig. 2.

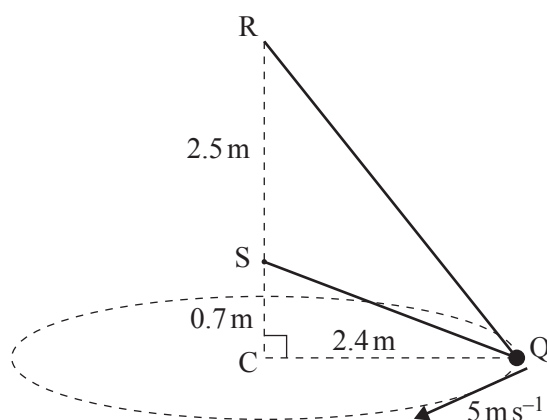


Fig. 2

- Find the tension in the string RQ and the tension in the string SQ. [7]

- 3 Two fixed points X and Y are 14.4 m apart and XY is horizontal. The midpoint of XY is M. A particle P is connected to X and to Y by two light elastic strings. Each string has natural length 6.4 m and modulus of elasticity 728 N. The particle P is in equilibrium when it is 3 m vertically below M, as shown in Fig. 3.

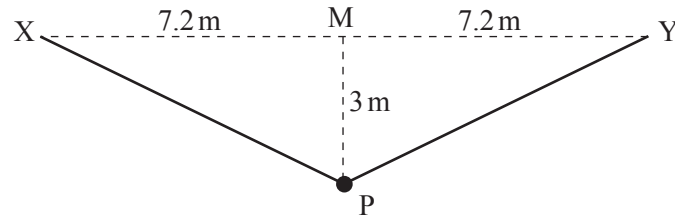


Fig. 3

- (i) Find the tension in each string when P is in the equilibrium position. [3]  
 (ii) Show that the mass of P is 12.5 kg. [3]

The particle P is released from rest at M, and moves in a vertical line.

- (iii) Find the acceleration of P when it is 2.1 m vertically below M. [5]  
 (iv) Explain why the maximum speed of P occurs at the equilibrium position. [1]  
 (v) Find the maximum speed of P. [6]

- 4 (a) The region enclosed between the curve  $y = x^4$  and the line  $y = h$  (where  $h$  is positive) is rotated about the  $y$ -axis to form a uniform solid of revolution. Find the  $y$ -coordinate of the centre of mass of this solid. [5]  
 (b) The region  $A$  is bounded by the  $x$ -axis, the curve  $y = x + \sqrt{x}$  for  $0 \leq x \leq 4$ , and the line  $x = 4$ . The region  $B$  is bounded by the  $y$ -axis, the curve  $y = x + \sqrt{x}$  for  $0 \leq x \leq 4$ , and the line  $y = 6$ . These regions are shown in Fig. 4.

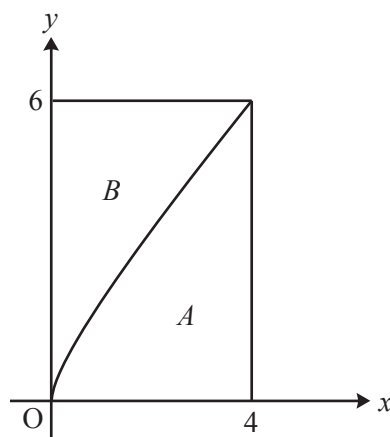


Fig. 4

- (i) A uniform lamina occupies the region  $A$ . Show that the  $x$ -coordinate of the centre of mass of this lamina is 2.56, and find the  $y$ -coordinate. [9]  
 (ii) Using your answer to part (i), or otherwise, find the coordinates of the centre of mass of a uniform lamina occupying the region  $B$ . [4]

**THERE ARE NO QUESTIONS PRINTED ON THIS PAGE.**



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**4763/01 Mechanics 3**

**PRINTED ANSWER BOOK**

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- MEI Examination Formulae and Tables (MF2)

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- Scientific or graphical calculator

**Duration:** 1 hour 30 minutes



Candidate forename		Candidate surname	
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Centre number						Candidate number				
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<b>1 (a)</b>	



<b>1 (b) (ii)</b>	





<b>2 (a) (i)</b>	

<b>2(a)(ii)</b>	

<b>2 (b)</b>	

**3 (i)**


**3 (ii)**


<b>3 (iii)</b>	
<b>3 (iv)</b>	



<b>4 (a)</b>	





<b>4 (b) (i) (continued)</b>	

<b>4(b)(ii)</b>	

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**Mathematics (MEI)**

Advanced GCE

Unit **4763**: Mechanics 3

**Mark Scheme for January 2013**

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

This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

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## 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. (eg 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 (eg 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.

Question			Answer	Marks	Guidance
1	(a)		$A\omega = 5.1$  $4.5^2 = \omega^2(A^2 - 6^2)$ $4.5^2 = 5.1^2 - 36\omega^2$ $\omega = 0.4$  Period ( $\frac{2\pi}{\omega}$ ) is $5\pi = 15.7$ s (3 sf) Amplitude ( $A$ ) is 12.75 m	B1 M1 A1 M1 A1 A1 <b>[6]</b>	Using $v^2 = \omega^2(A^2 - x^2)$  Eliminating $A$ or $\omega$  Allow $5\pi$
1	(b)	(i)	$[F] = \text{MLT}^{-2}$ $[G] = \left[ \frac{Fd^2}{m_1m_2} \right] = \frac{\text{MLT}^{-2}\text{L}^2}{\text{M}^2}$ $= \text{M}^{-1}\text{L}^3\text{T}^{-2}$	B1 M1 A1 <b>[3]</b>	Obtaining dimensions of $G$
1	(b)	(ii)	$\text{T}^{-1} = (\text{M}^{-1}\text{L}^3\text{T}^{-2})^\alpha \text{M}^\beta \text{L}^\gamma$ $\alpha = \frac{1}{2}$ $-\alpha + \beta = 0$ $\beta = \frac{1}{2}$ $3\alpha + \gamma = 0$ $\gamma = -\frac{3}{2}$	B1 M1 A1 M1 A1 <b>[5]</b>	Considering powers of $M$  Considering powers of $L$  <i>All marks FT from wrong <math>[G]</math> if comparable. No FT within part (ii).</i>

Question			Answer	Marks	Guidance
1	(b)	(iii)	$\omega = 2.0 \times 10^{-6} \times \left( \frac{4.86 \times 10^{14}}{2500} \right)^{\frac{1}{2}} \times \left( \frac{30000}{50} \right)^{-\frac{3}{2}}$	M1M1  A1	For $\left( \frac{4.86 \times 10^{14}}{2500} \right)^{\pm \frac{1}{2}}$ and $\left( \frac{30000}{50} \right)^{\pm \frac{3}{2}}$  Correct equation for $\omega$  <i>Requires <math>\beta \neq 0, \gamma \neq 0</math></i>  <i>FT if comparable</i>
		OR	$2.0 \times 10^{-6} = k \times G^{\frac{1}{2}} \times 2500^{\frac{1}{2}} \times 50^{-\frac{3}{2}}$ $kG^{\frac{1}{2}} = 1.414 \times 10^{-5}$ $\omega = 1.414 \times 10^{-5} \times (4.86 \times 10^{14})^{\frac{1}{2}} \times 30000^{-\frac{3}{2}}$		M1 <i>Requires <math>\beta \neq 0</math> or <math>\gamma \neq 0</math></i> M1 <i>Requires <math>\beta \neq 0</math> and <math>\gamma \neq 0</math></i> A1 Correct equation for $\omega$  Condone the use of any value for $G$ (including $G=1$ )  <i>FT if comparable</i>
			Angular speed is $6.0 \times 10^{-5} \text{ rad s}^{-1}$	A1 [4]	CAO
2	(a)	(i)	$\frac{1}{2}mv^2 - \frac{1}{2}m(1.2)^2 = mg(0.8 - 0.8 \cos \frac{1}{6}\pi)$ $v^2 = 3.5407$ Radial component $\left( \frac{v^2}{0.8} \right)$ is $4.43 \text{ ms}^{-2}$ (3 sf)  $(\pm)mg \sin \frac{1}{6}\pi = ma_T$  Tangential component is $4.9 \text{ ms}^{-2}$	M1 A1  A1  M1  A1 [5]	Equation involving initial KE, final KE and attempt at PE    Allow M1 for $\cos \frac{1}{6}\pi$ used instead of $\sin \frac{1}{6}\pi$ ; but M0 for $a_T = mg \sin \frac{1}{6}\pi$  Allow $\frac{1}{2}g$

Question		Answer	Marks	Guidance
2	(a) (ii)	$\frac{1}{2}mv^2 - \frac{1}{2}m(1.2)^2 = mg(0.8 - 0.8\cos\theta)$ $mg\cos\theta - R = \frac{mv^2}{0.8}$ Leaves surface when $R = 0$ $v^2 - 1.44 = 2 \times 9.8 \times 0.8 \left(1 - \frac{v^2}{7.84}\right)$ Speed is $2.39 \text{ ms}^{-1}$	M1 M1 A1 M1 M1 A1 <b>[6]</b>	$\theta$ between OP and upward vertical Allow $mgh$ for PE if $h$ is linked to $\theta$ in later work  e.g. Implied by $mg\cos\theta = \frac{mv^2}{0.8}$ $\cos\theta = \frac{107}{147} = 0.728$ $\theta = 0.756 \text{ rad}$ or $43.3^\circ$
2	(b)	$T_R \sin\alpha + T_S \sin\beta = mg$ $0.8T_R + 0.28T_S = 0.9 \times 9.8 \quad (= 8.82)$ $T_R \cos\alpha + T_S \cos\beta = m \frac{v^2}{r}$ $0.6T_R + 0.96T_S = 0.9 \times \frac{5^2}{2.4} \quad (= 9.375)$ Tension in string RQ is $9.737 \text{ N}$ Tension in string SQ is $3.68 \text{ N}$	M1 A1 M1 A1 M1 A1 A1 <b>[7]</b>	$\alpha = \hat{RQC} = 53.1^\circ$ , $\beta = \hat{SQC} = 16.3^\circ$  Three terms, and $v^2 / r$  <i>Dependent on previous MIMI</i>

Question		Answer	Marks	Guidance	
3	(i)	Length of each string is 7.8 m $T = \frac{728}{6.4}(7.8 - 6.4)$ Tension is 159.25 N	B1 M1 A1 [3]	Using Hooke's law	Must use extension
3	(ii)	$2T \cos \theta = mg$ $2 \times 159.25 \times \frac{5}{13} = m \times 9.8$ $m = \frac{122.5}{9.8} = 12.5 \text{ kg}$	M1 A1 E1 [3]	Resolving vertically FT <i>Working must lead to 12.5 to 3 sf</i>	$\theta = \widehat{XPM} = 67.4^\circ$
3	(iii)	New length of each string is 7.5 m $T = \frac{728}{6.4}(7.5 - 6.4) (= 125.125)$ $mg - 2T \cos \theta = ma$ $12.5 \times 9.8 - 2 \times 125.125 \times 0.28 = 12.5a$ Acceleration is $4.19 \text{ ms}^{-2}$ downwards (3 sf)	M1 A1 M1 A1 A1 [5]	Hooke's law with new extension Vertical equation of motion (3 terms) FT for incorrect $T$ <i>Some indication of downwards required</i>	
3	(iv)	At maximum speed, acceleration is zero Acceleration is zero in equilibrium position	B1 [1]	Mention of zero acceleration	<i>Reference to <math>v^2 = \omega^2(A^2 - x^2)</math>, SHM, etc, will usually be B0</i>

Question	Answer	Marks	Guidance
3 (v)	Change of PE is $12.5 \times 9.8 \times 3$ (= 367.5) Initial EE is $2 \times \frac{728 \times 0.8^2}{2 \times 6.4}$ (= 72.8) Final EE is $2 \times \frac{728 \times 1.4^2}{2 \times 6.4}$ (= 222.95) $\frac{1}{2}(12.5)v^2 - 367.5 + 222.95 = 72.8$ Maximum speed is $5.90 \text{ ms}^{-1}$ (3 sf)	B1 B1 B1 M1 A1 A1 [6]	Allow one string (36.4) Allow one string (111.475) Equation involving KE, PE and EE FT from any B0 above All signs must be correct CAO  <i>All terms must be non-zero</i>
4 (a)	$V = \int_0^h \pi(y^{\frac{1}{4}})^2 dy$ $= \pi \left[ \frac{2}{3} y^{\frac{3}{2}} \right]_0^h \quad \left( = \frac{2}{3} \pi h^{\frac{3}{2}} \right)$ $V \bar{y} = \int \pi x^2 y dy = \int_0^h \pi y^{\frac{1}{2}} y dy$ $= \pi \left[ \frac{2}{5} y^{\frac{5}{2}} \right]_0^h \quad \left( = \frac{2}{5} \pi h^{\frac{5}{2}} \right)$ $\bar{y} = \frac{\frac{2}{5} \pi h^{\frac{5}{2}}}{\frac{2}{3} \pi h^{\frac{3}{2}}} = \frac{3}{5} h$	M1 A1 M1 A1 A1 [5]	For $\int \dots (y^{\frac{1}{4}})^2 dy$ For $\frac{2}{3} y^{\frac{3}{2}}$ For $\int x^2 y dy$ For $\frac{2}{5} y^{\frac{5}{2}}$

4	Question	Answer	Marks	Guidance
	(b) (i)	$A = \int_0^4 (x + \sqrt{x}) dx$ $= \left[ \frac{1}{2}x^2 + \frac{2}{3}x^{\frac{3}{2}} \right]_0^4 \quad (= \frac{40}{3})$ $A\bar{x} = \int xy dx = \int_0^4 x(x + \sqrt{x}) dx$ $= \left[ \frac{1}{3}x^3 + \frac{2}{5}x^{\frac{5}{2}} \right]_0^4 \quad (= \frac{512}{15})$ $\bar{x} = \frac{\frac{512}{15}}{\frac{40}{3}} = \frac{64}{25} = 2.56$ $A\bar{y} = \int \frac{1}{2}y^2 dx = \int_0^4 \frac{1}{2}(x + \sqrt{x})^2 dx$ $= \left[ \frac{1}{6}x^3 + \frac{2}{5}x^{\frac{5}{2}} + \frac{1}{4}x^2 \right]_0^4 \quad (= \frac{412}{15})$ $\bar{y} = \frac{\frac{412}{15}}{\frac{40}{3}} = \frac{103}{50} = 2.06$	<p>M1</p> <p>A1</p> <p>M1</p> <p>A1</p> <p>E1</p> <p>M1</p> <p>A1A1</p> <p>A1</p> <p>[9]</p>	<p>For <math>\int (x + \sqrt{x}) dx</math></p> <p>For <math>\frac{1}{2}x^2 + \frac{2}{3}x^{\frac{3}{2}}</math></p> <p>For <math>\int xy dx</math></p> <p>For <math>\frac{1}{3}x^3 + \frac{2}{5}x^{\frac{5}{2}}</math></p> <p>For <math>\int \dots y^2 dx</math></p> <p>For <math>\frac{1}{6}x^3 + \frac{2}{5}x^{\frac{5}{2}} + \frac{1}{4}x^2</math></p> <p>Give A1 for two correct terms</p>



Question			Answer	Marks	Guidance
4	(b)	(ii)	$\text{Area of } B \text{ is } 24 - \frac{40}{3} = \frac{32}{3}$ $\frac{32}{3} \begin{pmatrix} \bar{x} \\ \bar{y} \end{pmatrix} + \frac{40}{3} \begin{pmatrix} 2.56 \\ 2.06 \end{pmatrix} = 24 \begin{pmatrix} 2 \\ 3 \end{pmatrix}$ $\begin{pmatrix} \bar{x} \\ \bar{y} \end{pmatrix} = \begin{pmatrix} 1.3 \\ 4.175 \end{pmatrix}$	M1 M1 A1 A1	CM of composite body Correct strategy CAO FT requires $0 < \bar{y} < 6$  (One coordinate sufficient)  <i>FT is <math>6.75 - 1.25\bar{y}_A</math></i> <i>No FT from wrong area</i>
		OR	$\int \frac{1}{4}(\sqrt{1+4y}-1)^2 y \, dy \text{ or } \int x(6-x-\sqrt{x}) \, dx$ $\text{or } \int \frac{1}{32}(\sqrt{1+4y}-1)^4 \, dy$ $\text{or } \int \frac{1}{2}(6-x-\sqrt{x})(6+x+\sqrt{x}) \, dx$ $\bar{x} = 1.3, \quad \bar{y} = 4.175$	M1 For any one of these  M1 For one successful integration A1A1	
				[4]	

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**January 2013**

## 4763 Mechanics 3

### General Comments

Candidates generally presented their answers well and demonstrated a very sound understanding of most of the topics being examined. The notable exception was Q.3 on elastic strings, where the motion was often wrongly assumed to be simple harmonic. Candidates did not appear to have any difficulty completing the paper in the time allowed.

### Comments on Individual Questions

- 1 The simple harmonic motion problem in part (a) was well understood and was usually answered correctly. Having found the parameters of the motion, some candidates omitted the calculation of the period.

In part (b)(i) the dimensions of  $G$  were almost always found correctly. The method for finding the powers in part (b)(ii) was also very well understood, although a significant number started with the wrong dimensions for angular speed, usually  $LT^{-1}$ . Most candidates then used their formula correctly in part (b)(iii) to find the new angular speed.

- 2 In part (a)(i) the tangential acceleration was usually found correctly, although there was some sine/cosine confusion. Many attempts at the radial acceleration started with an equation of motion, but most recovered from this and then considered energy.

In part (a)(ii) most candidates produced a radial equation of motion with zero normal reaction, together with an energy equation. However, there were some difficulties with the potential energy terms and the subsequent manipulation to find the speed.

In part (b) almost all candidates obtained two equations from the vertical equilibrium and radial acceleration. There were some careless slips in the trigonometry, such as taking  $RC$  to be 2.5 m instead of 3.2 m, and several made algebraic errors when solving the simultaneous equations.

- 3 This was found to be by far the most difficult question, with entirely inappropriate methods often being selected for parts (iii) and (v).

Parts (i) and (ii) on the equilibrium position were usually answered correctly.

In part (iii) it was necessary to apply Newton's second law in the vertical direction. Many of those who did this were successful, although some did not give the direction of the acceleration. Many used energy to find the speed of  $P$ , but this is not the first step in any valid method for finding its acceleration. Some tried to use formulae which only apply to simple harmonic motion.

In part (iv) about half the candidates gave a satisfactory explanation, usually by stating that the acceleration is zero in the equilibrium position. There were also very many references to simple harmonic motion here.

In part (v) the expected approach was to use energy; when doing this, common errors were omission of the initial elastic energy and using the elastic energy in just one string instead of the two. However, very many attempts did not consider energy at all, usually treating the motion as if it were simple harmonic.

- 4 In part (a) the method for finding the centre of mass of a solid of revolution was well understood and usually carried out accurately.

In part (b)(i) the given  $x$ -coordinate of the centre of mass of the lamina was almost always found legitimately. The  $y$ -coordinate was also usually found correctly, although some omitted the factor  $\frac{1}{2}$  and some made errors in the expansion and integration of  $(x + \sqrt{x})^2$ .

In part (b)(ii) the centre of mass of a composite body was well understood, and this part was usually answered correctly.

- (iC)** Most candidates realised that the new mean,  $\lambda = 10.5$ , was to be used. Many correct answers were seen through a variety of incorrect methods for finding  $P(5 \leq X \leq 10)$  followed; of which “ $P(X \leq 10) - P(X \leq 5)$ ” and “ $P(X \geq 5) - P(X \leq 10)$ ” were typical.
- (ii)** Many candidates obtained full marks here though some failed to apply the required continuity correction. A few candidates lost the final accuracy mark through premature rounding of their z-value prior to using Normal tables.
- (iii)** Most candidates provided a suitable comment here, with remarks about “independence” being the most popular.
- (iv)** This proved to be one of the most challenging parts of the paper. Despite answering part (iii) correctly many candidates reverted back to the inappropriate model by combining the means rather than considering the different combinations of “pairs” and “singles”. Of those attempting to consider combinations of pairs and singles only a small proportion obtained a fully correct solution; a variety of approaches was seen and those working systematically were the most successful.
- 3(iA)** Well answered, though inappropriate “continuity corrections” were seen on occasion.
- (iB)** Well answered, though arithmetic errors were quite common. In several cases,  $-1.667$  was used rather than  $-1.1667$  often as a result of candidates misreading their own figures. A few candidates lost accuracy by prematurely rounding their z-value before using the Normal tables.
- (ii)** Very well answered. Most candidates scored both marks.
- (iii)** On the whole, this was well answered. Many candidates provided clear, accurate methods leading to correct final answers. Some candidates started out with one of the required equations containing a sign error which was not picked up, even when the error led to a negative value for  $\sigma$ . Most candidates identified the correct z-values. In the poorest answers, continuity corrections were attempted and z-values were changed to absurd values, such as “ $1 - 0.8416$ ”, before substitution into equations. Over-specification of final answers was seen, on occasion, here.
- (iv)** Though one of the more challenging parts, many candidates scored full marks here. A variety of correct, “non-symmetrical” solutions were seen though most opted to use z-values of  $\pm 1.96$ .
- 4(a)** This question was well answered. Many candidates scored full marks. Marks lost typically for over-assertive conclusions, typically containing words such as “not enough evidence to prove that...”. The small number of candidates referring to correlation in their hypotheses often lost the first and last marks. Most candidates managed to accurately calculate the test statistic though some did not show all working as required. Most candidates stated the correct number of degrees of freedom and identified the correct critical value, though some thought that this was a 2-tailed test.
- (b)** Well answered. Most candidates accurately calculated the sample mean and provided hypotheses in terms of  $\mu$ . Note that candidates should be discouraged from referring to the “sample population mean” when defining  $\mu$ . In carrying out the test, the test statistic method proved the most popular; those who “reversed their numerator” needed to be very careful how they used their test statistic. Many appropriate, non-assertive conclusions were seen though some failed to include context in the final comments.