Write your name here

Surname	Other names

Pearson Edexcel International Advanced Level

Centre Number | Candidate Number

Mechanics M3

Advanced/Advanced Subsidiary

Wednesday 13 May 2015 – Morning
Time: 1 hour 30 minutes

Paper Reference
WME03/01

You must have:
Mathematical Formulae and Statistical Tables (Blue)

Total Marks

Candidates may use any calculator allowed by the regulations of the Joint Council for Qualifications. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B). Coloured pencils and highlighter pens must not be used.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided – *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Whenever a numerical value of g is required, take $g = 9.8$ m s^{-2}, and give your answer to either two significant figures or three significant figures.
- When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information

- The total mark for this paper is 75.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

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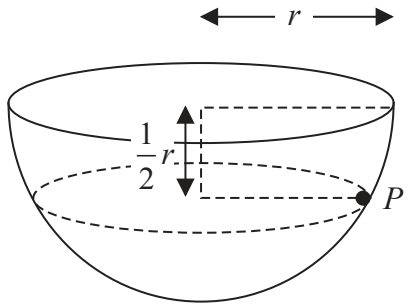

Figure 1

A hemispherical bowl, of internal radius r, is fixed with its circular rim upwards and horizontal. A particle P of mass m moves on the smooth inner surface of the bowl. The particle moves with constant angular speed in a horizontal circle. The centre of the circle is at a distance $\frac{1}{2}r$ vertically below the centre of the bowl, as shown in Figure 1.

The time taken by P to complete one revolution of its circular path is T.

Show that $T = \pi\sqrt{\frac{2r}{g}}$.

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Question 1 continued

Q1

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2. A spacecraft S of mass m moves in a straight line towards the centre of the Earth. The Earth is modelled as a sphere of radius R and S is modelled as a particle. When S is at a distance x, $x \geqslant R$, from the centre of the Earth, the force exerted by the Earth on S is directed towards the centre of the Earth. The force has magnitude $\frac{K}{x^2}$, where K is a constant.

(a) Show that $K = mgR^2$

(2)

When S is at a distance $3R$ from the centre of the Earth, the speed of S is V. Assuming that air resistance can be ignored,

(b) find, in terms of g, R and V, the speed of S as it hits the surface of the Earth.

(7)

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Question 2 continued

Q2

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3. At time $t = 0$, a particle P is at the origin O, moving with speed 8 m s^{-1} in the positive x direction. At time t seconds, $t \geqslant 0$, the acceleration of P has magnitude $2(t + 4)^{-\frac{1}{2}} \text{ m s}^{-2}$ and is directed towards O.

(a) Show that, at time t seconds, the velocity of P is $16 - 4(t + 4)^{\frac{1}{2}} \text{ m s}^{-1}$

(5)

(b) Find the distance of P from O when P comes to instantaneous rest.

(7)

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Question 3 continued

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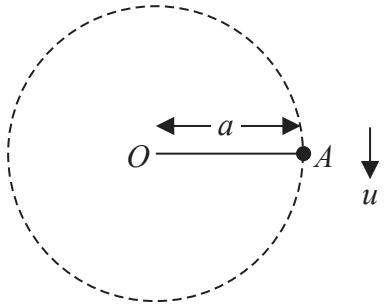

Figure 2

A particle of mass $3m$ 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. The particle is held at the point A, where OA is horizontal and $OA = a$. The particle is projected vertically downwards from A with speed u, as shown in Figure 2. The particle moves in complete vertical circles.

(a) Show that $u^2 \geqslant 3ag$.

(7)

Given that the greatest tension in the string is three times the least tension in the string,

(b) show that $u^2 = 6ag$.

(5)

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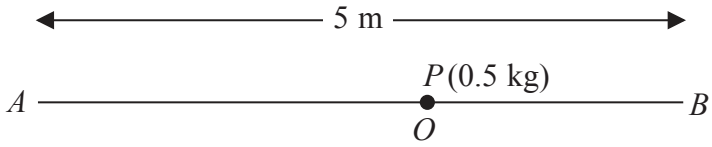

Figure 3

Two fixed points A and B are 5 m apart on a smooth horizontal floor. A particle P of mass 0.5 kg is attached to one end of a light elastic string, of natural length 2 m and modulus of elasticity 20 N. The other end of the string is attached to A. A second light elastic string, of natural length 1.2 m and modulus of elasticity 15 N, has one end attached to P and the other end attached to B.

Initially P rests in equilibrium at the point O, as shown in Figure 3.

(a) Show that $AO = 3$ m.

(4)

The particle is now pulled towards A and released from rest at the point C, where ACB is a straight line and $OC = 1$ m.

(b) Show that, while both strings are taut, P moves with simple harmonic motion.

(4)

(c) Find the speed of P at the instant when the string PB becomes slack.

(4)

The particle first comes to instantaneous rest at the point D.

(d) Find the distance DB.

(5)

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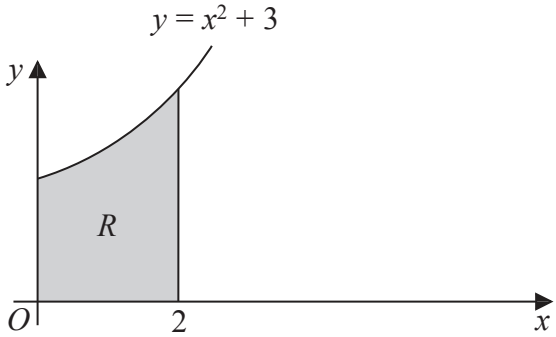

Figure 4

The shaded region R is bounded by part of the curve with equation $y = x^2 + 3$, the x-axis, the y-axis and the line with equation $x = 2$, as shown in Figure 4. The unit of length on each axis is one centimetre. The region R is rotated through 2π radians about the x-axis to form a uniform solid S.
Using algebraic integration,

(a) show that the volume of S is $\frac{202}{5}\pi\,\text{cm}^3$,

(4)

(b) show that, to 2 decimal places, the centre of mass of S is 1.30 cm from O.

(5)

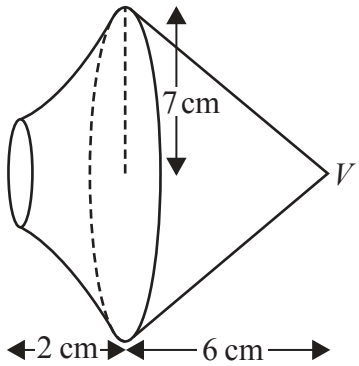

Figure 5

A uniform right circular solid cone, of base radius 7 cm and height 6 cm, is joined to S to form a solid T. The base of the cone coincides with the larger plane face of S, as shown in Figure 5. The vertex of the cone is V.
The mass per unit volume of S is twice the mass per unit volume of the cone.

(c) Find the distance from V to the centre of mass of T.

(5)

The point A lies on the circumference of the base of the cone. The solid T is suspended from A and hangs freely in equilibrium.

(d) Find the size of the angle between VA and the vertical.

(3)

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Q6

(Total 17 marks)

TOTAL FOR PAPER: 75 MARKS

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