Write your name here

Surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | Candidate Number

Mechanics M3

Advanced/Advanced Subsidiary

Wednesday 11 January 2017 – Afternoon
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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1.

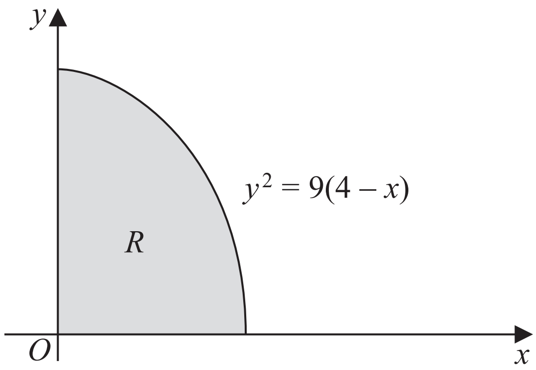

Figure 1

The shaded region R is bounded by the curve with equation $y^2 = 9(4 - x)$, the positive x-axis and the positive y-axis, as shown in Figure 1. A uniform solid S is formed by rotating R through 360° about the x-axis.

Use algebraic integration to find the x coordinate of the centre of mass of S.

(7)

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Question 1 continued

Q1

(Total 7 marks)

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2. A particle P of mass 0.6 kg is moving along the positive x-axis in the positive direction. The only force acting on P acts in the direction of x increasing and has magnitude $\left(3t + \frac{1}{2}\right)$ N, where t seconds is the time after P leaves the origin O.

When $t = 0$, P is at rest at O.

(a) Find an expression, in terms of t, for the velocity of P at time t seconds.

(2)

The particle passes through the point A with speed $\frac{10}{3}$ m s^{-1}.

(b) Find the distance OA.

(5)

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Question 2 continued

Q2

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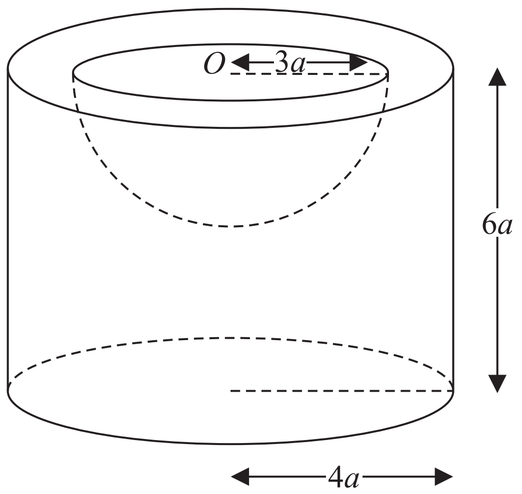

Figure 2

A uniform right circular solid cylinder has radius $4a$ and height $6a$. A solid hemisphere of radius $3a$ is removed from the cylinder forming a solid S. The upper plane face of the cylinder coincides with the plane face of the hemisphere. The centre of the upper plane face of the cylinder is O and this is also the centre of the plane face of the hemisphere, as shown in Figure 2. Find the distance from O to the centre of mass of S.

(6)

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Question 3 continued

Q3

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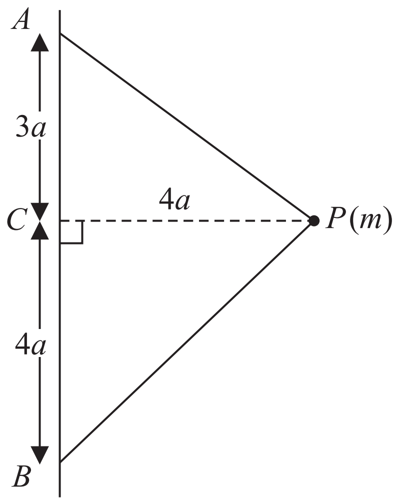

Figure 3

A light inextensible string has its ends attached to two fixed points A and B. The point A is vertically above B and $AB = 7a$. A particle P of mass m is fixed to the string and moves with constant angular speed ω in a horizontal circle of radius $4a$. The centre of the circle is C, where C lies on AB and $AC = 3a$, as shown in Figure 3. Both parts of the string are taut.

(a) Show that the tension in AP is $\frac{5}{7}m(4a\omega^2 + g)$.
(8)

(b) Find the tension in BP.
(2)

(c) Deduce that $\omega \geqslant \sqrt{\frac{g}{ka}}$, stating the value of k.
(2)

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Question 4 continued

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Question 4 continued

Question 4 continued

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Q4

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5. A particle P of mass $4m$ is attached to one end of a light elastic string of natural length l and modulus of elasticity $3mg$. The other end of the string is attached to a fixed point O on a rough horizontal table. The particle lies at rest at the point A on the table, where $OA = \frac{4}{3}l$. The coefficient of friction between P and the table is μ.

(a) Show that $\mu \geqslant \frac{1}{4}$

(4)

The particle is now moved along the table to the point B, where $OB = 2l$, and released from rest. Given that $\mu = \frac{2}{5}$

(b) show that P comes to rest before the string becomes slack.

(5)

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Question 5 continued

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Question 5 continued

Q5

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6. One end of a light elastic string, of natural length $5l$ and modulus of elasticity $20mg$, is attached to a fixed point A. A particle P of mass $2m$ is attached to the free end of the string and P hangs freely in equilibrium at the point B.

(a) Find the distance AB.

(3)

The particle is now pulled vertically downwards from B to the point C and released from rest. In the subsequent motion the string does not become slack.

(b) Show that P moves with simple harmonic motion with centre B.

(5)

(c) Find the period of this motion.

(2)

The greatest speed of P during this motion is $\frac{1}{5}\sqrt{gl}$

(d) Find the amplitude of this motion.

(3)

The point D is the midpoint of BC and the point E is the highest point reached by P.

(e) Find the time taken by P to move directly from D to E.

(4)

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Question 6 continued

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Question 6 continued

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Question 6 continued

Q6

(Total 17 marks)

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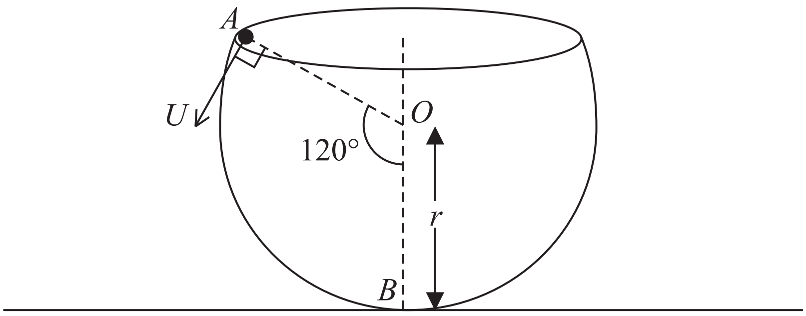

Figure 4

A hollow sphere has internal radius r and centre O. A bowl with a plane circular rim is formed by removing part of the sphere. The bowl is fixed to a horizontal floor with the rim uppermost and horizontal. The point B is the lowest point of the inner surface of the bowl. The point A, where angle $AOB = 120°$, lies on the rim of the bowl, as shown in Figure 4. A particle P of mass m is projected from A, with speed U at 90° to OA, and moves on the smooth inner surface of the bowl. The motion of P takes place in the vertical plane OAB.

(a) Find, in terms of m, g, U and r, the magnitude of the force exerted on P by the bowl at the instant when P passes through B.

(8)

(b) Find, in terms of g, U and r, the greatest height above the floor reached by P.

(4)

Given that $U > \sqrt{2gr}$

(c) show that, after leaving the surface of the bowl, P does not fall back into the bowl.

(5)

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Question 7 continued

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Question 7 continued

Q7

(Total 17 marks)

TOTAL FOR PAPER: 75 MARKS

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