Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel GCE

Centre Number	Candidate Number

Wednesday 15 May 2019

Morning (Time: 1 hour 30 minutes) | Paper Reference **6679/01**

Mechanics M3

Advanced/Advanced Subsidiary

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

Total Marks

Candidates may use any calculator permitted by Pearson regulations. 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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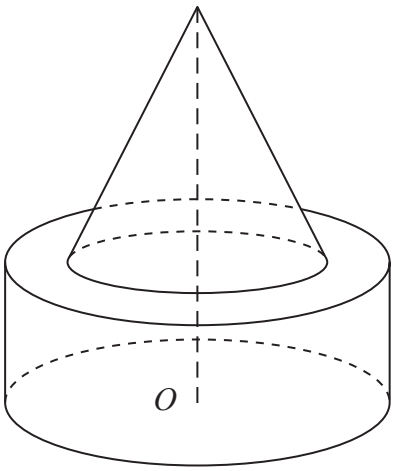

Figure 1

Figure 1 shows a traffic cone which is made by joining a uniform right circular conical shell to a uniform right circular solid cylinder. The centre of the base of the conical shell coincides with the centre of the upper plane face of the cylinder. The centre of the lower plane face of the cylinder is O. The vertex of the conical shell is vertically above O and the axis of symmetry of the traffic cone is vertical. The cylinder has mass M and height h. The conical shell has mass $\frac{2}{5}M$.

Given that the centre of mass of the traffic cone is at a distance $\frac{3}{4}h$ above O, find, in terms of h, the height of the conical shell.

(4)

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Question 1 continued

Q1

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2. A particle P of mass m is fired vertically upwards from a point on the surface of the Earth. Initially P moves in a straight line directly away from the centre of the Earth. When P is at a distance x from the centre of the Earth, the gravitational force exerted by the Earth on P is directed towards the centre of the Earth and has magnitude $\frac{k}{x^2}$, where k is a constant.

At the surface of the Earth the acceleration due to gravity is g. The Earth is modelled as a fixed sphere of radius R.

(a) Show that $k = mgR^2$.

(2)

When P is at a height $\frac{R}{3}$ above the surface of the Earth, P is moving away from the Earth with speed $\sqrt{\frac{2gR}{5}}$. Given that air resistance can be ignored,

(b) find, in terms of R, the greatest height of P above the surface of the Earth.

(7)

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Question 2 continued

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Question 2 continued

Q2

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3. A particle P of mass 0.5 kg is attached to one end of a light elastic string of natural length 1.5 m. The other end of the string is attached to a fixed point O on a rough horizontal plane. The coefficient of friction between P and the plane is $\frac{3}{4}$. The particle is held at rest at a point B on the plane, where $OB = 2$ m. When P is at B the tension in the string is 25 N. The particle is then released from rest.

The point D is 1.5 m from O and ODB is a straight line.

(a) Find the speed of P at the instant when P passes through D.

(6)

The particle comes to rest at the point C.

(b) Find the distance BC.

(3)

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Question 3 continued

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Question 3 continued

Q3

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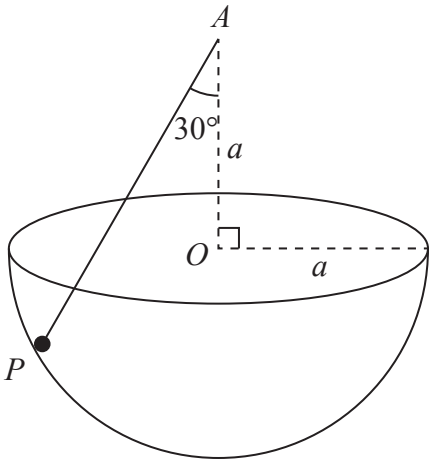

Figure 2

Figure 2 shows a hemispherical bowl of internal radius a fixed with its circular rim upwards and horizontal. The centre of the rim is O. One end of a light inextensible string is attached to a fixed point A vertically above O, where $OA = a$. A particle P of mass m is attached to the other end of the string. The particle moves in a horizontal circle on the smooth inner surface of the bowl with constant angular speed ω with the string taut. The string makes a constant angle of 30° with the downward vertical.

(a) Find, in terms of m, a, ω and g, the tension in the string.

(7)

The particle remains in contact with the bowl.

(b) Show that the time taken by P to make one complete revolution is less than

$$2\pi\sqrt{\frac{3a}{2g}}$$

(5)

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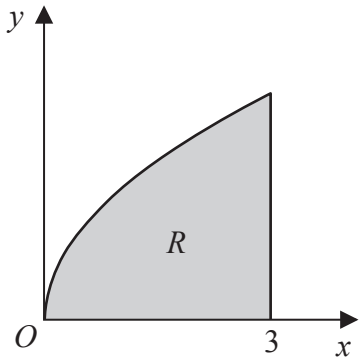

Figure 3

Figure 3 shows the region R bounded by the curve with equation $y^2 = 3x$, the x-axis and the line with equation $x = 3$

A uniform solid S is formed by rotating R through one complete revolution about the x-axis.

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

(6)

The solid is initially placed with its circular plane face on a plane which is inclined at an angle α to the horizontal. The plane is sufficiently rough to prevent S from sliding. Given that S does not topple

(b) find, to the nearest degree, the maximum value of α.

(3)

The solid has mass M. A stud of mass kM is attached to S at a point A on the circumference of its plane face. The solid is now freely suspended from the point B, where AB is a diameter of the plane face of S, and hangs in equilibrium. The angle between AB and the downward vertical is 10°.

(c) Find, to 3 significant figures, the value of k.

(4)

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Question 5 continued

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6. A particle P is free to move on the smooth inner surface of a fixed hollow sphere of internal radius r and centre O. The particle is projected from the lowest point A of the inner surface of the sphere with speed U, where $U > \sqrt{2gr}$. The particle moves in a vertical circle, centre O, on the inner surface of the sphere. The particle leaves the surface of the sphere at the point B, where the angle between OB and the upward vertical is α.

(a) Show that

$$\cos \alpha = \frac{1}{3gr}(U^2 - 2gr)$$

(7)

After losing contact with the sphere, P passes through the point C, where OC is horizontal. The speed of P as it passes through C is V.

Given that $\cos \alpha = \frac{1}{4}$

(b) find V in terms of r and g.

(5)

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Question 6 continued

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Question 6 continued

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Question 6 continued

(Total 12 marks)

Q6

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7. Two fixed points A and B are 4 m apart on a smooth horizontal floor. A particle P of mass 0.4 kg is attached to one end of a light elastic spring, of natural length 1.6 m and modulus of elasticity 12 N. The other end of the spring is attached to A. A second light elastic spring, 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.

Given that P rests in equilibrium at point C on the floor,

(a) find the length of

(i) AC

(ii) BC

(5)

The particle now receives an impulse so that P moves directly towards B. In the subsequent motion P does not reach A or B.

(b) Show that P oscillates with simple harmonic motion about C.

(4)

The magnitude of the impulse received by P is $\frac{8\sqrt{2}}{5}$ Ns. The time for one complete oscillation is S. The time in each complete oscillation for which P is within 0.4 m of C is kS.

(c) Find the value of k.

(7)

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Q7

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TOTAL FOR PAPER: 75 MARKS

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