Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Wednesday 15 May 2019

Morning (Time: 1 hour 30 minutes) | Paper Reference **WME03/01**

Mathematics

International Advanced Subsidiary/Advanced Level
Mechanics M3

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

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).
- **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.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 7 questions in this question paper. 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.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ▶

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Pearson

Answer ALL questions. Write your answers in the spaces provided.

1. A particle P of mass 0.5 kg is moving along the positive x-axis under the action of a single force, directed towards the origin O. When $OP = x$ metres, the force has magnitude $\frac{k}{x^2}$ newtons, where k is a constant, and the speed of P is $v\,\text{m s}^{-1}$.

When P is 2 m from O, the speed of P is $5\,\text{m s}^{-1}$ and P is moving in the positive x direction.

When P is 5 m from O, the speed of P is $4\,\text{m s}^{-1}$ and P is moving in the positive x direction.

Find v^2 in terms of x.

(8)

Question 1 continued

Question 1 continued

Question 1 continued

Q1

(Total 8 marks)

2. One end of a light elastic spring, of natural length l and modulus of elasticity $2mg$, is attached to a particle of mass m. The other end of the spring is attached to a fixed point A on a rough horizontal plane. The particle is held at a point B on the plane, where $AB = 1.25l$, and released from rest. The particle first comes to instantaneous rest at the point C on the plane, where $AC = 0.9l$.

Find the coefficient of friction between the particle and the plane.

(6)

Question 2 continued

Q2

(Total 6 marks)

3.

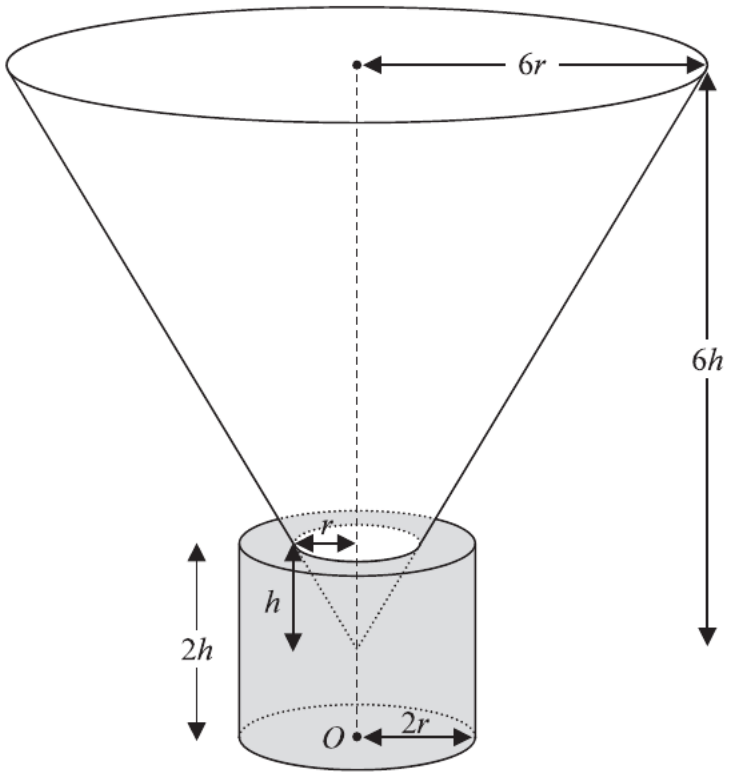

Figure 1

A cone is removed from a uniform solid right circular cylinder of mass M to form the solid with a conical hole shown shaded in Figure 1. A container is made by fixing a uniform conical shell of mass $\frac{1}{12}M$ in the hole. The cylinder has radius $2r$ and height $2h$, the conical hole has base radius r and height h and the conical shell has base radius $6r$ and height $6h$. The vertex of the shell coincides with the vertex of the hole. The axis of the shell, the axis of the hole and the axis of the cylinder are all vertical and coincide. The centre of the plane circular base of the container is O, as shown in Figure 1.

Find, in terms of h, the distance of the centre of mass of the container from O.

(6)

Question 3 continued

Question 3 continued

Question 3 continued

Q3

(Total 6 marks)

4.

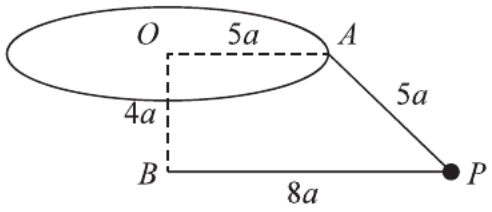

Figure 2

One end of a light inextensible string of length $5a$ is attached to a point A on the circumference of a circular disc of radius $5a$ and centre O. The other end of the string is attached to a particle P of mass m. A second light inextensible string has length $8a$. This string has one end attached to the point B vertically below O, where $OB = 4a$, and the other end attached to P, as shown in Figure 2. The disc rotates in a horizontal plane with constant angular speed. The particle P moves in a horizontal circle centre B with the same constant angular speed as the disc. Both strings are taut and are in a vertical plane through O throughout the motion.

Given that string PB will break if the tension in it exceeds $\frac{5}{4}mg$, find the greatest possible angular speed of P.

(10)

Question 4 continued

Question 4 continued

Question 4 continued

Q4

(Total 10 marks)

5.

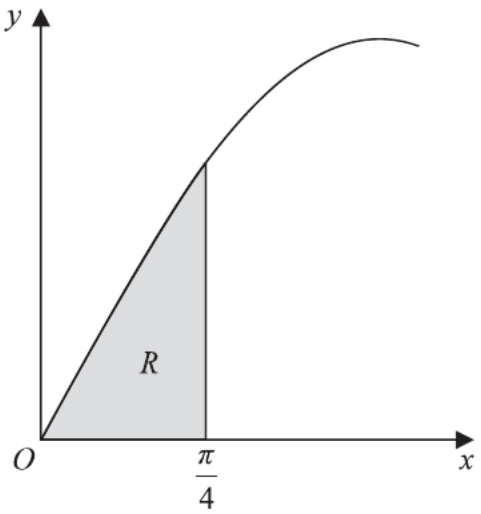

Figure 3

The region R, shown shaded in Figure 3, is bounded by part of the curve with equation $y = \sin x$, the line with equation $x = \frac{\pi}{4}$ and the x-axis. A uniform solid S is formed by rotating R through 2π radians about the x-axis.

(a) Use calculus to show that the volume of S is $\frac{\pi}{8}(\pi - 2)$.

(4)

(b) Use calculus to find, to 3 significant figures, the x coordinate of the centre of mass of S.

(8)

The point A lies on the circumference of the circular plane face of S. The solid S is freely suspended from A and hangs in equilibrium.

(c) Find, to the nearest degree, the size of the angle between OA and the vertical.

(4)

Question 5 continued

Question 5 continued

Question 5 continued

Q5

(Total 16 marks)

6. A particle P moves in a vertical circle, with centre O and radius r, on the smooth inner surface of a fixed hollow spherical shell. The point A lies on the inner surface of the shell and the line OA is at 30° below the horizontal. Initially P is projected downwards from A with speed u in a direction perpendicular to OA. The particle first loses contact with the shell at the point B where the line OB is at 30° above the horizontal.

(a) Show that the speed of P at B is $\sqrt{\frac{rg}{2}}$

(4)

(b) Hence find u in terms of r and g.

(4)

After P has lost contact with the shell, P moves freely under gravity.

The lowest point of the inner surface of the shell is C.

(c) Find the greatest height reached by P above the level of C.

(5)

Question 6 continued

Question 6 continued

Question 6 continued

(Total 13 marks)

Q6

7.

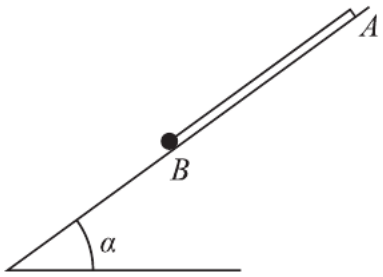

Figure 4

A particle P of mass m is attached to one end of a light elastic string, of natural length l and modulus of elasticity λ. The other end of the string is attached to a fixed point A on a smooth plane which is inclined to the horizontal at angle α, where $\sin\alpha = \frac{3}{5}$. The particle rests in equilibrium on the plane at the point B with the string lying along a line of greatest slope of the plane, as shown in Figure 4.

Given that $AB = \frac{7}{5}l$

(a) show that $\lambda = \frac{3}{2}mg$

(3)

The particle is now pulled down the line of greatest slope to the point C, where $BC = \frac{4}{5}l$, and released from rest.

(b) (i) Show that, while the string remains taut, P moves with simple harmonic motion with centre B.

(ii) Explain briefly why the centre of the motion is at B.

(5)

(c) Find the time taken by P to travel directly from C to B.

(2)

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

(d) Find, in terms of l and g, the time taken by P to travel directly from C to D.

(6)

Question 7 continued

Question 7 continued

Question 7 continued

Question 7 continued

Q7

(Total 16 marks)

TOTAL FOR PAPER: 75 MARKS

END