Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

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 (Yellow), 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 $g = 9.8\,\text{m s}^{-2}$, and give your answer to either two significant figures or three significant figures.

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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1.

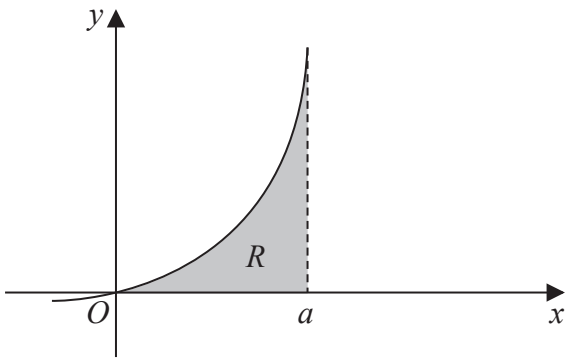

Figure 1

A uniform lamina is in the shape of the region R.

Region R is bounded by the curve with equation $y = x(x + a)$ where a is a positive constant, the positive x-axis and the line with equation $x = a$, as shown shaded in Figure 1.

Find the ***y* coordinate** of the centre of mass of the lamina.

(7)

Question 1 continued

(Total for Question 1 is 7 marks)

2.

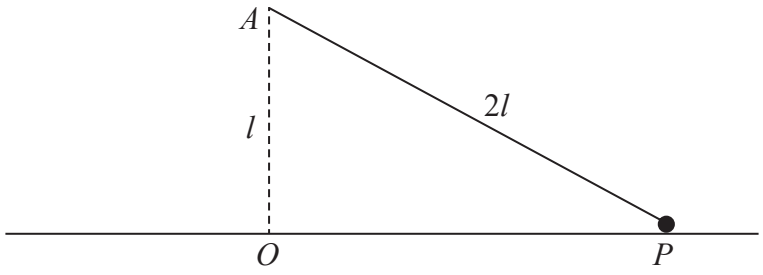

Figure 2

A particle P of mass m is attached to one end of a light inextensible string of length $2l$. The other end of the string is attached to a fixed point A above a smooth horizontal floor. The particle moves in a horizontal circle on the floor with the string taut. The centre O of the circle is vertically below A with $OA = l$, as shown in Figure 2.

The particle moves with constant angular speed ω and remains in contact with the floor.

Show that

$$\omega \leqslant \sqrt{\frac{g}{l}}$$

(8)

Question 2 continued

Question 2 continued

Question 2 continued

(Total for Question 2 is 8 marks)

3. A particle P of mass $m$kg is initially held at rest at the point O on a smooth inclined plane. The plane is inclined at an angle α to the horizontal, where $\sin\alpha = \frac{2}{5}$

The particle is released from rest and slides down the plane against a force which acts towards O. The force has magnitude $\frac{1}{3}mx^2$ N, where x metres is the distance of P from O.

(a) Find the speed of P when $x = 2$

(6)

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

(b) Find the distance OA.

(2)

Question 3 continued

Question 3 continued

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Question 3 continued

(Total for Question 3 is 8 marks)

4.

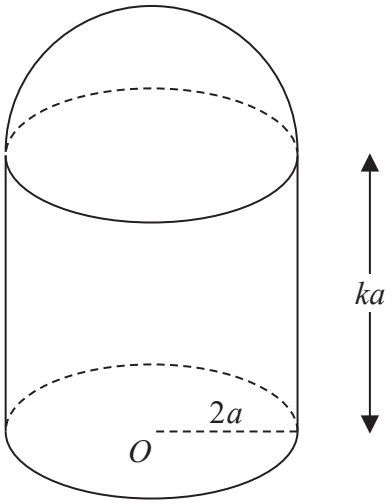

Figure 3

A thin uniform right hollow cylinder, of radius $2a$ and height ka, has a base but no top. A thin uniform hemispherical shell, also of radius $2a$, is made of the same material as the cylinder. The hemispherical shell is attached to the end of the cylinder forming a container C. The open circular rim of the cylinder coincides with the rim of the hemispherical shell. The centre of the base of C is O, as shown in Figure 3.

(a) Show that the distance from O to the centre of mass of C is

$$\frac{(k^2 + 4k + 4)}{2(k + 3)}a$$

(5)

The container is placed with its circular base on a plane which is inclined at 30° to the horizontal. The plane is sufficiently rough to prevent C from sliding. The container is on the point of toppling.

(b) Find the value of k.

(3)

Question 4 continued

Question 4 continued

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Question 4 continued

(Total for Question 4 is 8 marks)

5. A particle P is moving along the x-axis. At time t seconds the displacement of P from the origin O is x metres, where $x = 4\cos\left(\frac{1}{5}\pi t\right)$

(a) Prove that P is moving with simple harmonic motion.

(3)

(b) Find the period of the motion.

(2)

(c) State the amplitude of the motion.

(1)

(d) Find, in terms of π, the maximum speed of P

(2)

The points A and B lie on the x-axis, on opposite sides of O, with $OA = 1.5\,\text{m}$ and $OB = 2.5\,\text{m}$.

(e) Find the time taken by P to move directly from A to B.

(4)

Question 5 continued

Question 5 continued

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Question 5 continued

(Total for Question 5 is 12 marks)

6. A particle P of mass 1.2 kg is attached to the midpoint of a light elastic string of natural length 0.5 m and modulus of elasticity λ newtons.

The fixed points A and B are 0.8 m apart on a horizontal ceiling. One end of the string is attached to A and the other end of the string is attached to B.

Initially P is held at rest at the midpoint M of the line AB and the tension in the string is 30 N.

(a) Show that $\lambda = 50$

(3)

The particle is now held at rest at the point C, where C is 0.3 m vertically below M. The particle is released from rest.

(b) Find the magnitude of the initial acceleration of P

(6)

(c) Find the speed of P at the instant immediately before it hits the ceiling.

(6)

Question 6 continued

Question 6 continued

Question 6 continued

(Total for Question 6 is 15 marks)

7.

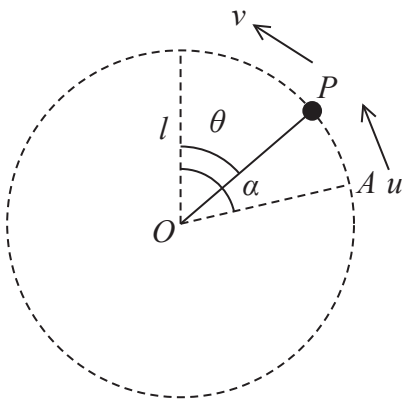

Figure 4

A particle P of mass m is attached to one end of a light rod of length l. The other end of the rod is attached to a fixed point O. The rod can rotate freely in a vertical plane about O. The particle is projected with speed u from a point A. The line OA makes an angle α with the upward vertical through O, where $\alpha < \frac{\pi}{2}$

When OP makes an angle θ with the upward vertical through O, the speed of P is v, as shown in Figure 4.

(a) Show that $v^2 = u^2 - 2gl(\cos\theta - \cos\alpha)$

(4)

Given that $\cos\alpha = \frac{2}{5}$ and that $u = \sqrt{3gl}$

(b) show that P moves in a complete vertical circle.

(4)

As the rod rotates, the least tension in the rod is T and the greatest tension is kT

(c) Find the exact value of k

(9)

Question 7 continued

Question 7 continued

Question 7 continued

Question 7 continued

(Total for Question 7 is 17 marks)

TOTAL FOR PAPER IS 75 MARKS