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.**

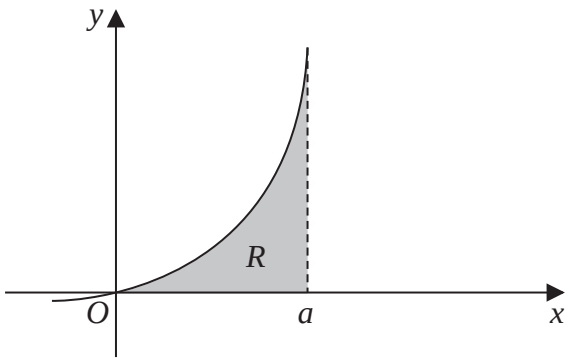


**Figure 1**

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.**

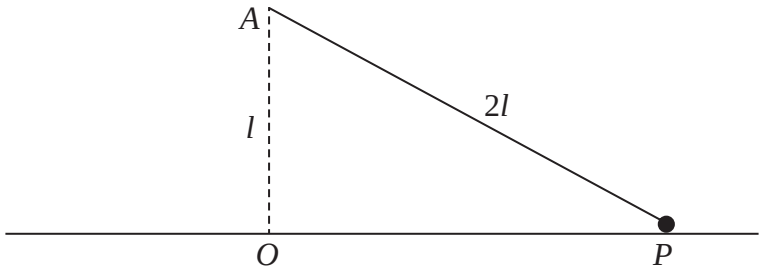


**Figure 2**

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 $\omega$ 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 $\alpha$ 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.**

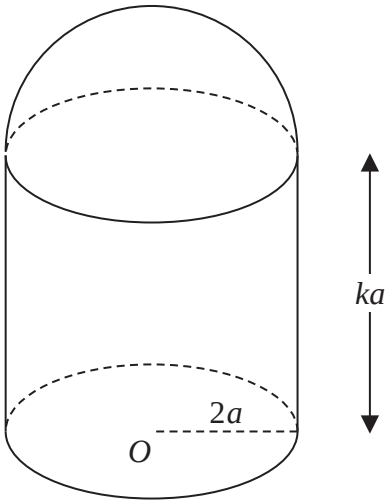


**Figure 3**

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**

**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 $\pi$, 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**

**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 $\lambda$ 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.**

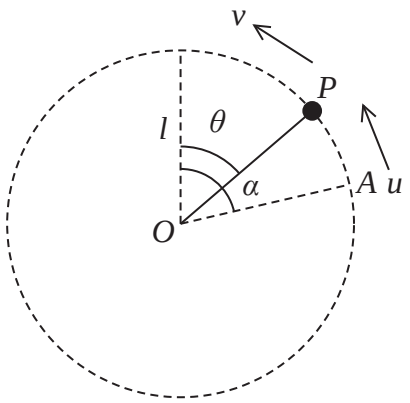


**Figure 4**

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 $\alpha$ with the upward vertical through $O$, where $\alpha < \frac{\pi}{2}$

When $OP$ makes an angle $\theta$ 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**