Please check the examination details below before entering your candidate information

| Candidate surname | Other names |
|---|---|

**Pearson Edexcel**
**International Advanced Level**

Centre Number | Candidate Number

**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 $g = 9.8$ 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.
- Good luck with your examination.

*Turn over* ▶

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**1.**

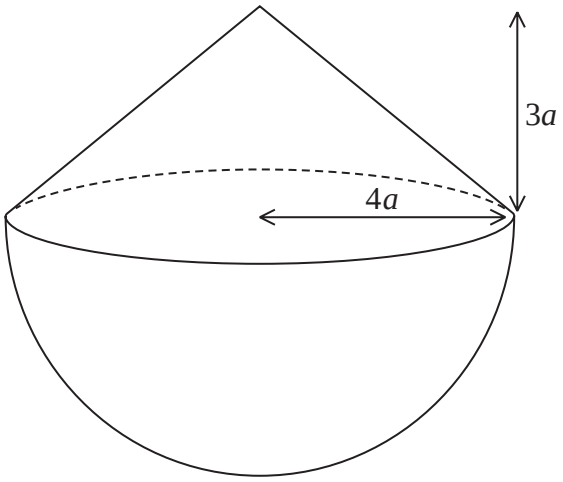


**Figure 1**

A hollow toy is formed by joining a uniform right circular conical shell $C$, with radius $4a$ and height $3a$, to a uniform hemispherical shell $H$, with radius $4a$. The circular edge of $C$ coincides with the circular edge of $H$, as shown in Figure 1.

The mass per unit area of $C$ is $\lambda$ and the mass per unit area of $H$ is $k\lambda$ where $k$ is a constant.

Given that the centre of mass of the toy is a distance $4a$ from the vertex of the cone, find the value of $k$.

**(6)**

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**Question 1 continued**

**(Total for Question 1 is 6 marks)**

**2.**

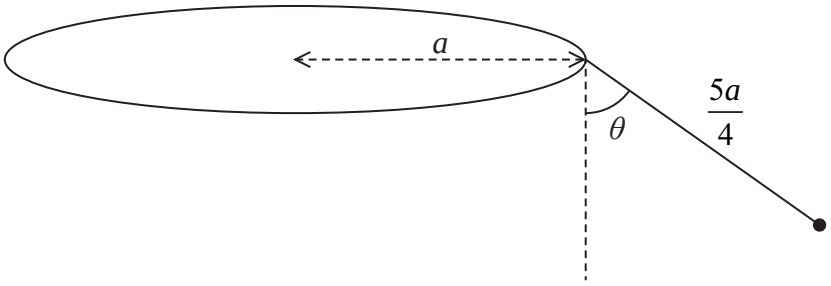


**Figure 2**

Figure 2 shows a fairground ride that consists of a chair of mass $m$ attached to one end of a rigid arm of length $\frac{5a}{4}$. The other end of the arm is freely hinged to the rim of a thin horizontal circular disc of radius $a$. The disc rotates with constant angular speed $\omega$ about a vertical axis through the centre of the disc. As the ride rotates the arm remains in a vertical plane through the centre of the disc. The arm makes a constant angle $\theta$ with the vertical, where $\tan\theta = \frac{3}{4}$

The chair is modelled as a particle and the arm is modelled as a light rod.

(a) Find the tension in the arm in terms of $m$ and $g$

**(3)**

(b) Find $\omega$ in terms of $a$ and $g$

**(6)**

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**Question 2 continued**

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**Question 2 continued**

**(Total for Question 2 is 9 marks)**

**3.** The finite region enclosed by the curve with equation $y = 3 - \sqrt{x}$ and the lines $x = 0$ and $y = 0$ is rotated through $2\pi$ radians about the $x$-axis, to form a uniform solid $S$.

Use algebraic integration to

(a) show that the volume of $S$ is $\frac{27}{2}\pi$

**(4)**

(b) find the $x$ coordinate of the centre of mass of $S$.

**(5)**

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**Question 3 continued**

**Question 3 continued**

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**Question 3 continued**

**(Total for Question 3 is 9 marks)**

**4.**

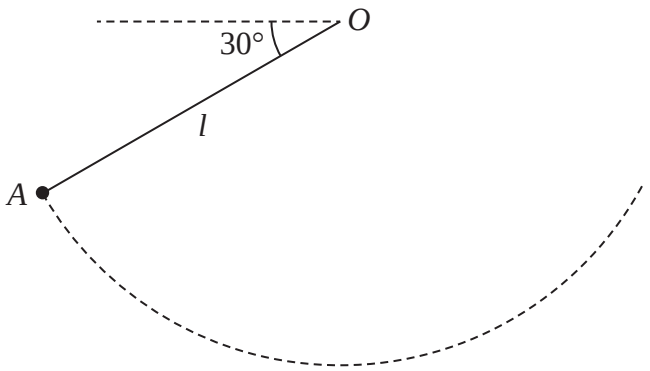


**Figure 3**

A circus performer has mass $m$. She is attached to one end of a cable of length $l$. The other end of the cable is attached to a fixed point $O$

Initially she is held at rest at point $A$ with the cable taut and at an angle of 30° below the horizontal, as shown in Figure 3.

The circus performer is released from $A$ and she moves on a vertical circular path with centre $O$

The circus performer is modelled as a particle and the cable is modelled as light and inextensible.

(a) Find, in terms of $m$ and $g$, the tension in the cable at the instant immediately after the circus performer is released.

**(2)**

(b) Show that, during the motion following her release, the greatest tension in the cable is 4 times the least tension in the cable.

**(7)**

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**Question 4 continued**

**Question 4 continued**

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**Question 4 continued**

**(Total for Question 4 is 9 marks)**

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**5.** A particle $P$ of mass 0.5 kg moves on the $x$-axis under the action of a single force.

At time $t$ seconds, $t \geqslant 0$

- $OP = x$ metres, $0 \leqslant x < \frac{\pi}{2}$
- the force has magnitude $\sin 2x$ N and is directed towards the origin $O$
- $P$ is moving in the positive $x$ direction with speed $v\,\text{m s}^{-1}$

At time $t = 0$, $P$ passes through the origin with speed $2\,\text{m s}^{-1}$

(a) Show that $v = 2\cos x$

**(6)**

(b) Show that $t = \frac{1}{2}\ln\left(\sqrt{2}+1\right)$ when $x = \frac{\pi}{4}$

**(5)**

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**Question 5 continued**

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**Question 5 continued**

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**Question 5 continued**

**(Total for Question 5 is 11 marks)**

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**6.** A particle $P$ of mass 0.4 kg is attached to one end of a light elastic string, of natural length 0.8 m and modulus of elasticity 0.6 N. The other end of the string is fixed to a point $A$ on a rough horizontal table. The coefficient of friction between $P$ and the table is $\frac{1}{7}$

The particle $P$ is projected from $A$, with speed $1.8\,\text{m}\,\text{s}^{-1}$, along the surface of the table.

After travelling 0.8 m from $A$, the particle passes through the point $B$ on the table.

(a) Find the speed of $P$ at the instant it passes through $B$.

**(5)**

The particle $P$ comes to rest at the point $C$ on the table, where $ABC$ is a straight line.

(b) Find the total distance travelled by $P$ as it moves directly from $A$ to $C$.

**(6)**

(c) Show that $P$ remains at rest at $C$.

**(3)**

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**Question 6 continued**

**Question 6 continued**

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**Question 6 continued**

**(Total for Question 6 is 14 marks)**

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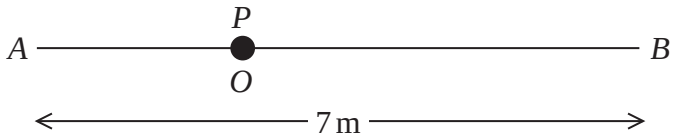


**Figure 4**

The fixed points $A$ and $B$ are 7 m apart on a smooth horizontal surface.

A light elastic string has natural length 2 m and modulus of elasticity 4 N. One end of the string is attached to a particle $P$ of mass 2 kg and the other end is attached to $A$

Another light elastic string has natural length 3 m and modulus of elasticity 2 N. One end of this string is attached to $P$ and the other end is attached to $B$

The particle $P$ rests in equilibrium at the point $O$, where $AOB$ is a straight line, as shown in Figure 4.

(a) Show that $OA = 2.5$ m.

**(4)**

The particle $P$ now receives an impulse of magnitude 6 N s in the direction $OB$

(b) (i) Show that $P$ initially moves with simple harmonic motion with centre $O$

(ii) Determine the amplitude of this simple harmonic motion.

**(8)**

The point $C$ lies on $OB$. As $P$ passes through $C$ the string attached to $B$ becomes slack.

(c) Find the speed of $P$ as it passes through $C$

**(2)**

(d) Find the time taken for $P$ to travel directly from $O$ to $C$

**(3)**

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**Question 7 continued**

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**Question 7 continued**

**(Total for Question 7 is 17 marks)**

**TOTAL FOR PAPER IS 75 MARKS**

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