Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Thursday 23 January 2025

Afternoon (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 $g = 9.8\,\text{m}\,\text{s}^{-2}$, 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. **In this question you must show all stages of your working.**
Solutions relying entirely on calculator technology are not acceptable.

A particle P starts from the origin O and moves along the positive x-axis.

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

- the distance of P from O is x metres
- the acceleration of P has magnitude $a\,\text{m s}^{-2}$
- the speed of P is $v\,\text{m s}^{-1}$, where

$$v = \frac{1}{8}t^2 \qquad (0 \leqslant t < 4)$$

$$v = \frac{1}{8}t^2 - \frac{8}{t} + k \qquad (t \geqslant 4)$$

and k is a constant.

(a) Find the value of a when $t = 8$

(3)

Given that v is a continuous function of t and that $x = 0$ when $t = 0$

(b) find the exact value of x when $t = 8$

(6)

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Question 1 continued

(Total for Question 1 is 9 marks)

2. A light elastic string AB has natural length $3a$ and modulus of elasticity $\frac{20mg}{7}$

When the string is unstretched, two particles, each of mass m, are attached to the string, one at P, where $AP = a$ and the other at Q, where $AQ = 2a$.

The end A of the string is then attached to a point X on a horizontal ceiling and the end B is attached to another point Y on the ceiling, where $XY > 3a$.

The particles hang at rest in equilibrium and the two portions of the string, XP and YQ, both make an angle θ with the horizontal, as shown in Figure 1.

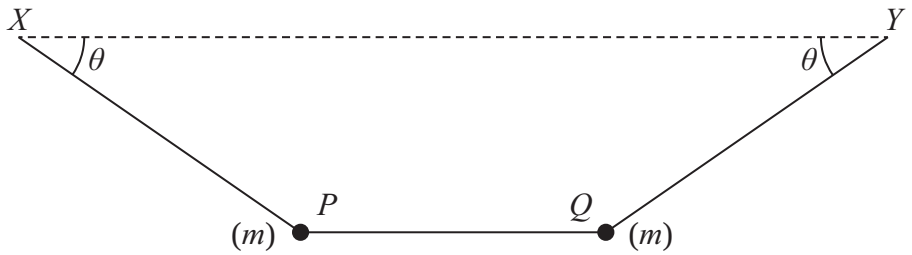

Figure 1

Given that $\tan\theta = \frac{3}{4}$, find XY in terms of a.

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Question 2 continued

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Question 2 continued

(Total for Question 2 is 10 marks)

3.

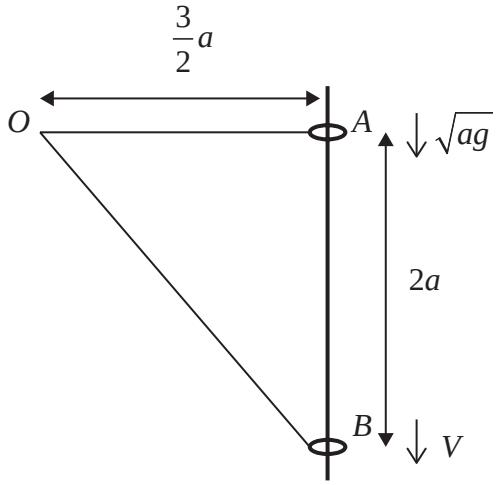

Figure 2

A light elastic string has natural length a and modulus of elasticity mg.
One end of the elastic string is attached to a fixed point O.
The other end is attached to a small smooth ring of mass m.

The ring is threaded on a fixed smooth vertical pole which is a distance $\frac{3}{2}a$ from O.

Initially, the ring is held at the point A on the pole with the elastic string horizontal.

The ring is then projected vertically downwards with speed $\sqrt{ag}$ and reaches the point B, where $AB = 2a$, with speed V, as shown in Figure 2.
Air resistance is assumed to be negligible.

Find V in terms of a and g.

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Question 3 continued

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Question 3 continued

(Total for Question 3 is 7 marks)

4.

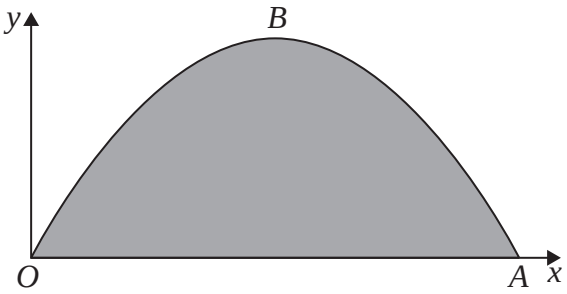

Figure 3

Figure 3 shows a shaded uniform lamina OAB which is in the shape of the region enclosed by the x-axis and the curve with equation $y = \frac{1}{a}(ax - x^2)$, where a is a positive constant. The centre of mass of the lamina is at G.

(a) Find, in terms of a, the y coordinate of G.

(6)

The lamina is now freely pivoted in a vertical plane about a smooth horizontal axis which passes through O and is perpendicular to the plane of the lamina.

The lamina is held in equilibrium by a horizontal force which is applied to the lamina at A. The line OA makes an angle θ with the downward vertical through O, where $\tan\theta = \frac{3}{4}$, as shown in Figure 4.

The line of action of the force lies in the plane of the lamina.

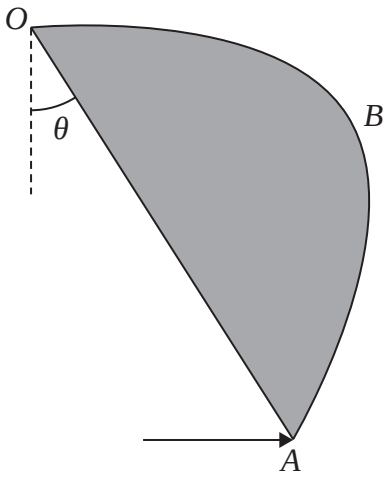

Figure 4

The mass of the lamina is M and the magnitude of the applied force is F.

(b) Find F in terms of M and g.

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Question 4 continued

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Question 4 continued

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5.

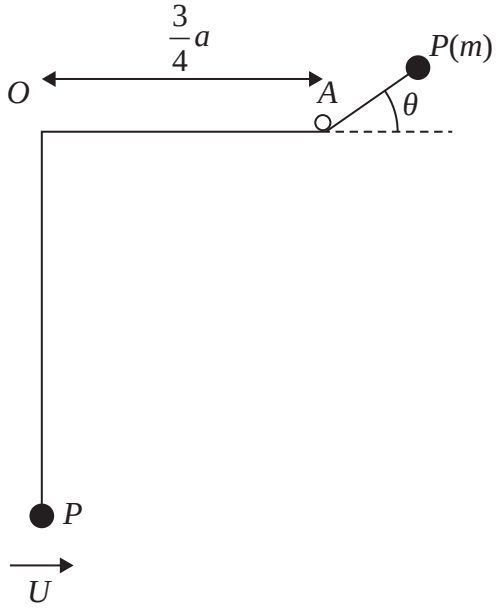

Figure 5

One end of a light inextensible string of length a is attached to a fixed point O. The other end is attached to a particle P of mass m. The particle is held at rest with the string taut and vertical.

The particle is then projected horizontally with speed U, where $U > \sqrt{2ag}$.

When the string is horizontal, it comes into contact with a small smooth peg.

The peg is fixed at the point A on the same horizontal level as O, with $OA = \frac{3}{4}a$.

After the string makes contact with A, the particle P initially moves in a vertical circle centre A.

When the string is taut and AP makes an angle θ with the horizontal, as shown in Figure 5, the speed of P is V and the tension in the string is T.

(a) Show that $V^2 = U^2 - \frac{ag}{2}(4 + \sin\theta)$

(4)

(b) Find T in terms of m, g, U, a and θ

(4)

Given that $U = \sqrt{\frac{19ag}{8}}$

(c) find, in terms of a, the height of P above the level of A when the string goes slack.

(2)

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Question 5 continued

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Question 5 continued

(Total for Question 5 is 10 marks)

6.

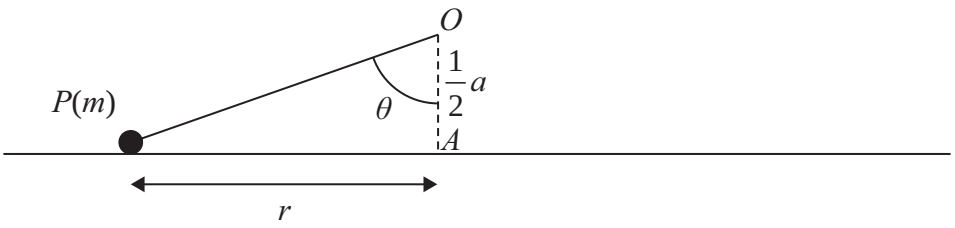

Figure 6

A fixed point O is a distance $\frac{1}{2}a$ above a smooth horizontal table. The point A is on the table, vertically below O.

A light elastic string has natural length a and modulus of elasticity $3mg$. One end of the elastic string is attached to O. The other end of the elastic string is attached to a particle P of mass m.

The particle P moves on the table in a circle centre A, radius r with the elastic string taut and angle $POA = \theta$, where θ is a constant, as shown in Figure 6.

Given that P moves with constant angular speed $\sqrt{\frac{g}{a}}$

(a) show that $OP = \frac{3}{2}a$.

(8)

(b) Find, in terms of m and g, the magnitude of the force exerted on P by the table.

(4)

(c) Find, in terms of m, g and a, the sum of the kinetic energy of P and the elastic energy stored in the string. Give your answer in simplest form.

(4)

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Question 6 continued

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7.

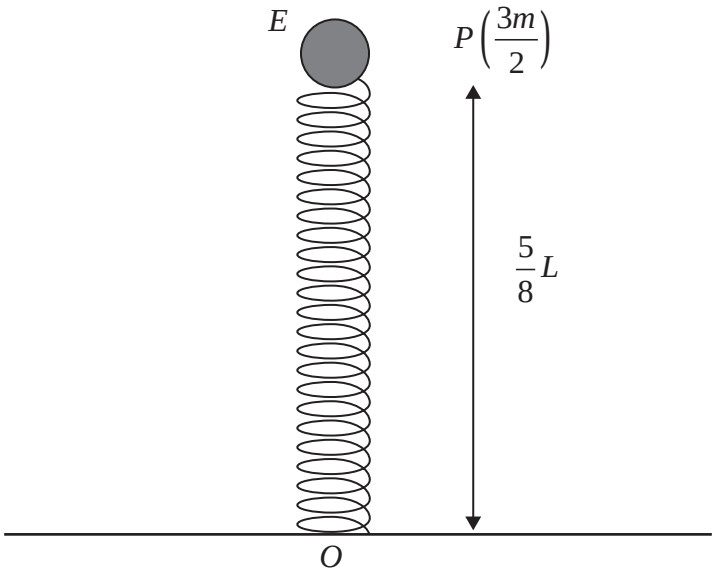

Figure 7

A light elastic spring has natural length L and modulus of elasticity $4mg$. One end of the spring is attached to a point O on a horizontal surface. The other end is attached to a particle P of mass $\frac{3m}{2}$. The particle is at rest in equilibrium at the point E, with the spring vertical and $OE = \frac{5}{8}L$, as shown in Figure 7.

The particle P is then pushed vertically downwards through a distance $\frac{1}{2}L$ and, at time $t = 0$, released from rest.

(a) Show that P then moves with simple harmonic motion about E, with period $\pi\sqrt{\frac{3L}{2g}}$

(6)

(b) Find the exact value of t at the instant when P is first moving upwards and decelerating with magnitude $\frac{2}{3}g$

(5)

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TOTAL FOR PAPER IS 75 MARKS

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