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 $g = 9.8$ 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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Pearson

1. A light elastic string AB has natural length $11a$ and modulus of elasticity $6mg$

A particle of mass $4m$ is attached to the point C on the string where $AC = 8a$ and a particle of mass $2m$ is attached to the end B

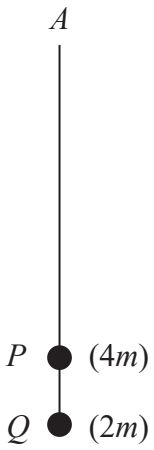

Figure 1

The end A of the string is attached to a fixed point and the string hangs vertically below A with the particle of mass $4m$ in equilibrium at the point P and the particle of mass $2m$ in equilibrium at the point Q, as shown in Figure 1.

(a) Find the length AP

(3)

(b) Find the length PQ

(3)

Question 1 continued

(Total for Question 1 is 6 marks)

2.

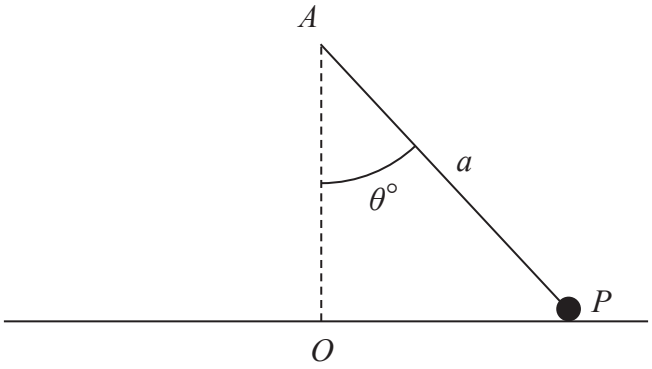

Figure 2

A particle P of mass m is attached to one end of a light inextensible string of length a. The other end of the string is attached to a point A which lies above a smooth horizontal table. The particle P moves in a horizontal circle on the table with the string taut. The centre of the circle is the point O on the table, where AO is vertical and the string makes a constant angle θ° with AO, as shown in Figure 2.

Given that P moves with constant angular speed $\sqrt{\frac{2g}{a}}$, find the range of possible values of θ

(7)

Question 2 continued

Question 2 continued

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Question 2 continued

(Total for Question 2 is 7 marks)

3. A particle P is moving along the x-axis. At time t seconds, where $t \geqslant 0$, P is x metres from the origin O and is moving with speed $v\,\text{m s}^{-1}$

The acceleration of P has magnitude $\dfrac{2}{(2x+1)^3}\,\text{m s}^{-2}$ and is directed towards O

When $t = 0$, P passes through O in the positive x direction with speed $1\,\text{m s}^{-1}$

(a) Find v in terms of x

(4)

(b) Show that $x = \dfrac{1}{2}\left(\sqrt{(4t+1)} - 1\right)$

(4)

Question 3 continued

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Question 3 continued

(Total for Question 3 is 8 marks)

4. A uniform solid hemisphere H has radius r and centre O

(a) Show that the centre of mass of H is $\frac{3r}{8}$ from O

$\left[\textit{You may assume that the volume of } H \textit{ is } \frac{2\pi r^3}{3} \right]$

(4)

A uniform solid S, shown below in Figure 3, is formed by attaching a uniform solid right circular cylinder of height h and radius r to H, so that one end of the cylinder coincides with the plane face of H.

The point A is the point on H such that $OA = r$ and OA is perpendicular to the plane face of H

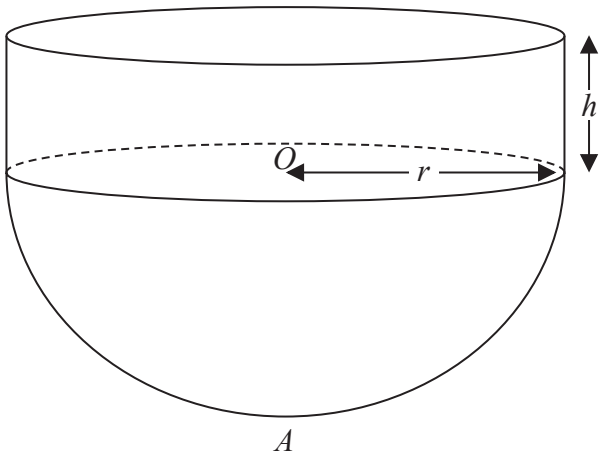

Figure 3

(b) Show that the distance of the centre of mass of S from A is

$$\frac{5r^2 + 12rh + 6h^2}{8r + 12h}$$

(5)

The solid S can rest in equilibrium on a horizontal plane with any point of the curved surface of the hemisphere in contact with the plane.

(c) Find r in terms of h.

(2)

Question 4 continued

Question 4 continued

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Question 4 continued

(Total for Question 4 is 11 marks)

5.

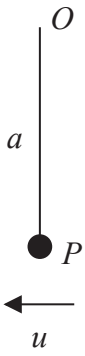

Figure 4

A particle P of mass m is attached to one end of a light inextensible string of length a. The other end of the string is attached to a fixed point O. The particle P is held at rest vertically below O, with the string taut, as shown in Figure 4.

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

Air resistance is modelled as being negligible.

At the instant when the string makes an angle θ with the upward vertical through O, the speed of P is v and the string goes slack.

(a) Show that $3v^2 = u^2 - 2ag$

(7)

From the instant when the string goes slack to the instant when OP is next horizontal, P moves as a projectile.

The time from the instant when the string goes slack to the instant when OP is next horizontal is T

Given that $\theta = 30°$

(b) show that $T = \dfrac{2v}{g}$

(4)

(c) Hence, show that the string goes taut again when it is next horizontal.

(2)

Question 5 continued

Question 5 continued

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Question 5 continued

(Total for Question 5 is 13 marks)

6. A particle P of mass m is attached to one end of a light elastic spring of natural length $2l$. The other end of the spring is attached to a fixed point A. The particle P hangs in equilibrium vertically below A, at the point E where $AE = 6l$. The particle P is then raised a vertical distance $2l$ and released from rest.

Air resistance is modelled as being negligible.

(a) Show that P moves with simple harmonic motion of period T where

$$T = 4\pi\sqrt{\frac{l}{g}}$$

(8)

(b) Find, in terms of m, l and g, the kinetic energy of P as it passes through E

(3)

(c) Find, in terms of T, the exact time from the instant when P is released to the instant when P has moved a distance $3l$.

(4)

Question 6 continued

Question 6 continued

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Question 6 continued

(Total for Question 6 is 15 marks)

7.

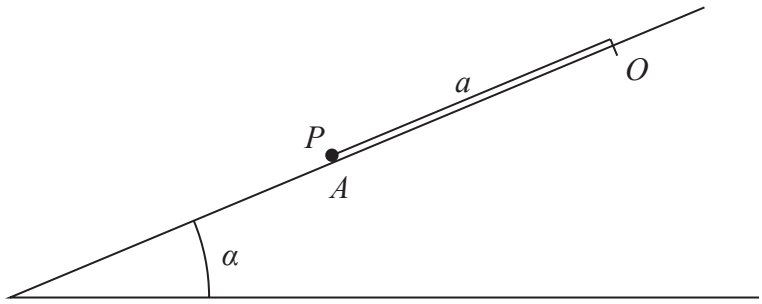

Figure 5

A particle P of mass m is attached to one end of a light elastic string of natural length a and modulus of elasticity $2mg$. The other end of the string is attached to a fixed point O on a rough plane which is inclined to the horizontal at an angle α

The string lies along a line of greatest slope of the plane.

The particle P is held at rest on the plane at the point A, where $OA = a$, as shown in Figure 5.

The particle P is released from A and slides down the plane, coming to rest at the point B. The coefficient of friction between P and the plane is μ, where $\mu < \tan\alpha$

Air resistance is modelled as being negligible.

(a) Show that $AB = a(\sin\alpha - \mu\cos\alpha)$.

(5)

Given that $\tan\alpha = \frac{3}{4}$ and $\mu = \frac{1}{2}$

(b) find, in terms of a and g, the maximum speed of P as it moves from A to B

(7)

(c) Describe the motion of P after it reaches B, justifying your answer.

(3)

Question 7 continued

Question 7 continued

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Question 7 continued

Question 7 continued

(Total for Question 7 is 15 marks)

TOTAL FOR PAPER IS 75 MARKS

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