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 ▶

P71668A

©2021 Pearson Education Ltd.

E:1/1/1/

P 7 1 6 6 8 A 0 1 2 8

Pearson

Leave blank

1. A particle P is moving in a straight line with simple harmonic motion of period 4 s. The centre of the motion is the point O

At time $t = 0$, P passes through O

At time $t = 0.5$ s, P is moving with speed $2\,\text{m s}^{-1}$

(a) Show that the amplitude of the motion is $\frac{4\sqrt{2}}{\pi}$ m

(4)

(b) Find the maximum speed of P

(2)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 1 continued

(Total 6 marks)

Q1

Leave blank

2. In this question solutions relying on calculator technology are not acceptable.

A particle P of mass 2 kg is moving along the positive x-axis.

At time t seconds, where $t \geqslant 0$, P is x metres from the origin O and is moving away from O with speed $v\,\text{m s}^{-1}$ where $v = \dfrac{1}{\sqrt{(2x+1)}}$

(a) Find the magnitude of the resultant force acting on P when its speed is $\dfrac{1}{3}\,\text{m s}^{-1}$

(6)

When $t = 0$, P is at O

(b) Find the value of t when P is 7.5 m from O

(5)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 2 continued

Leave blank

Question 2 continued

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 2 continued

(Total 11 marks)

Q2

Leave blank

3.

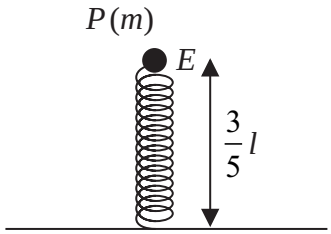

Figure 1

A particle P of mass m is attached to one end of a light elastic spring of natural length l and modulus of elasticity kmg, where k is a constant. The other end of the spring is fixed to horizontal ground.

The particle P rests in equilibrium, with the spring vertical, at the point E.

The point E is at a height $\frac{3}{5}l$ above the ground, as shown in Figure 1.

(a) Show that $k = \frac{5}{2}$

(2)

The particle P is now moved a distance $\frac{1}{4}l$ vertically downwards from E and released from rest. Air resistance is modelled as being negligible.

(b) Show that P moves with simple harmonic motion.

(4)

(c) Find the speed of P as it passes through E.

(4)

(d) Find the time from the instant P is released to the first instant it passes through E.

(2)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 3 continued

Leave blank

Question 3 continued

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 3 continued

(Total 12 marks)

Q3

Leave blank

4. A light elastic string has natural length $2a$ and modulus of elasticity $2mg$.

One end of the elastic string is attached to a fixed point O. A particle P of mass $\frac{1}{2}m$ is attached to the other end of the elastic string.

The point A is vertically below O with $OA = 4a$.

Particle P is held at A and released from rest. The speed of P at the instant when it has moved a distance a upwards is $\sqrt{3ag}$

Air resistance to the motion of P is modelled as having magnitude kmg, where k is a constant.

Using the model and the work-energy principle,

(a) show that $k = \frac{1}{4}$

(7)

Particle P is now held at O and released from rest. As P moves downwards, it reaches its maximum speed as it passes through the point B.

(b) Find the distance OB.

(4)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 4 continued

Leave blank

Question 4 continued

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 4 continued

(Total 11 marks)

Q4

Leave blank

5.

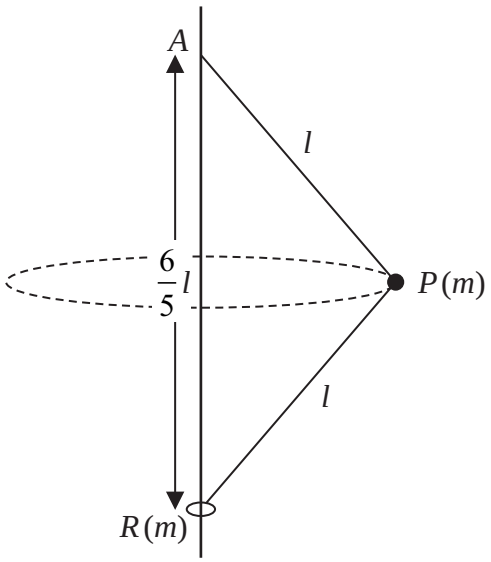

Figure 2

A small smooth ring R of mass m is threaded on to a thin smooth fixed vertical pole. One end of a light inextensible string of length $2l$ is attached to a point A on the pole. The other end of the string is attached to R. A particle P of mass m is attached to the midpoint of the string. The particle P moves with constant angular speed in a horizontal circle, with both halves of the string taut, and $AR = \frac{6l}{5}$, as shown in Figure 2.

It may be assumed that in this motion the string does not wrap itself around the pole and that at any instant, the triangle APR lies in a vertical plane.

(a) Show that the tension in the lower half of the string is $\frac{5mg}{3}$

(3)

(b) Find, in terms of l and g, the time for P to complete one revolution.

(8)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 5 continued

Leave blank

Question 5 continued

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 5 continued

(Total 11 marks)

Q5

Leave blank

6.

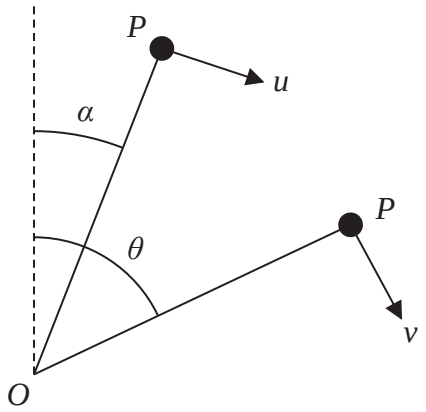

Figure 3

A light rod of length a is free to rotate in a vertical plane about a horizontal axis through one end O. A particle P of mass m is attached to the other end of the rod. The particle P is held at rest with the rod making an angle α with the upward vertical through O, where $\tan\alpha = \frac{3}{4}$

The particle P is then projected with speed u in a direction which is perpendicular to the rod. At the instant when the rod makes an angle θ with the upward vertical through O, the speed of P is v, as shown in Figure 3.

Air resistance is assumed to be negligible.

(a) Show that $v^2 = u^2 + \frac{2ag}{5}(4 - 5\cos\theta)$

(4)

It is given that $u^2 = \frac{6ag}{5}$ and P moves in complete vertical circles.

When $\theta = \beta$, the force exerted on P by the rod is zero.

(b) Find the value of $\cos\beta$

(6)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 6 continued

Leave blank

Question 6 continued

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 6 continued

(Total 10 marks)

Q6

Leave blank

7. [*You may assume that the volume of a cone of height h and base radius r is* $\frac{1}{3}\pi r^2 h$.]

A uniform solid right circular cone C, with vertex V, has base radius r and height h.

(a) Show that the centre of mass of C is $\frac{3}{4}h$ from V

(4)

A solid F, shown below in Figure 4, is formed by removing the solid right circular cone C' from C, where cone C' has height $\frac{1}{3}h$ and vertex V

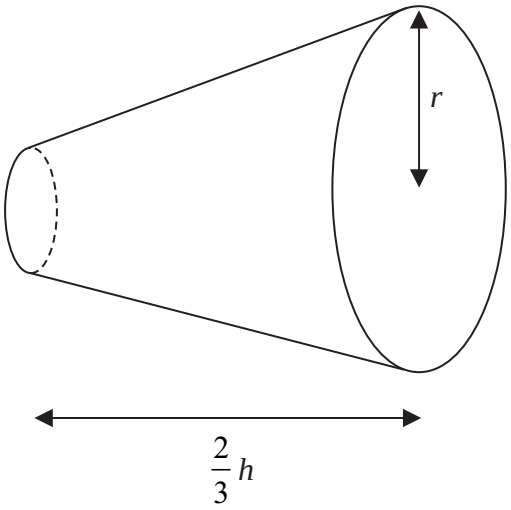

Figure 4

(b) Show that the distance of the centre of mass of F from its larger plane face is $\frac{3}{13}h$

(5)

The solid F rests in equilibrium with its curved surface in contact with a horizontal plane.

(c) Show that $13r^2 \leqslant 17h^2$

(5)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 7 continued

Leave blank

Question 7 continued

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 7 continued

Leave blank

Question 7 continued

Q7

(Total 14 marks)

TOTAL FOR PAPER = 75 MARKS

END

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA