Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number	Candidate Number

Sample Assessment Materials

(Time: 1 hour 30 minutes) | Paper Reference **9FM0/4C**

Further Mathematics

Advanced

Paper 4C: Further Mechanics 2

You must have:
Mathematical Formulae and Statistical Tables, calculator

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for algebraic 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.
- Answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 8 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.

Turn over ▶

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Pearson

Answer ALL questions. Write your answers in the spaces provided.

1. A particle of mass 0.5 kg is attached to one end of a light elastic string. The other end of the string is attached to a fixed point O on a smooth horizontal surface. The string has natural length 2 m and modulus of elasticity 8 N. The particle moves on the surface in a horizontal circle about O with constant angular speed 1.5 rad s^{-1}.

Find the radius of the circle.

(5)

Question 1 continued

(Total for Question 1 is 5 marks)

2.

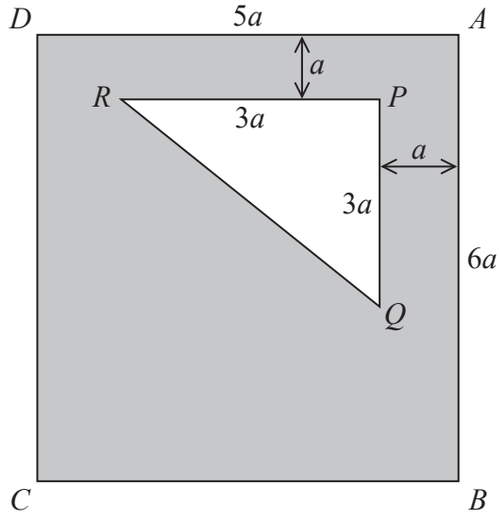

Figure 1

Figure 1 shows a shaded template, T, formed by removing an isosceles right-angled triangle PQR from a uniform rectangular lamina $ABCD$. The rectangle has side AB of length $6a$ and side AD of length $5a$. The triangle has equal sides PQ and PR of length $3a$. Side PQ of the triangle is parallel to side AB of the rectangle and the distance between AB and PQ is a. Side PR of the triangle is parallel to side AD of the rectangle and the distance between PR and AD is a.

(a) Show that distance of the centre of mass of T from AB is $\frac{44}{17}a$.

(5)

The template T is freely pivoted at A. A horizontal force is applied to T at B so that T rests in equilibrium with AB vertical. The line of action of the force lies in the vertical plane containing T.

Given that the weight of T is 85 N,

(b) find the magnitude of the force exerted on T by the pivot at A.

(4)

Question 2 continued

Question 2 continued

Question 2 continued

(Total for Question 2 is 9 marks)

3. A particle, P, of mass 2 kg is attached to one end of a light elastic spring of natural length 0.8 m and modulus of elasticity 49 N. The other end of the spring is attached to a fixed point A. Particle P hangs freely in equilibrium, with P vertically below A.

The particle is now pulled vertically down to the point B, where $AB = 1.4$ m, and released from rest.

(a) Show that P moves with simple harmonic motion about its equilibrium position.

(5)

(b) Find the length of time, in each complete oscillation, for which P is more than 1.2 m vertically below A.

(4)

Question 3 continued

(Total for Question 3 is 9 marks)

4.

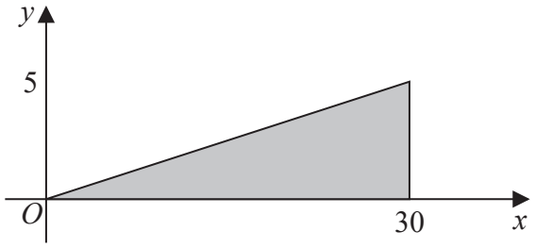

Figure 2

A solid right circular cone has height 30 m and base radius 5 m. The cone is modelled as the solid generated when the shaded region in Figure 2 is rotated through 360° about the x-axis. The cone is non-uniform so that the mass per unit volume of the cone at the point (x, y) is $\frac{x}{100}$ kg m^{-3}, where $0 \leqslant x \leqslant 30$.

(a) Show that the mass of the cone is $\frac{225\pi}{4}$ kg.

(3)

(b) Find the distance of the centre of mass of the cone from its vertex.

(4)

Question 4 continued

(Total for Question 4 is 7 marks)

5. For a particle above the surface of the Earth, at a distance x from the centre of the Earth, the magnitude of the gravitational force acting on the particle due to the Earth is inversely proportional to x^2.

At the surface of the Earth, the acceleration due to gravity is g.

The Earth can be modelled as a fixed sphere of radius R.

A particle P of mass m is at a point that is at a distance $(x - R)$ above the surface of the Earth.

(a) Show that the magnitude of the Earth's gravitational force acting on P is $\frac{mgR^2}{x^2}$

(3)

A rocket is fired vertically upwards with speed U from a point on the surface of the Earth. When the rocket is at a height $2R$ above the surface of the Earth, the speed of the rocket is $\sqrt{gR}$. The rocket is modelled as a particle of constant mass m and the Earth is modelled as a fixed sphere of radius R. All forces acting on the rocket, other than the Earth's gravitational force, can be ignored.

(b) Find an expression for U in terms of g and R.

(5)

(c) Suggest one way in which the model could be refined to make it more realistic.

(1)

Question 5 continued

Question 5 continued

Question 5 continued

(Total for Question 5 is 9 marks)

6. A particle, P, is moving along the positive x-axis in the direction of x increasing. When the displacement of P from the origin, O, is x metres, the velocity of P is $v\,\text{m}\,\text{s}^{-1}$, where

$$v = 9 - \frac{3}{x}, \qquad x \geqslant 1$$

At time $t = 0$ seconds, $x = 1$

At time $t = T$ seconds, $x = 3$

(a) Find the acceleration of P when $x = 3$

(4)

(b) Show that $T = \frac{2}{9} + \frac{1}{27}\ln 4$

(6)

Question 6 continued

(Total for Question 6 is 10 marks)

7.

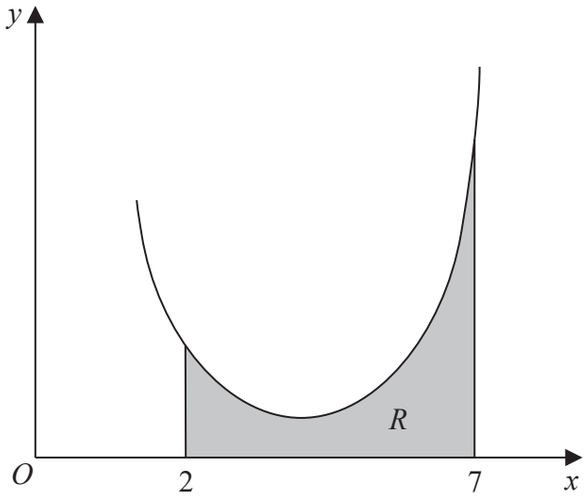

Figure 3

Figure 3 shows the shaded region, R, bounded by the curve with equation $y = \dfrac{1}{\sqrt{16-(x-4)^2}}$, the x-axis and the lines with equations $x = 2$ and $x = 7$

A uniform solid of revolution, S, is formed by rotating R through 360° about the x-axis.

(a) Show that the x coordinate of the centre of mass of S is $\dfrac{8\ln 6}{\ln 21}$

(9)

The solid S is placed with its smaller plane face on an inclined plane that is at an angle $\alpha°$ to the horizontal. The inclined plane is sufficiently rough to prevent S from sliding.

Given that S does not topple,

(b) find the greatest possible value of α.

(3)

Question 7 continued

Question 7 continued

Question 7 continued

(Total for Question 7 is 12 marks)

8.

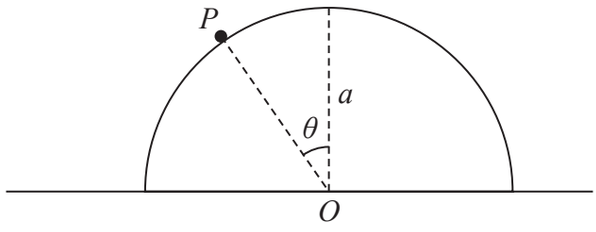

Figure 4

Figure 4 shows a smooth solid hemisphere with radius a and centre O, fixed with its circular plane face on a horizontal surface. A particle, P, of mass m is slightly disturbed from rest at the highest point on the surface of the hemisphere.

When OP has turned through an angle θ, the particle is still on the surface of the hemisphere, and the normal reaction between P and the hemisphere has magnitude R.

(a) Show that $R = mg(3\cos\theta - 2)$.

(6)

(b) Deduce the value of $\cos\theta$ when P loses contact with the hemisphere, giving a reason for your answer.

(2)

(c) Find the direction of motion of P at the instant when it hits the horizontal surface.

(6)

Question 8 continued

Question 8 continued

(Total for Question 8 is 14 marks)

TOTAL FOR PAPER IS 75 MARKS

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