

CANDIDATE
NAME

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MATHEMATICS

9709/51

Paper 5 Mechanics 2 **(M2)**

May/June 2017

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: List of Formulae (MF9)

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name in the spaces at the top of this page.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

DO NOT WRITE IN ANY BARCODES.

Answer **all** the questions.

Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.

Where a numerical value for the acceleration due to gravity is needed, use 10 m s^{-2} .

The use of an electronic calculator is expected, where appropriate.

You are reminded of the need for clear presentation in your answers.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [] at the end of each question or part question.

The total number of marks for this paper is 50.

This document consists of **14** printed pages and **2** blank pages.



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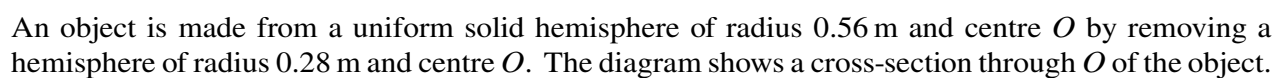
- 1** A particle is projected with speed 20 m s^{-1} at an angle of 60° above the horizontal. Calculate the time after projection when the particle is descending at an angle of 40° below the horizontal. [4]

This image shows a full page of white paper with horizontal dashed lines, typical of primary school writing paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

P is released from rest by removing the 7 N force. In its subsequent motion P first comes to instantaneous rest at a point where $BP = 0.3$ m and the elastic string makes an angle of 30° with the horizontal (see Fig. 2).

[4]

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and extend across the width of the page. There are no margins, text, or other markings on the paper.



- [The volume of a hemisphere is $\frac{2}{3}\pi r^3$.]

[illegible]

The object has weight 24 N. A uniform hemisphere H of radius 0.28 m is placed in the hollow part of the object to create a non-uniform hemisphere with centre O . The centre of mass of the non-uniform hemisphere is 0.15 m from O .

(ii) Calculate the weight of H .

[3]

This image shows a full page of white paper with horizontal dotted lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting practice. There are no margins, text, or other markings on the page.

- 4 A particle is projected from a point O on horizontal ground. The initial components of the velocity of the particle are 10 m s^{-1} horizontally and 15 m s^{-1} vertically. At time $t \text{ s}$ after projection, the horizontal and vertically upwards displacements of the particle from O are $x \text{ m}$ and $y \text{ m}$ respectively.

(i) Express x and y in terms of t , and hence find the equation of the trajectory of the particle. [4]

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The horizontal ground is at the top of a vertical cliff. The point O is at a distance d m from the edge of the cliff. The particle is projected towards the edge of the cliff and does not strike the ground before it passes over the edge of the cliff.

(ii) Show that d is less than 30.

[2]

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(iii) Find the value of x when the particle is 14 m below the level of O .

[2]

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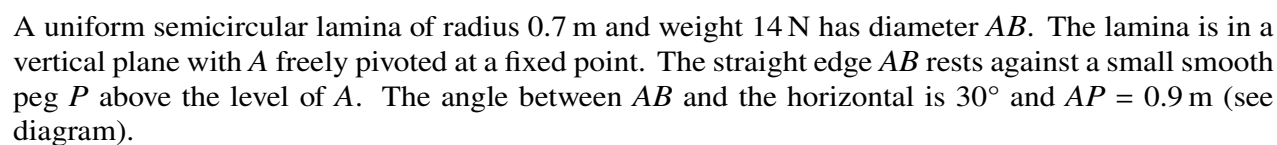
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- 6** A particle P of mass 0.15 kg is attached to one end of a light elastic string of natural length 0.4 m and modulus of elasticity 12 N . The other end of the string is attached to a fixed point A . The particle P moves in a horizontal circle which has its centre vertically below A , with the string inclined at θ° to the vertical and $AP = 0.5\text{ m}$.

(i) Find the angular speed of P and the value of θ . [5]

This image shows a full page of white paper with horizontal dotted lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting practice. There are no margins, text, or other markings on the page.

- (ii) Calculate the difference between the elastic potential energy stored in the string and the kinetic energy of P . [4]

[illegible]

- 7 A particle P of mass 0.5 kg is at rest at a point O on a rough horizontal surface. At time $t = 0$, where t is in seconds, a horizontal force acting in a fixed direction is applied to P . At time $t \text{ s}$ the magnitude of the force is $0.6t^2 \text{ N}$ and the velocity of P away from O is $v \text{ m s}^{-1}$. It is given that P remains at rest at O until $t = 0.5$.

(i) Calculate the coefficient of friction between P and the surface, and show that

$$\frac{dv}{dt} = 1.2t^2 - 0.3 \quad \text{for } t > 0.5. \quad [3]$$

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(ii) Express v in terms of t for $t > 0.5$. [3]

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(iii) Find the displacement of P from O when $t = 1.2$.

[3]

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