Cambridge International A Level

Cambridge Assessment International Education
Cambridge International Advanced Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER			

2733434510

MATHEMATICS **9709/52**

Paper 5 Mechanics 2 **(M2)** **February/March 2019**

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 in the space provided. If additional space is required, you should use the lined page at the end of this booklet. The question number(s) must be clearly shown.
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 $10\,\text{m}\,\text{s}^{-2}$.
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 **13** printed pages and **3** blank pages.

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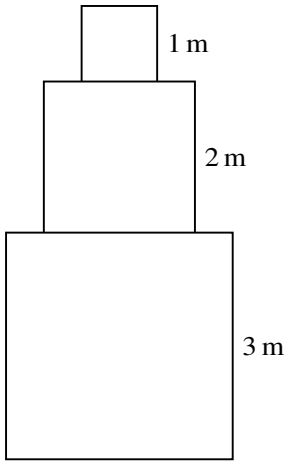
1 A particle is projected with speed $24\ \text{m s}^{-1}$ at an angle of 30° above the horizontal. Find the speed and direction of motion of the particle at the instant 4 s after projection. [5]

2



A uniform object is made by joining together three solid cubes with edges 3 m, 2 m and 1 m. The object has an axis of symmetry, with the cubes stacked vertically and the cube of edge 2 m between the other two cubes (see diagram).

(i) Calculate the distance of the centre of mass of the object above the base of the largest cube. [3]

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The smallest cube is now removed from the object. It is replaced by a heavier uniform cube with 1 m edges which is made of a different material. The centre of mass of the object is now at the base of the 2 m cube.

(ii) Find the ratio of the masses of the two cubes of edge 1 m. [3]

3 A small ball is projected from a point O on horizontal ground. At time t s after projection the horizontal and vertically upwards displacements of the ball from O are x m and y m respectively, where $x = 4t$ and $y = 6t - 5t^2$.

(i) Find the equation of the trajectory of the ball. [2]

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(ii) Hence or otherwise calculate the angle of projection of the ball and its initial speed. [4]

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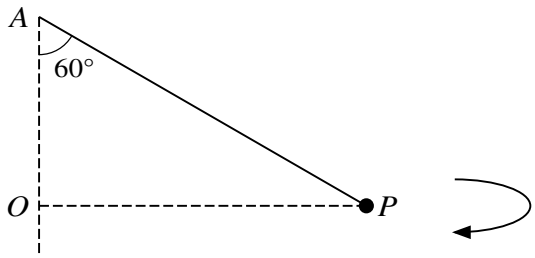

A particle P of mass 0.3 kg is attached to a fixed point A by a light elastic string of natural length 0.8 m and modulus of elasticity 16 N. The particle P moves in a horizontal circle which has centre O. It is given that AO is vertical and that angle OAP is 60° (see diagram). Calculate the speed of P. [6]

5 A particle P of mass 0.3 kg is attached to one end of a light elastic string of natural length 0.6 m and modulus of elasticity 24 N. The other end of the string is attached to a fixed point O. The particle P is released from rest at the point 0.4 m vertically below O.

(i) Find the greatest speed of P. [5]

(ii) Calculate the greatest distance of P below O. [3]

6

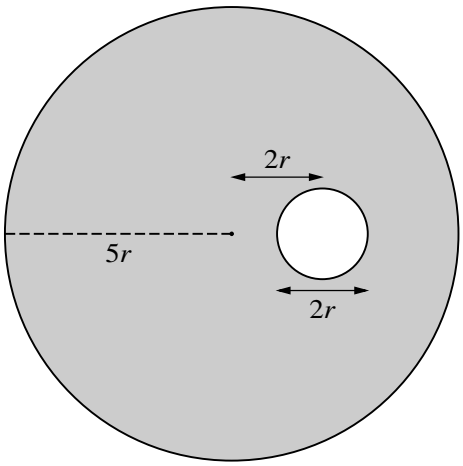

Fig. 1

Fig. 1 shows the cross-section of a solid cylinder through which a cylindrical hole has been drilled to make a uniform prism. The radius of the cylinder is $5r$ and the radius of the hole is r. The centre of the hole is a distance $2r$ from the centre of the cylinder.

(i) Find, in terms of r, the distance of the centre of mass of the prism from the centre of the cylinder. [4]

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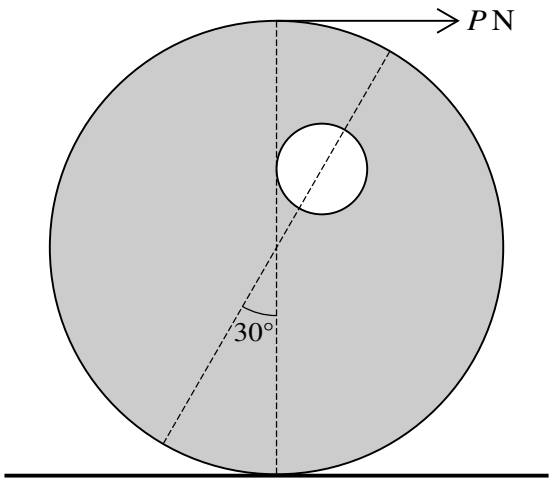

Fig. 2

The prism has weight W N and is placed with its curved surface on a rough horizontal plane. The axis of symmetry of the cross-section makes an angle of 30° with the vertical. A horizontal force of magnitude P N acting in the plane of the cross-section through the centre of mass is applied to the cylinder at the highest point of this cross-section (see Fig. 2). The prism rests in limiting equilibrium.

(ii) Find the coefficient of friction between the prism and the plane. [4]

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7 A particle P is projected horizontally from a point O on a rough horizontal surface. The coefficient of friction between the particle and the surface is 0.2. A horizontal force of magnitude $0.06t$ N directed away from O acts on P, where t s is the time after projection. P comes to rest when $t = 4$.

(i) The particle begins to move again when $t = 8$. Show that the mass of P is 0.24 kg. [2]

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(ii) Show that, for $0 \leqslant t \leqslant 4$, $\frac{\mathrm{d}v}{\mathrm{d}t} = 0.25t - 2$, and find the speed of projection of P. [5]

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(iii) Find the distance from O at which P comes to rest. [4]

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Additional Page

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