Cambridge International A Level

Cambridge International Examinations
Cambridge International Advanced Level

MATHEMATICS **9709/53**

Paper 5 Mechanics 2 **(M2)** **May/June 2014**

1 hour 15 minutes

Additional Materials: Answer Booklet/Paper
Graph Paper
List of Formulae (MF9)

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READ THESE INSTRUCTIONS FIRST

If you have been given an Answer Booklet, follow the instructions on the front cover of the Booklet.
Write your Centre number, candidate number and name on all the work you hand in.
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.

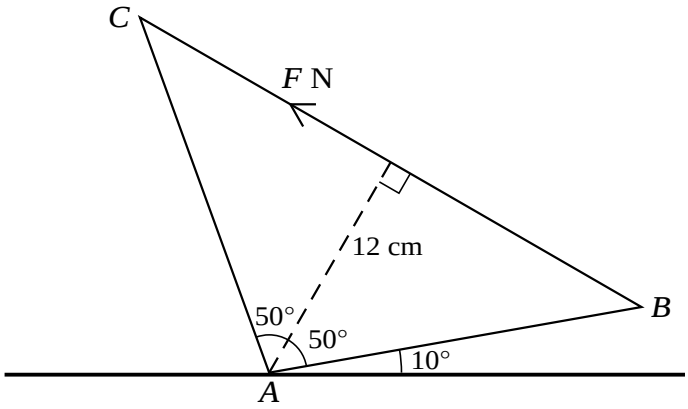
Answer **all** the questions.
Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.
Where a numerical value for the acceleration due to gravity is needed, use $10\,\text{m}\,\text{s}^{-2}$.
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.
Questions carrying smaller numbers of marks are printed earlier in the paper, and questions carrying larger numbers of marks later in the paper.

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1 A light elastic string has modulus of elasticity 5 N and natural length 1.5 m. One end of the string is attached to a fixed point O and a particle P of mass 0.1 kg is attached to the other end of the string. P is released from rest at the point 2.4 m vertically below O. Calculate the speed of P at the instant the string first becomes slack. [3]

2



A uniform lamina ABC in the shape of an isosceles triangle has weight 24 N. The perpendicular distance from A to BC is 12 cm. The lamina rests in a vertical plane in equilibrium, with the vertex A in contact with a horizontal surface. Angle $BAC = 100°$ and AB makes an angle of 10° with the horizontal. Equilibrium is maintained by a force of magnitude F N acting along BC (see diagram). Show that $F = 8$. [3]

3 A small block B of mass 0.2 kg is placed at a fixed point O on a smooth horizontal surface. A horizontal force of magnitude 0.42 N is applied to B. At time t s after the force is first applied, the velocity of B away from O is v m s^{-1}.

(i) Find the value of v when $t = 1$. [2]

For $t > 1$ an additional force, of magnitude $0.32t$ N and directed towards O, is applied to B. The force of magnitude 0.42 N continues to act as before.

(ii) Find the value of v when $t = 2$. [3]

For $t > 2$ a third force, of magnitude $0.06t^2$ N and directed away from O, is applied to B. The other two forces continue to act as before.

(iii) Show that the velocity of B is the same when $t = 2$ and when $t = 3$. [3]

4 One end of a light inextensible string of length 2.4 m is attached to a fixed point A. The other end of the string is attached to a particle P of mass 0.2 kg. P moves with constant speed in a horizontal circle which has its centre vertically below A, with the string taut and making an angle of 60° with the vertical.

(i) Find the speed of P. [4]

The string of length 2.4 m is removed, and P is now connected to A by a light inextensible string of length 1.2 m. The particle P moves with angular speed 4 rad s^{-1} in a horizontal circle with its centre vertically below A.

(ii) Calculate the angle between the string and the vertical. [4]

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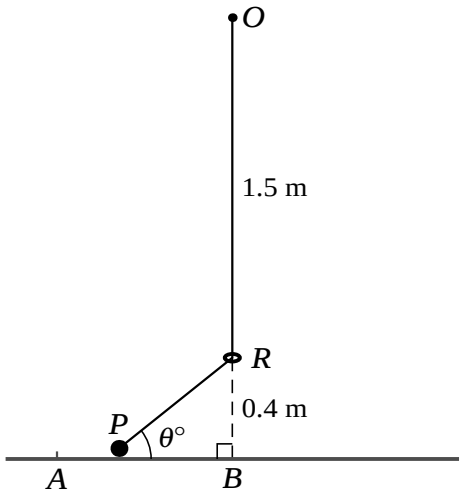
5 A small ball is thrown horizontally with speed $5\,\text{m s}^{-1}$ from a point O on the roof of a building. At time t s after projection, the horizontal and vertically downwards displacements of the ball from O are x m and y m respectively.

(i) Express x and y in terms of t, and hence show that the equation of the trajectory of the ball is $y = 0.2x^2$. [3]

The ball strikes the horizontal ground which surrounds the building at a point A.

(ii) Given that $OA = 18$ m, calculate the value of x at A, and the speed of the ball immediately before it strikes the ground at A. [6]

6



A particle P of mass 0.6 kg is attached to one end of a light elastic string of natural length 1.5 m and modulus of elasticity 9 N. The string passes through a small smooth ring R fixed at a height of 0.4 m above a rough horizontal surface. The other end of the string is attached to a fixed point O which is 1.5 m vertically above R. The points A and B are on the horizontal surface, and B is vertically below R. When P is on the surface between A and B, RP makes an acute angle $\theta°$ with the horizontal (see diagram).

(i) Show that the normal force exerted on P by the surface has magnitude 3.6 N, for all values of θ. [3]

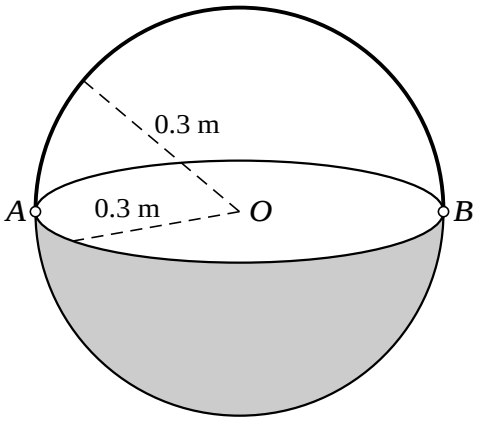
P is projected with speed $2.5\,\text{m s}^{-1}$ towards B from its initial position at A where $\theta = 30$. The speed of P when it passes through B is $3\,\text{m s}^{-1}$.

(ii) Find the work done against friction as P moves from A to B. [4]

(iii) Calculate the value of the coefficient of friction between P and the surface. [2]

[Question 7 is printed on the next page.]

7



The diagram shows a container which consists of a bowl of weight 14 N and a handle of weight 8 N. The bowl of the container is in the form of a uniform hemispherical shell with centre O and radius 0.3 m. The handle is in the form of a uniform semicircular arc of radius 0.3 m and is freely hinged to the bowl at A and B, where AB is a diameter of the bowl.

(i) Calculate the distance of the centre of mass of the container from O for the position indicated in the diagram, where the handle is perpendicular to the rim of the bowl. [3]

(ii) Show that the distance of the centre of mass of the container from O when the handle lies on the rim of the bowl is 0.118 m, correct to 3 significant figures. [5]

In the case when the handle lies on the rim of the bowl, the container rests in equilibrium with the curved surface of the bowl on a horizontal table.

(iii) Find the angle which the plane containing the rim of the bowl makes with the horizontal. [2]

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