Cambridge International Examinations
Cambridge International Advanced Level

MATHEMATICS **9709/52**

Paper 5 Mechanics 2 **(M2)** **February/March 2016**

1 hour 15 minutes

* 7 9 3 9 8 4 2 8 6 7 *

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

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 $10\,\mathrm{m\,s^{-2}}$.
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.
Questions carrying smaller numbers of marks are printed earlier in the paper, and questions carrying larger numbers of marks later in the paper.

This document consists of **3** printed pages and **1** blank page.

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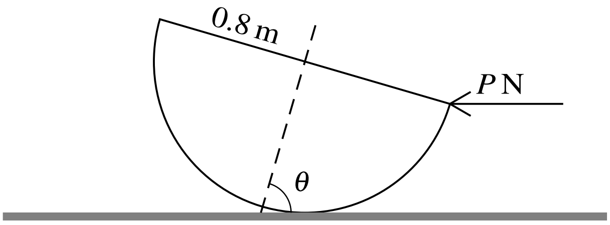
1 A particle is projected from a point on horizontal ground. At the instant 2 s after projection, the particle has travelled a horizontal distance of 30 m and is at its greatest height above the ground. Find the initial speed and the angle of projection of the particle. [5]

2



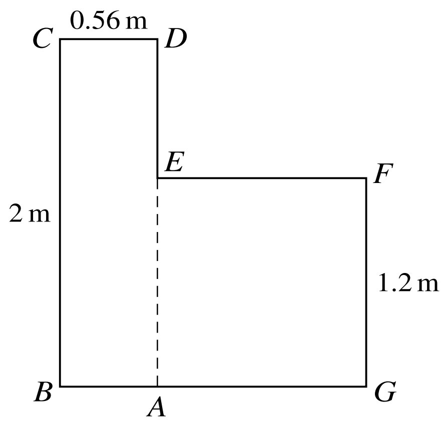
A uniform solid hemisphere of weight 60 N and radius 0.8 m rests in limiting equilibrium with its curved surface on a rough horizontal plane. The axis of symmetry of the hemisphere is inclined at an angle of θ to the horizontal, where $\cos\theta = 0.28$. Equilibrium is maintained by a horizontal force of magnitude P N applied to the lowest point of the circular rim of the hemisphere (see diagram).

(i) Show that $P = 8.75$. [3]

(ii) Find the coefficient of friction between the hemisphere and the plane. [2]

3 A stone is thrown with speed $9\,\text{m s}^{-1}$ at an angle of 60° above the horizontal from a point on horizontal ground. Find the distance between the two points at which the path of the stone makes an angle of 45° with the horizontal. [5]

4



A uniform lamina is made by joining a rectangle $ABCD$, in which $AB = CD = 0.56$ m and $BC = AD = 2$ m, and a square $EFGA$ of side 1.2 m. The vertex E of the square lies on the edge AD of the rectangle (see diagram). The centre of mass of the lamina is a distance h m from BC and a distance v m from BAG.

(i) Find the value of h and show that $v = h$. [4]

The lamina is freely suspended at the point B and hangs in equilibrium.

(ii) State the angle which the edge BC makes with the horizontal. [1]

Instead, the lamina is now freely suspended at the point F and hangs in equilibrium.

(iii) Calculate the angle between FG and the vertical. [2]

5 A particle P of mass 0.6 kg is attached to one end of a light elastic string of natural length 0.8 m and modulus of elasticity 24 N. The other end of the string is attached to a fixed point A, and P hangs in equilibrium.

(i) Calculate the extension of the string. [2]

P is projected vertically downwards from the equilibrium position with speed $4.5\,\mathrm{m\,s^{-1}}$.

(ii) Find the distance AP when the speed of P is $3.5\,\mathrm{m\,s^{-1}}$ and P is below the equilibrium position. [4]

(iii) Calculate the speed of P when it is 0.5 m above the equilibrium position. [3]

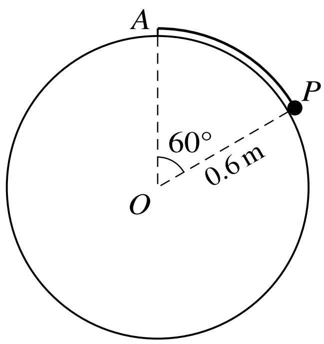
6 A particle P of mass 0.2 kg is released from rest at a point O on a plane inclined at 30° to the horizontal. At time t s after its release, P has velocity $v\,\mathrm{m\,s^{-1}}$ and displacement x m down the plane from O. The coefficient of friction between P and the plane increases as P moves down the plane, and equals $0.1x^2$.

(i) Show that $2v\frac{\mathrm{d}v}{\mathrm{d}x} = 10 - (\sqrt{3})x^2$. [2]

(ii) Calculate the maximum speed of P. [5]

(iii) Find the value of x at the point where P comes to rest. [2]

7



One end of a light inextensible string is attached to the highest point A of a solid fixed sphere with centre O and radius 0.6 m. The other end of the string is attached to a particle P of mass 0.2 kg which rests in contact with the smooth surface of the sphere. The angle AOP = 60° (see diagram). The sphere exerts a contact force of magnitude R N on P and the tension in the string is T N.

(i) By resolving vertically, show that $R + (\sqrt{3})T = 4$. [2]

P is now set in motion, and moves with angular speed $\omega\,\mathrm{rad\,s^{-1}}$ in a horizontal circle on the surface of the sphere.

(ii) Find an equation involving R, T and ω. [2]

(iii) Hence

(a) calculate R when $\omega = 2$, [2]

(b) find the greatest possible value of T and the corresponding speed of P. [4]

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