Cambridge International A Level

Cambridge International Examinations
Cambridge International Advanced Level

MATHEMATICS **9709/53**

Paper 5 Mechanics 2 **(M2)** **October/November 2014**

1 hour 15 minutes

4858798201

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.

CAMBRIDGE
International Examinations

1 A golf ball B is projected from a point O on horizontal ground. B hits the ground for the first time at a point 48 m away from O at time 2.4 s after projection. Calculate the angle of projection. [3]

2 A particle P of mass 0.2 kg is attached to one end of a light elastic string of natural length 0.8 m and modulus of elasticity 64 N. The other end of the string is attached to a fixed point A on a smooth horizontal surface. P is placed on the surface at a point 0.8 m from A. The particle P is then projected with speed $10\,\mathrm{m\,s^{-1}}$ directly away from A.

(i) Calculate the distance AP when P is at instantaneous rest. [3]

(ii) Calculate the speed of P when it is 1.0 m from A. [3]

3 A small ball of mass m kg is projected vertically upwards with speed $14\,\mathrm{m\,s^{-1}}$. The ball has velocity $v\,\mathrm{m\,s^{-1}}$ upwards when it is x m above the point of projection. A resisting force of magnitude $0.02mv$ N acts on the ball during its upward motion.

(i) Show that, while the ball is moving upwards, $\left(\frac{500}{v+500} - 1\right)\frac{\mathrm{d}v}{\mathrm{d}x} = 0.02$. [3]

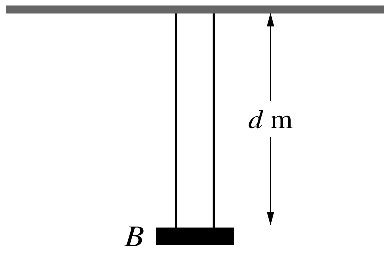
(ii) Find the greatest height of the ball above its point of projection. [3]

4 A particle P is projected with speed $50\,\mathrm{m\,s^{-1}}$ at an angle of 30° above the horizontal from a point O on a horizontal plane.

(i) Calculate the speed of P when it has been in motion for 4 s, and calculate another time at which P has this speed. [5]

(ii) Find the distance OP when P has been in motion for 4 s. [2]

5



Two light elastic strings each have one end attached to a fixed horizontal beam. One string has natural length 0.6 m and modulus of elasticity 12 N; the other string has natural length 0.7 m and modulus of elasticity 21 N. The other ends of the strings are attached to a small block B of weight W N. The block hangs in equilibrium d m below the beam, with both strings vertical (see diagram).

(i) Given that the tensions in the strings are equal, find d and W. [4]

The small block is now raised vertically to the point 0.7 m below the beam, and then released from rest.

(ii) Find the greatest speed of the block in its subsequent motion. [4]

6 A horizontal disc with a rough surface rotates about a fixed vertical axis which passes through the centre of the disc. A particle P of mass 0.2 kg is in contact with the surface and rotates with the disc, without slipping, at a distance 0.5 m from the axis. The greatest speed of P for which this motion is possible is $1.5\,\text{m}\,\text{s}^{-1}$.

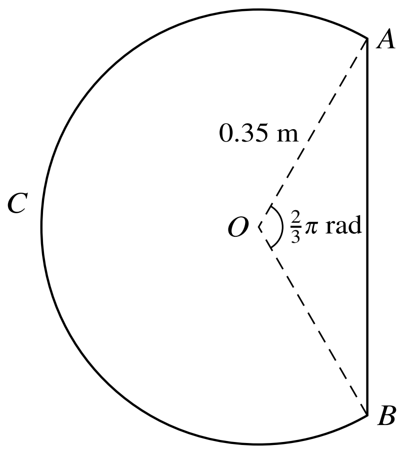
(i) Calculate the coefficient of friction between the disc and P. [2]

P is now attached to one end of a light elastic string, which is connected at its other end to a point on the vertical axis above the disc. The tension in the string is equal to half the weight of P. The disc rotates with constant angular speed $\omega\,\text{rad}\,\text{s}^{-1}$ and P rotates with the disc without slipping. P moves in a circle of radius 0.5 m, and the taut string makes an angle of 30° with the horizontal.

(ii) Find the greatest and least values of ω for which this motion is possible. [5]

(iii) Calculate the value of ω for which the disc exerts no frictional force on P. [2]

7



A uniform lamina ABC is in the form of a major segment of a circle with centre O and radius 0.35 m. The straight edge of the lamina is AB, and angle $AOB = \frac{2}{3}\pi$ radians (see diagram).

(i) Show that the centre of mass of the lamina is 0.0600 m from O, correct to 3 significant figures. [6]

The weight of the lamina is 14 N. It is placed on a rough horizontal surface with A vertically above B and the lowest point of the arc BC in contact with the surface. The lamina is held in equilibrium in a vertical plane by a force of magnitude F N acting at A.

(ii) Find F in each of the following cases:

(a) the force of magnitude F N acts along AB; [2]

(b) the force of magnitude F N acts along the tangent to the circular arc at A. [3]

BLANK PAGE