CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

HIGHER MATHEMATICS   **8719/05**

MATHEMATICS   **9709/05**

Paper 5 Mechanics 2 **(M2)**

May/June 2003

1 hour 15 minutes

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 on both sides of the paper.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

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 $10 \, \text{m s}^{-2}$.
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.
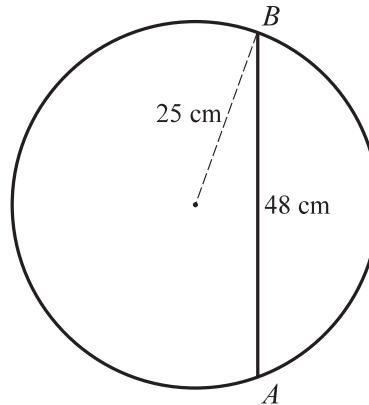The use of an electronic calculator is expected, where appropriate.
You are reminded of the need for clear presentation in your answers.

This document consists of **4** printed pages.

UNIVERSITY *of* CAMBRIDGE
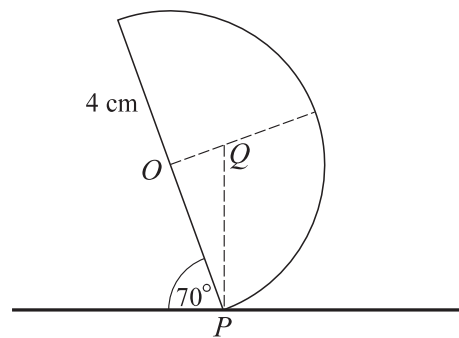Local Examinations Syndicate

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[Turn over

1

A frame consists of a uniform circular ring of radius 25 cm and mass 1.5 kg, and a uniform rod of length 48 cm and mass 0.6 kg. The ends A and B of the rod are attached to points on the circumference of the ring, as shown in the diagram. Find the distance of the centre of mass of the frame from the centre of the ring. [4]

2

A uniform solid hemisphere, with centre O and radius 4 cm, is held so that a point P of its rim is in contact with a horizontal surface. The plane face of the hemisphere makes an angle of $70°$ with the horizontal. Q is the point on the axis of symmetry of the hemisphere which is vertically above P. The diagram shows the vertical cross-section of the hemisphere which contains O, P and Q.

(i) Determine whether or not the centre of mass of the hemisphere is between O and Q. [3]

The hemisphere is now released.

(ii) State whether or not the hemisphere falls on to its plane face, giving a reason for your answer. [2]

3
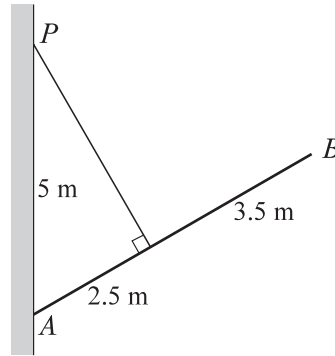
A uniform beam AB has length 6 m and mass 45 kg. One end of a light inextensible rope is attached to the beam at the point 2.5 m from A. The other end of the rope is attached to a fixed point P on a vertical wall. The beam is in equilibrium with A in contact with the wall at a point 5 m below P. The rope is taut and at right angles to AB (see diagram). Find

  (i) the tension in the rope,   [4]

 (ii) the horizontal and vertical components of the force exerted by the wall on the beam at A.   [3]

4   A particle of mass 0.2 kg moves in a straight line on a smooth horizontal surface. When its displacement from a fixed point on the surface is x m, its velocity is $v\,\text{m s}^{-1}$. The motion is opposed by a force of magnitude $\dfrac{1}{3v}$ N.

  (i) Show that $3v^2\dfrac{\mathrm{d}v}{\mathrm{d}x} = -5$.   [3]

 **(ii)** Find the value of v when $x = 7.4$, given that $v = 4$ when $x = 0$.   [4]

5
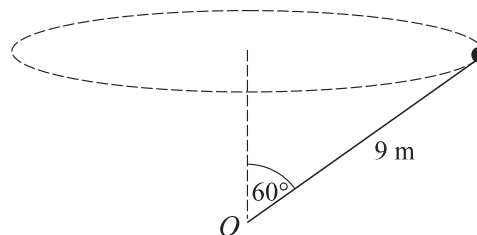
A toy aircraft of mass 0.5 kg is attached to one end of a light inextensible string of length 9 m. The other end of the string is attached to a fixed point O. The aircraft moves with constant speed in a horizontal circle. The string is taut, and makes an angle of $60°$ with the upward vertical at O (see diagram). In a simplified model of the motion, the aircraft is treated as a particle and the force of the air on the aircraft is taken to act vertically upwards with magnitude 8 N. Find

  (i) the tension in the string,   [3]

 (ii) the speed of the aircraft.   [4]

[Turn over

6 A particle is projected with speed 60 m s^{-1} from a point on horizontal ground. The angle of projection is $\alpha°$ above the horizontal. The particle reaches the ground again after 10 s.

   (i) Find the value of α. [3]

   (ii) Find the greatest height reached by the particle. [2]

   (iii) At time T s after the instant of projection the direction of motion of the particle is at an angle of $45°$ above the horizontal. Find the value of T. [4]

7
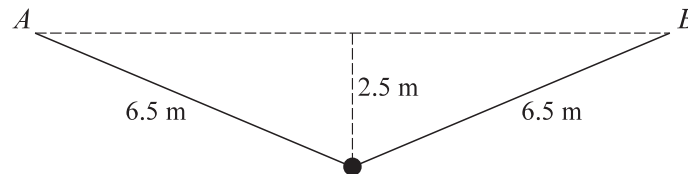
A light elastic string has natural length 10 m and modulus of elasticity 130 N. The ends of the string are attached to fixed points A and B, which are at the same horizontal level. A small stone is attached to the mid-point of the string and hangs in equilibrium at a point 2.5 m below AB, as shown in the diagram. With the stone in this position the length of the string is 13 m.

   (i) Find the tension in the string. [2]

   (ii) Show that the mass of the stone is 3 kg. [2]

The stone is now held at rest at a point 8 m vertically below the mid-point of AB.

   (iii) Find the elastic potential energy of the string in this position. [3]

   (iv) The stone is now released. Find the speed with which it passes through the mid-point of AB. [4]