UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

MATHEMATICS **9709/53**

Paper 5 Mechanics 2 **(M2)** **October/November 2011**

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 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 $10\,\text{m}\,\text{s}^{-2}$.
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.

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

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1 A particle is projected with speed $17\,\text{m s}^{-1}$ at an angle of 50° above the horizontal from a point on horizontal ground. Calculate the speed of the particle 2 s after the instant of projection. [3]

2 An object is made from two identical uniform rods AB and BC each of length 0.6 m and weight 7 N. The rods are rigidly joined to each other at B and angle $ABC = 90^\circ$.

(i) Calculate the distance of the centre of mass of the object from B. [1]

The object is freely suspended at A and a force of magnitude F N is applied to the rod BC at C. The object is in equilibrium with AB inclined at 45° to the horizontal.

(ii) (a)

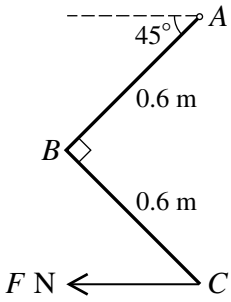


Fig. 1

Calculate F given that the force acts horizontally as shown in Fig. 1. [2]

(b)

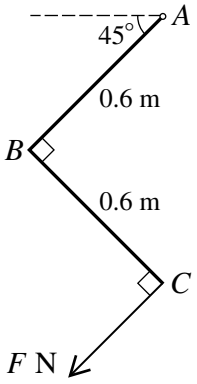


Fig. 2

Calculate F given instead that the force acts perpendicular to the rod as shown in Fig. 2. [2]

3 A particle P is projected with speed $25\,\text{m s}^{-1}$ at an angle of 45° above the horizontal from a point O on horizontal ground. At time t s after projection the horizontal and vertically upward displacements of P 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 path of P is $y = x - 0.016x^2$. [4]

(ii) Calculate the horizontal distance between the two positions at which P is 2.4 m above the ground. [2]

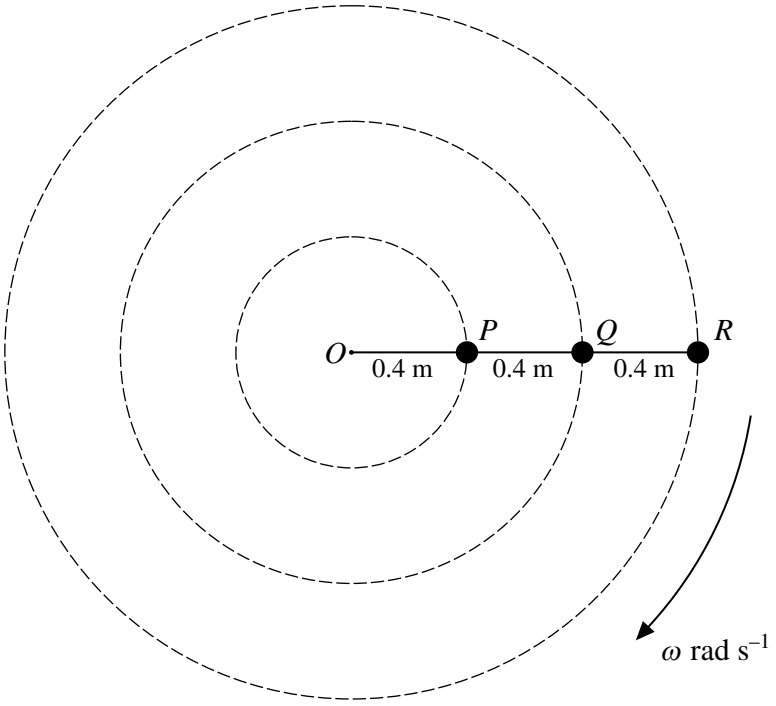
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4 A particle P of mass 0.4 kg is projected horizontally with velocity 8 m s^{-1} from a point O on a smooth horizontal surface. The motion of P is opposed by a resisting force of magnitude $0.2v^2$ N, where v m s^{-1} is the velocity of P at time t s after projection.

(i) Show that $v = \dfrac{8}{1+4t}$. [4]

(ii) Calculate the distance OP when $t = 1.5$. [4]

5



One end of a light inextensible string of length 1.2 m is attached to a fixed point O on a smooth horizontal surface. Particles P, Q and R are attached to the string so that $OP = PQ = QR = 0.4$ m. The particles rotate in horizontal circles about O with constant angular speed ω rad s^{-1} and with O, P, Q and R in a straight line (see diagram). R has mass 0.2 kg, and the tensions in the parts of the string attached to Q are 6 N and 10 N.

(i) Show that $\omega = 5$. [2]

(ii) Calculate the mass of Q. [3]

(iii) Given that the kinetic energy of P is equal to the kinetic energy of R, calculate the tension in the part of the string attached to O. [4]

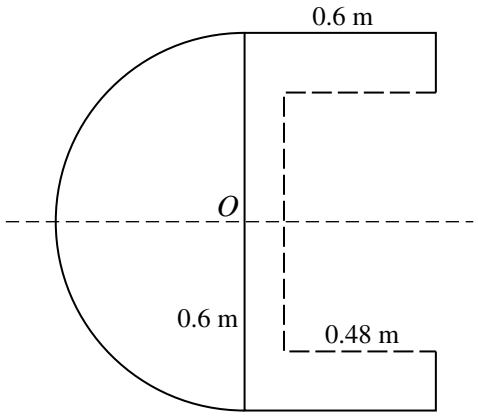
[Questions 6 and 7 are printed on the next page.]

6 A uniform solid consists of a hemisphere with centre O and radius 0.6 m joined to a cylinder of radius 0.6 m and height 0.6 m. The plane face of the hemisphere coincides with one of the plane faces of the cylinder.

(i) Calculate the distance of the centre of mass of the solid from O. [4]

[The volume of a hemisphere of radius r is $\frac{2}{3}\pi r^3$.]

(ii)



A cylindrical hole, of length 0.48 m, starting at the plane face of the solid, is made along the axis of symmetry (see diagram). The resulting solid has its centre of mass at O. Show that the area of the cross-section of the hole is $\frac{3}{16}\pi\,\text{m}^2$. [4]

(iii) It is possible to increase the length of the cylindrical hole so that the solid still has its centre of mass at O. State the increase in the length of the hole. [1]

7 One end of a light elastic string of natural length 0.4 m and modulus of elasticity 20 N is attached to a particle P of mass 0.8 kg. The other end of the string is attached to a fixed point O at the top of a smooth plane inclined at 30° to the horizontal. The particle rests in equilibrium on the plane.

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

P is projected from its equilibrium position up the plane along a line of greatest slope. In the subsequent motion P just reaches O, and later just reaches the foot of the plane. Calculate

(ii) the speed of projection of P, [4]

(iii) the length of the line of greatest slope of the plane. [4]

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