UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

MATHEMATICS **9709/53**

Paper 5 Mechanics 2 **(M2)** **May/June 2010**

1 hour 15 minutes

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

* 6 9 9 0 4 7 2 6 1 *

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.

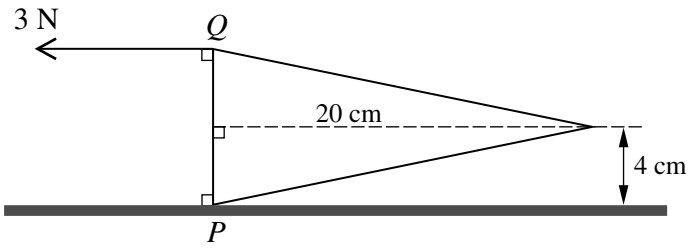
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
The total number of marks for this paper is 50.
Questions carrying smaller numbers of marks are printed earlier in the paper, and questions carrying larger numbers of marks later in the paper.

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

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1 A particle is projected horizontally with speed $12\,\text{m s}^{-1}$ from the top of a high cliff. Find the direction of motion of the particle after 2 s. [3]

2



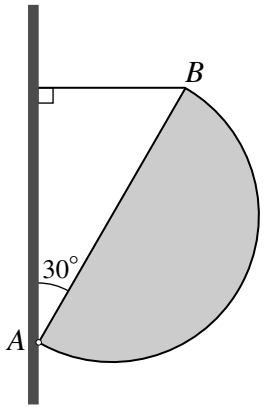
A uniform solid cone has height 20 cm and base radius 4 cm. PQ is a diameter of the base of the cone. The cone is held in equilibrium, with P in contact with a horizontal surface and PQ vertical, by a force applied at Q. This force has magnitude 3 N and acts parallel to the axis of the cone (see diagram). Calculate the mass of the cone. [4]

3 Two particles P and Q are projected simultaneously with speed $40\,\text{m s}^{-1}$ from a point O on a horizontal plane. Both particles subsequently pass at different times through the point A which has horizontal and vertically upward displacements from O of 40 m and 15 m respectively.

(i) By considering the equation of the trajectory of a projectile, show that each angle of projection satisfies the equation $\tan^2\theta - 8\tan\theta + 4 = 0$. [3]

(ii) Calculate the distance between the points at which P and Q strike the plane. [5]

4



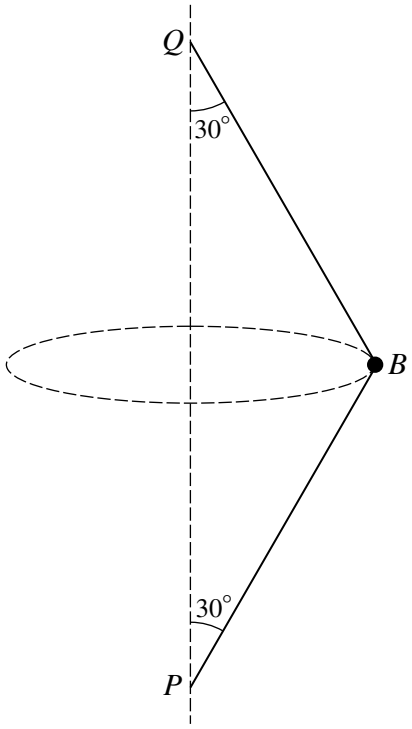
AB is the diameter of a uniform semicircular lamina which has radius 0.3 m and mass 0.4 kg. The lamina is hinged to a vertical wall at A with AB inclined at 30° to the vertical. One end of a light inextensible string is attached to the lamina at B and the other end of the string is attached to the wall vertically above A. The lamina is in equilibrium in a vertical plane perpendicular to the wall with the string horizontal (see diagram).

(i) Show that the tension in the string is 2.00 N correct to 3 significant figures. [4]

(ii) Find the magnitude and direction of the force exerted on the lamina by the hinge. [3]

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5



A small ball B of mass 0.4 kg is attached to fixed points P and Q on a vertical axis by two light inextensible strings of equal length. Both strings are taut and each is inclined at 30° to the vertical. The ball moves in a horizontal circle (see diagram).

(i) It is given that when the ball moves with speed $6\,\text{m s}^{-1}$ the tension in the string QB is three times the tension in the string PB. Calculate the radius of the circle. [4]

The ball now moves along this circular path with the minimum possible speed.

(ii) State the tension in the string PB in this case, and find the speed of the ball. [4]

6 A particle P of mass 0.5 kg moves in a straight line on a smooth horizontal surface. At time t s, the displacement of P from a fixed point on the line is x m and the velocity of P is $v\,\text{m s}^{-1}$. It is given that when $t = 0$, $x = 0$ and $v = 9$. The motion of P is opposed by a force of magnitude $3\sqrt{v}$ N.

(i) By solving an appropriate differential equation, show that $v = (27 - 9x)^{\frac{2}{3}}$. [5]

(ii) Calculate the value of x when $t = 0.5$. [4]

7 One end of a light elastic string of natural length 3 m and modulus of elasticity 24 N is attached to a fixed point O. A particle P of mass 0.4 kg is attached to the other end of the string. P is projected vertically downwards from O with initial speed $2\,\text{m s}^{-1}$. When the extension of the string is x m the speed of P is $v\,\text{m s}^{-1}$.

(i) Show that $v^2 = 64 + 20x - 20x^2$. [4]

(ii) Find the greatest speed of the particle. [3]

(iii) Calculate the greatest tension in the string. [4]

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