UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

MATHEMATICS **9709/51**

Paper 5 Mechanics 2 **(M2)** **May/June 2013**

1 hour 15 minutes

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

* 4 9 7 1 4 7 8 5 3 0 *

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 small ball is projected with speed $20\,\text{m s}^{-1}$ 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 upwards displacements of the ball from O are x m and y m respectively.

(i) Express x and y in terms of t. [2]

(ii) Show that the equation of the trajectory of the ball is $y = x - \frac{1}{40}x^2$. [2]

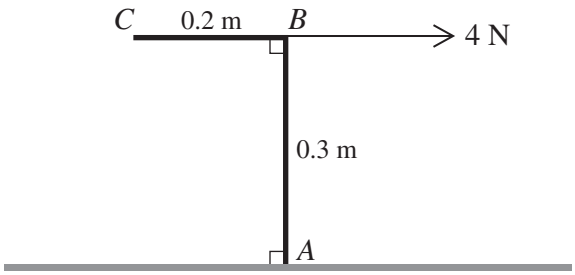
(iii) State the distance from O of the point at which the ball first strikes the ground. [1]

2 A particle P of mass 0.4 kg is attached to one end of a light elastic string of natural length 1.2 m and modulus of elasticity 19.2 N. The other end of the string is attached to a fixed point A. The particle P is released from rest at the point 2.7 m vertically above A. Calculate

(i) the initial acceleration of P, [3]

(ii) the speed of P when it reaches A. [4]

3



A uniform object ABC is formed from two rods AB and BC joined rigidly at right angles at B. The rod AB has length 0.3 m and the rod BC has length 0.2 m. The object rests with the end A on a rough horizontal surface and the rod AB vertical. The object is held in equilibrium by a horizontal force of magnitude 4 N applied at B and acting in the direction CB (see diagram).

(i) Find the distance of the centre of mass of the object from AB. [3]

(ii) Calculate the weight of the object. [2]

(iii) Find the least possible value of the coefficient of friction between the surface and the object. [2]

4 A particle of mass 0.2 kg is projected vertically downwards with initial speed $4\,\text{m s}^{-1}$. A resisting force of magnitude $0.09v$ N acts vertically upwards on the particle during its descent, where $v\,\text{m s}^{-1}$ is the downwards velocity of the particle at time t s after being set in motion.

(i) Show that the acceleration of the particle is $(10 - 0.45v)\,\text{m s}^{-2}$. [1]

(ii) Find v when $t = 1.5$. [5]

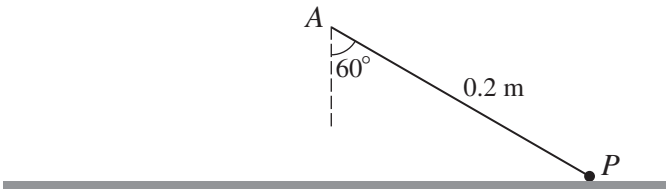
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5 A particle P is projected with speed $50\,\text{m s}^{-1}$ at an angle of $40°$ above the horizontal from a point O. For the instant 2.5 s after projection, calculate

(i) the speed of P, [3]

(ii) the angle between OP and the horizontal. [4]

6

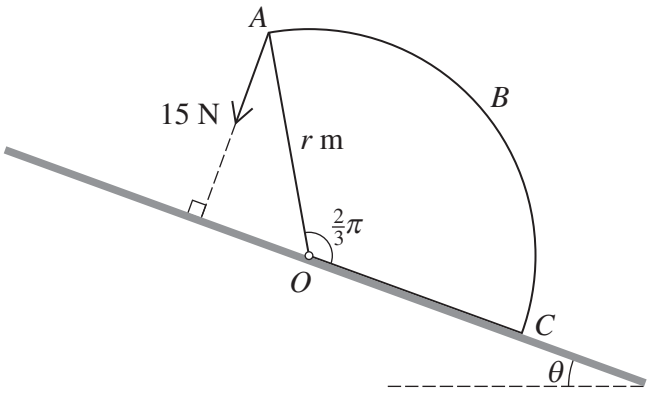


One end of a light inextensible string of length 0.2 m is attached to a fixed point A which is above a smooth horizontal table. A particle P of mass 0.3 kg is attached to the other end of the string. P moves on the table in a horizontal circle, with the string taut and making an angle of $60°$ with the downward vertical (see diagram).

(i) Calculate the tension in the string if the speed of P is $1.2\,\text{m s}^{-1}$. [3]

(ii) For the motion as described, show that the angular speed of P cannot exceed $10\,\text{rad s}^{-1}$, and hence find the greatest possible value for the kinetic energy of P. [6]

7



$OABC$ is the cross-section through the centre of mass of a uniform prism of weight 20 N. The cross-section is in the shape of a sector of a circle with centre O, radius $OA = r$ m and angle $AOC = \frac{2}{3}\pi$ radians. The prism lies on a plane inclined at an angle θ radians to the horizontal, where $\theta < \frac{1}{3}\pi$. OC lies along a line of greatest slope with O higher than C. The prism is freely hinged to the plane at O. A force of magnitude 15 N acts at A, in a direction towards to the plane and at right angles to it (see diagram). Given that the prism remains in equilibrium, find the set of possible values of θ. [9]

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