UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

MATHEMATICS **9709/51**

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

1 hour 15 minutes

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

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READ THESE INSTRUCTIONS FIRST

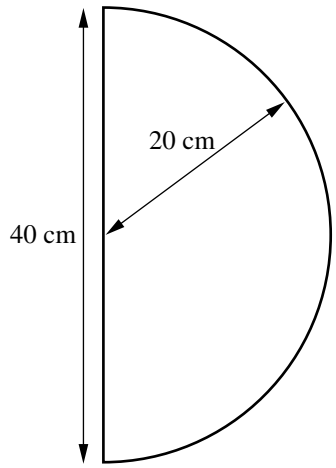
If you have been given an Answer Booklet, follow the instructions on the front cover of the Booklet.
Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, 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.

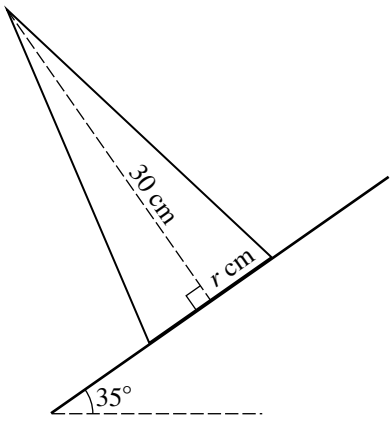
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1



A frame consists of a uniform semicircular wire of radius 20 cm and mass 2 kg, and a uniform straight wire of length 40 cm and mass 0.9 kg. The ends of the semicircular wire are attached to the ends of the straight wire (see diagram). Find the distance of the centre of mass of the frame from the straight wire. [4]

2



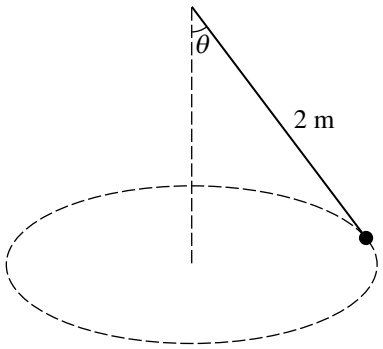
A uniform solid cone has height 30 cm and base radius r cm. The cone is placed with its axis vertical on a rough horizontal plane. The plane is slowly tilted and the cone remains in equilibrium until the angle of inclination of the plane reaches 35°, when the cone topples. The diagram shows a cross-section of the cone.

(i) Find the value of r. [3]

(ii) Show that the coefficient of friction between the cone and the plane is greater than 0.7. [2]

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3

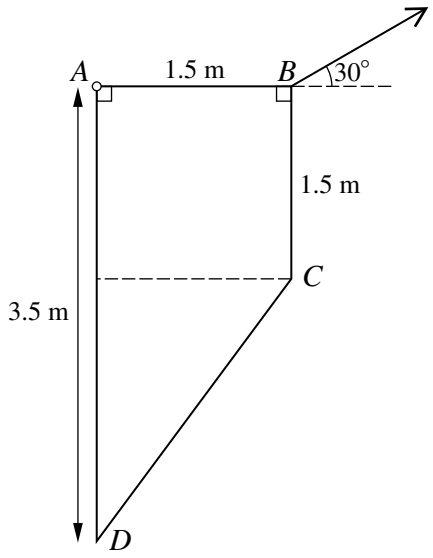


A particle of mass 0.24 kg is attached to one end of a light inextensible string of length 2 m. The other end of the string is attached to a fixed point. The particle moves with constant speed in a horizontal circle. The string makes an angle θ with the vertical (see diagram), and the tension in the string is T N. The acceleration of the particle has magnitude 7.5 m s^{-2}.

(i) Show that $\tan\theta = 0.75$ and find the value of T. [4]

(ii) Find the speed of the particle. [2]

4



A uniform lamina of weight 15 N is in the form of a trapezium $ABCD$ with dimensions as shown in the diagram. The lamina is freely hinged at A to a fixed point. One end of a light inextensible string is attached to the lamina at B. The lamina is in equilibrium with AB horizontal; the string is taut and in the same vertical plane as the lamina, and makes an angle of 30° upwards from the horizontal (see diagram). Find the tension in the string. [5]

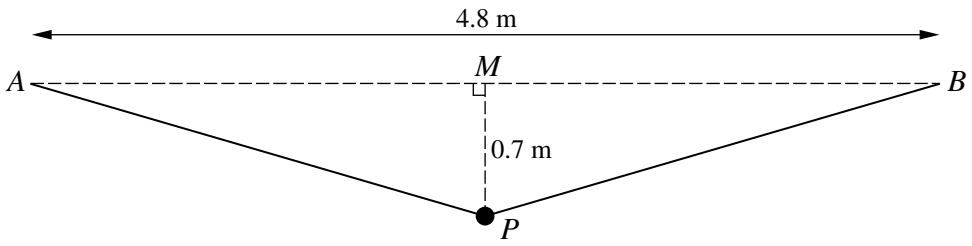
5 A particle is projected from a point O on horizontal ground. The velocity of projection has magnitude $20\,\text{m s}^{-1}$ and direction upwards at an angle θ to the horizontal. The particle passes through the point which is 7 m above the ground and 16 m horizontally from O, and hits the ground at the point A.

(i) Using the equation of the particle's trajectory and the identity $\sec^2\theta = 1 + \tan^2\theta$, show that the possible values of $\tan\theta$ are $\frac{3}{4}$ and $\frac{17}{4}$. [4]

(ii) Find the distance OA for each of the two possible values of $\tan\theta$. [3]

(iii) Sketch in the same diagram the two possible trajectories. [2]

6



A particle P of mass 0.35 kg is attached to the mid-point of a light elastic string of natural length 4 m. The ends of the string are attached to fixed points A and B which are 4.8 m apart at the same horizontal level. P hangs in equilibrium at a point 0.7 m vertically below the mid-point M of AB (see diagram).

(i) Find the tension in the string and hence show that the modulus of elasticity of the string is 25 N. [4]

P is now held at rest at a point 1.8 m vertically below M, and is then released.

(ii) Find the speed with which P passes through M. [6]

7 A particle P of mass 0.25 kg moves in a straight line on a smooth horizontal surface. P starts at the point O with speed $10\,\text{m s}^{-1}$ and moves towards a fixed point A on the line. At time t s the displacement of P from O is x m and the velocity of P is $v\,\text{m s}^{-1}$. A resistive force of magnitude $(5 - x)$ N acts on P in the direction towards O.

(i) Form a differential equation in v and x. By solving this differential equation, show that $v = 10 - 2x$. [6]

(ii) Find x in terms of t, and hence show that the particle is always less than 5 m from O. [5]

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