

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

**HIGHER MATHEMATICS**  
**MATHEMATICS**

**8719/05**  
**9709/05**

Paper 5 Mechanics 2 **(M2)**

October/November 2005

**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.

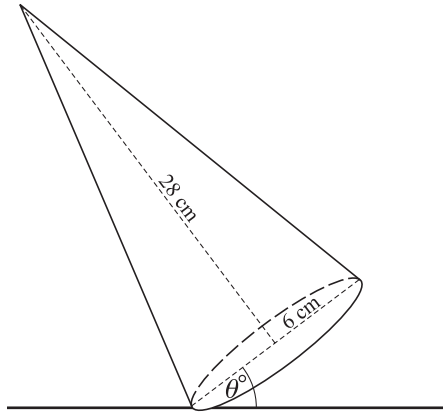
The use of an electronic calculator is expected, where appropriate.

You are reminded of the need for clear presentation in your answers.

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

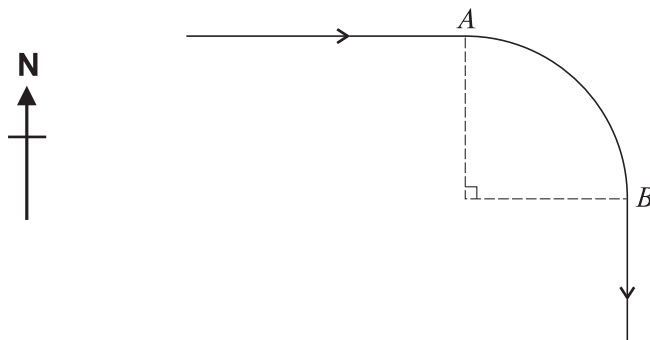


1



A uniform solid cone has vertical height 28 cm and base radius 6 cm. The cone is held with a point of the circumference of its base in contact with a horizontal table, and with the base making an angle of  $\theta^\circ$  with the horizontal (see diagram). When the cone is released, it moves towards the equilibrium position in which its base is in contact with the table. Show that  $\theta < 40.6$ , correct to 1 decimal place. [3]

2

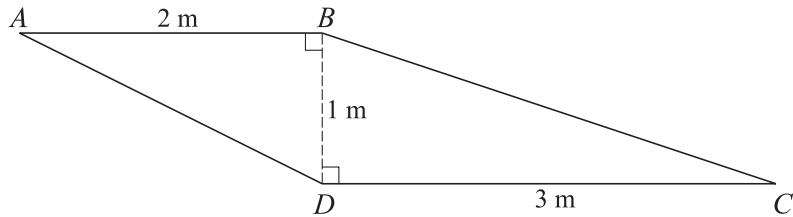


An aircraft flies horizontally at a constant speed of  $220 \text{ m s}^{-1}$ . Initially it is flying due east. On reaching a point  $A$  it flies in a circular arc from  $A$  to  $B$ , taking 50 s. At  $B$  the aircraft is flying due south (see diagram).

(i) Show that the radius of the arc is approximately 7000 m. [3]

(ii) Find the magnitude of the acceleration of the aircraft while it is flying between  $A$  and  $B$ . [2]

3



A uniform lamina  $ABCD$  is in the form of a trapezium in which  $AB$  and  $DC$  are parallel and have lengths 2 m and 3 m respectively.  $BD$  is perpendicular to the parallel sides and has length 1 m (see diagram).

(i) Find the distance of the centre of mass of the lamina from  $BD$ . [3]

The lamina has weight  $W$  N and is in equilibrium, suspended by a vertical string attached to the lamina at  $B$ . The lamina rests on a vertical support at  $C$ . The lamina is in a vertical plane with  $AB$  and  $DC$  horizontal.

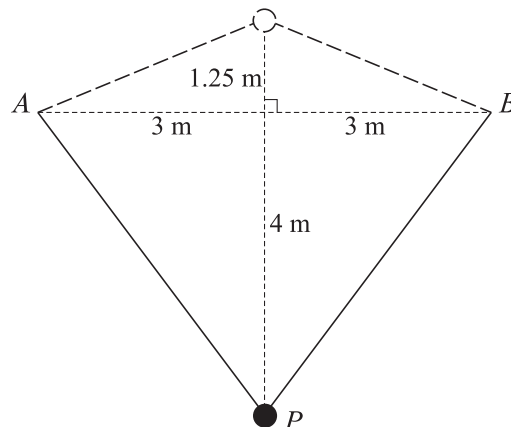
(ii) Find, in terms of  $W$ , the tension in the string and the magnitude of the force exerted on the lamina at  $C$ . [3]

4 A particle is projected from horizontal ground with speed  $u$  m s<sup>-1</sup> at an angle of  $\theta^\circ$  above the horizontal. The greatest height reached by the particle is 10 m and the particle hits the ground at a distance of 40 m from the point of projection. In either order,

(i) find the values of  $u$  and  $\theta$ ,

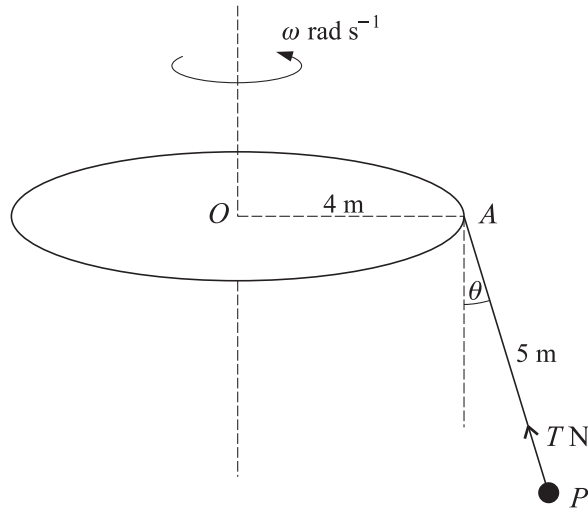
(ii) find the equation of the trajectory, in the form  $y = ax - bx^2$ , where  $x$  m and  $y$  m are the horizontal and vertical displacements of the particle from the point of projection. [7]

5



A particle  $P$  of mass 0.2 kg is attached to the mid-point of a light elastic string of natural length 5.5 m and modulus of elasticity  $\lambda$  N. The ends of the string are attached to fixed points  $A$  and  $B$  which are at the same horizontal level and 6 m apart.  $P$  is held at rest at a point 1.25 m vertically above the mid-point of  $AB$  and then released.  $P$  travels a distance 5.25 m downwards before coming to instantaneous rest (see diagram). By considering the changes in gravitational potential energy and elastic potential energy as  $P$  travels downwards, find the value of  $\lambda$ . [8]

6



A horizontal circular disc of radius 4 m is free to rotate about a vertical axis through its centre  $O$ . One end of a light inextensible rope of length 5 m is attached to a point  $A$  of the circumference of the disc, and an object  $P$  of mass 24 kg is attached to the other end of the rope. When the disc rotates with constant angular speed  $\omega \text{ rad s}^{-1}$ , the rope makes an angle of  $\theta$  radians with the vertical and the tension in the rope is  $T \text{ N}$  (see diagram). You may assume that the rope is always in the same vertical plane as the radius  $OA$  of the disc.

(i) Given that  $\cos \theta = \frac{24}{25}$ , find the value of  $\omega$ . [5]

(ii) Given instead that the speed of  $P$  is twice the speed of the point  $A$ , find

(a) the value of  $T$ , [3]

(b) the speed of  $P$ . [2]

7 A particle of mass 0.25 kg moves in a straight line on a smooth horizontal surface. A variable resisting force acts on the particle. At time  $t \text{ s}$  the displacement of the particle from a point on the line is  $x \text{ m}$ , and its velocity is  $(8 - 2x) \text{ m s}^{-1}$ . It is given that  $x = 0$  when  $t = 0$ .

(i) Find the acceleration of the particle in terms of  $x$ , and hence find the magnitude of the resisting force when  $x = 1$ . [3]

(ii) Find an expression for  $x$  in terms of  $t$ . [6]

(iii) Show that the particle is always less than 4 m from its initial position. [2]

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