

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)**

May/June 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.

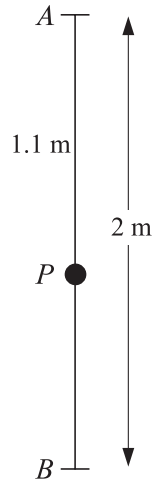
Answer **all** the questions.  
Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.  
Where a numerical value for the acceleration due to gravity is needed, use  $10 \text{ m s}^{-2}$ .  
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 **5** printed pages and **3** blank pages.

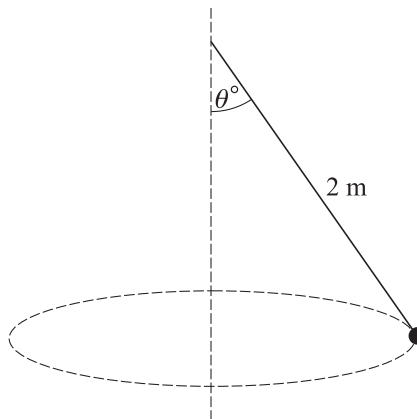


1



A particle  $P$  of mass  $m$  kg is attached to the mid-point of a light elastic string of natural length 0.8 m and modulus of elasticity 8 N. One end of the string is attached to a fixed point  $A$  and the other end is attached to a fixed point  $B$  which is 2 m vertically below  $A$ . When the particle is in equilibrium the distance  $AP$  is 1.1 m (see diagram). Find the value of  $m$ . [4]

2



A particle of mass 0.15 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 magnitude of the acceleration of the particle is  $7 \text{ m s}^{-2}$ . The string makes an angle of  $\theta^\circ$  with the downward vertical, as shown in the diagram. Find

- (i) the value of  $\theta$  to the nearest whole number, [3]
- (ii) the tension in the string, [1]
- (iii) the speed of the particle. [2]

3

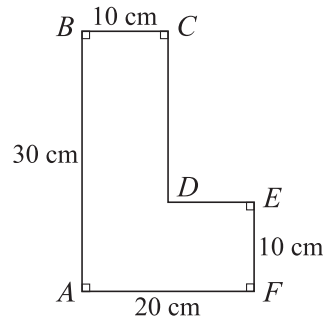


Fig. 1

$ABCDEF$  is the L-shaped cross-section of a uniform solid. This cross-section passes through the centre of mass of the solid and has dimensions as shown in Fig. 1.

- (i) Find the distance of the centre of mass of the solid from the edge  $AB$  of the cross-section. [3]

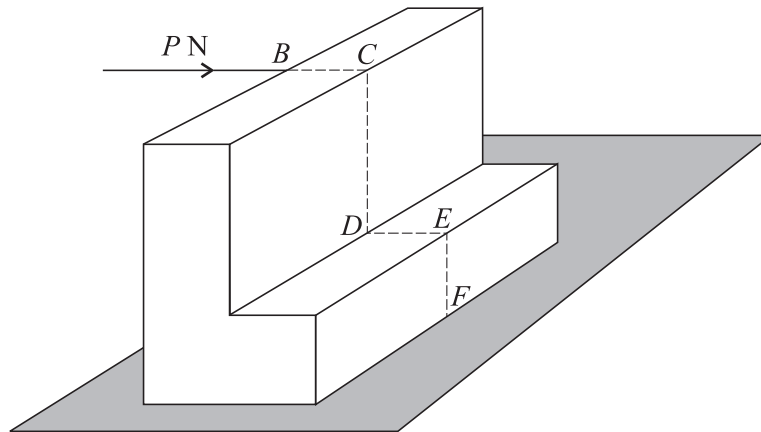


Fig. 2

The solid rests in equilibrium with the face containing the edge  $AF$  of the cross-section in contact with a horizontal table. The weight of the solid is  $W$  N. A horizontal force of magnitude  $P$  N is applied to the solid at the point  $B$ , in the direction of  $BC$  (see Fig. 2). The table is sufficiently rough to prevent sliding.

- (ii) Find  $P$  in terms of  $W$ , given that the equilibrium of the solid is about to be broken. [3]

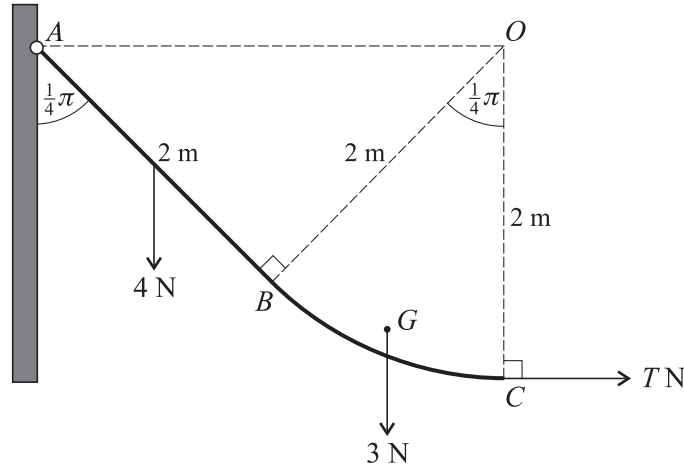
- 4 A particle  $P$  of mass  $0.4$  kg is attached to one end of a light elastic string of natural length  $1.5$  m and modulus of elasticity  $6$  N. The other end of the string is attached to a fixed point  $O$  on a rough horizontal table.  $P$  is released from rest at a point on the table  $3.5$  m from  $O$ . The speed of  $P$  at the instant the string becomes slack is  $6 \text{ m s}^{-1}$ . Find

- (i) the work done against friction during the period from the release of  $P$  until the string becomes slack, [5]
- (ii) the coefficient of friction between  $P$  and the table. [2]

- 5 The acceleration of a particle moving in a straight line is  $(x - 2.4) \text{ m s}^{-2}$  when its displacement from a fixed point  $O$  of the line is  $x \text{ m}$ . The velocity of the particle is  $v \text{ m s}^{-1}$ , and it is given that  $v = 2.5$  when  $x = 0$ . Find

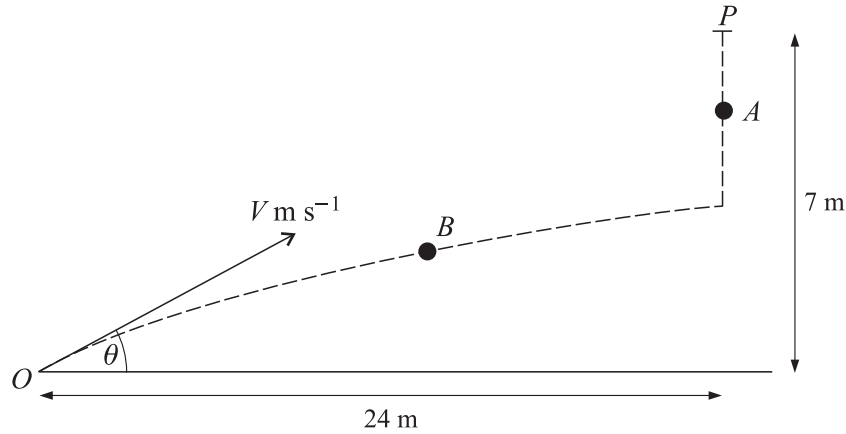
- (i) an expression for  $v$  in terms of  $x$ , [5]  
 (ii) the minimum value of  $v$ . [2]

6



A rigid rod consists of two parts. The part  $BC$  is in the form of an arc of a circle of radius  $2 \text{ m}$  and centre  $O$ , with angle  $BOC = \frac{1}{4}\pi$  radians.  $BC$  is uniform and has weight  $3 \text{ N}$ . The part  $AB$  is straight and of length  $2 \text{ m}$ ; it is uniform and has weight  $4 \text{ N}$ . The part  $AB$  of the rod is a tangent to the arc  $BC$  at  $B$ . The end  $A$  of the rod is freely hinged to a fixed point of a vertical wall. The rod is held in equilibrium, with the straight part  $AB$  making an angle of  $\frac{1}{4}\pi$  radians with the wall, by means of a horizontal string attached to  $C$ . The string is in the same vertical plane as the rod, and the tension in the string is  $T \text{ N}$  (see diagram).

- (i) Show that the centre of mass  $G$  of the part  $BC$  of the rod is at a distance of  $2.083 \text{ m}$  from the wall, correct to 4 significant figures. [4]  
 (ii) Find the value of  $T$ . [3]  
 (iii) State the magnitude of the horizontal component and the magnitude of the vertical component of the force exerted on the rod by the hinge. [1]



A particle  $A$  is released from rest at time  $t = 0$ , at a point  $P$  which is 7 m above horizontal ground. At the same instant as  $A$  is released, a particle  $B$  is projected from a point  $O$  on the ground. The horizontal distance of  $O$  from  $P$  is 24 m. Particle  $B$  moves in the vertical plane containing  $O$  and  $P$ , with initial speed  $V \text{ m s}^{-1}$  and initial direction making an angle of  $\theta$  above the horizontal (see diagram). Write down

- (i) an expression for the height of  $A$  above the ground at time  $t$  s, [1]
- (ii) an expression in terms of  $V$ ,  $\theta$  and  $t$  for
  - (a) the horizontal distance of  $B$  from  $O$ , [1]
  - (b) the height of  $B$  above the ground. [1]

At time  $t = T$  the particles  $A$  and  $B$  collide at a point above the ground.

- (iii) Show that  $\tan \theta = \frac{7}{24}$  and that  $VT = 25$ . [6]
- (iv) Deduce that  $7V^2 > 3125$ . [3]

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