



UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS  
General Certificate of Education Advanced Level

**MATHEMATICS**

**9709/05**

Paper 5 Mechanics 2 (M2)

**May/June 2008**

**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.

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  $10 \text{ m s}^{-2}$ .

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.

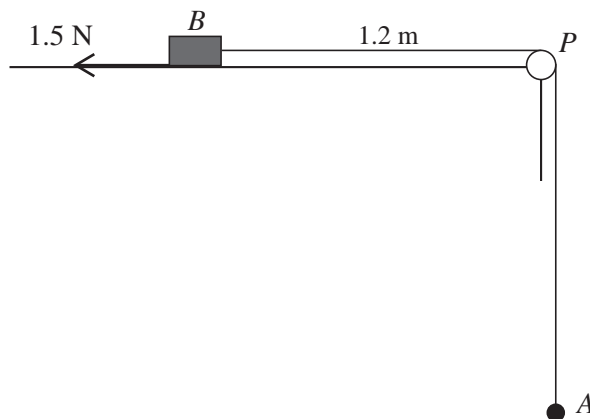
Questions carrying smaller numbers of marks are printed earlier in the paper, and questions carrying larger numbers of marks later in the paper.

This document consists of 4 printed pages.



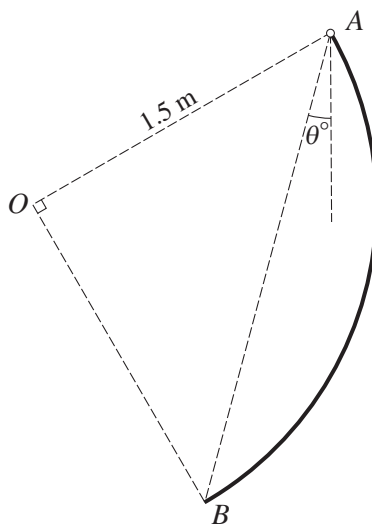
2

1



A particle  $A$  and a block  $B$  are attached to opposite ends of a light elastic string of natural length  $2\text{ m}$  and modulus of elasticity  $6\text{ N}$ . The block is at rest on a rough horizontal table. The string passes over a small smooth pulley  $P$  at the edge of the table, with the part  $BP$  of the string horizontal and of length  $1.2\text{ m}$ . The frictional force acting on  $B$  is  $1.5\text{ N}$  and the system is in equilibrium (see diagram). Find the distance  $PA$ . [3]

2



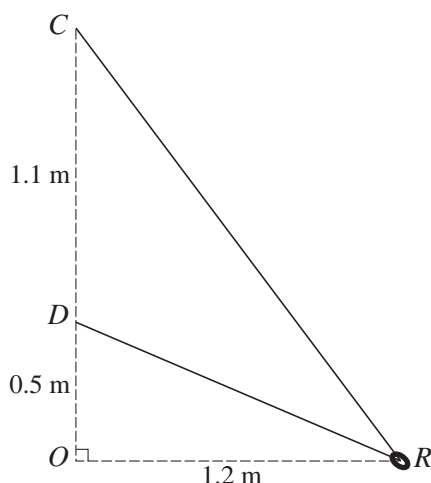
A uniform rigid wire  $AB$  is in the form of a circular arc of radius  $1.5\text{ m}$  with centre  $O$ . The angle  $AOB$  is a right angle. The wire is in equilibrium, freely suspended from the end  $A$ . The chord  $AB$  makes an angle of  $\theta^\circ$  with the vertical (see diagram).

(i) Show that the distance of the centre of mass of the arc from  $O$  is  $1.35\text{ m}$ , correct to 3 significant figures. [2]

(ii) Find the value of  $\theta$ . [3]

3

3

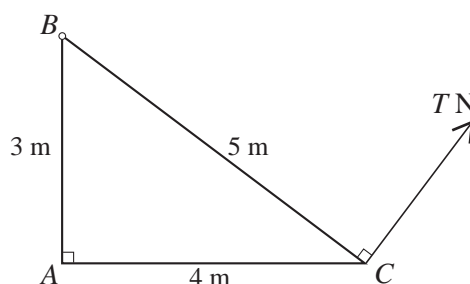


One end of a light inextensible string is attached to a point  $C$ . The other end is attached to a point  $D$ , which is 1.1 m vertically below  $C$ . A small smooth ring  $R$ , of mass 0.2 kg, is threaded on the string and moves with constant speed  $v \text{ m s}^{-1}$  in a horizontal circle, with centre at  $O$  and radius 1.2 m, where  $O$  is 0.5 m vertically below  $D$  (see diagram).

(i) Show that the tension in the string is 1.69 N, correct to 3 significant figures. [3]

(ii) Find the value of  $v$ . [3]

4



Uniform rods  $AB$ ,  $AC$  and  $BC$  have lengths 3 m, 4 m and 5 m respectively, and weights 15 N, 20 N and 25 N respectively. The rods are rigidly joined to form a right-angled triangular frame  $ABC$ . The frame is hinged at  $B$  to a fixed point and is held in equilibrium, with  $AC$  horizontal, by means of an inextensible string attached at  $C$ . The string is at right angles to  $BC$  and the tension in the string is  $T \text{ N}$  (see diagram).

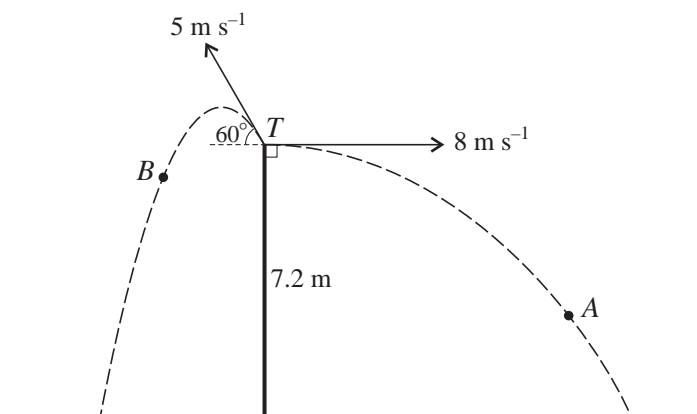
(i) Find the value of  $T$ . [2]

A uniform triangular lamina  $PQR$ , of weight 60 N, has the same size and shape as the frame  $ABC$ . The lamina is now attached to the frame with  $P$ ,  $Q$  and  $R$  at  $A$ ,  $B$  and  $C$  respectively. The composite body is held in equilibrium with  $A$ ,  $B$  and  $C$  in the same positions as before. Find

(ii) the new value of  $T$ , [2]

(iii) the magnitude of the vertical component of the force acting on the composite body at  $B$ . [2]

5



Particles  $A$  and  $B$  are projected simultaneously from the top  $T$  of a vertical tower, and move in the same vertical plane.  $T$  is  $7.2$  m above horizontal ground.  $A$  is projected horizontally with speed  $8 \text{ m s}^{-1}$  and  $B$  is projected at an angle of  $60^\circ$  above the horizontal with speed  $5 \text{ m s}^{-1}$ .  $A$  and  $B$  move away from each other (see diagram).

- (i) Find the time taken for  $A$  to reach the ground. [2]

At the instant when  $A$  hits the ground,

- (ii) show that  $B$  is approximately  $5.2$  m above the ground, [2]  
 (iii) find the distance  $AB$ . [3]

- 6 One end of a light elastic string of natural length  $1.25$  m and modulus of elasticity  $20$  N is attached to a fixed point  $O$ . A particle  $P$  of mass  $0.5$  kg is attached to the other end of the string.  $P$  is held at rest at  $O$  and then released. When the extension of the string is  $x$  m the speed of  $P$  is  $v \text{ m s}^{-1}$ .

- (i) Show that  $v^2 = -32x^2 + 20x + 25$ . [4]  
 (ii) Find the maximum speed of  $P$ . [3]  
 (iii) Find the acceleration of  $P$  when it is at its lowest point. [4]

- 7 A particle  $P$  of mass  $0.5$  kg moves on a horizontal surface along the straight line  $OA$ , in the direction from  $O$  to  $A$ . The coefficient of friction between  $P$  and the surface is  $0.08$ . Air resistance of magnitude  $0.2v$  N opposes the motion, where  $v \text{ m s}^{-1}$  is the speed of  $P$  at time  $t$  s. The particle passes through  $O$  with speed  $4 \text{ m s}^{-1}$  when  $t = 0$ .

- (i) Show that  $2.5 \frac{dv}{dt} = -(v + 2)$  and hence find the value of  $t$  when  $v = 0$ . [7]  
 (ii) Show that  $\frac{dx}{dt} = 6e^{-0.4t} - 2$ , where  $x$  m is the displacement of  $P$  from  $O$  at time  $t$  s, and hence find the distance  $OP$  when  $v = 0$ . [5]

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