



UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS  
General Certificate of Education Advanced Level

**MATHEMATICS**

**9709/05**

Paper 5 Mechanics 2 (M2)

**May/June 2007**

**1 hour 15 minutes**

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



**READ THESE INSTRUCTIONS FIRST**

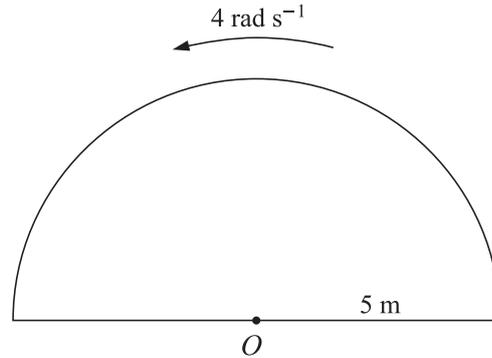
If you have been given an Answer Booklet, follow the instructions on the front cover of the Booklet.  
Write your Centre number, candidate number and name on all the work you hand in.  
Write in dark blue or black pen.  
You may use a soft pencil for any diagrams or graphs.  
Do not use staples, paper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

1



A uniform semicircular lamina has radius 5 m. The lamina rotates in a horizontal plane about a vertical axis through  $O$ , the mid-point of its diameter. The angular speed of the lamina is  $4 \text{ rad s}^{-1}$  (see diagram). Find

(i) the distance of the centre of mass of the lamina from  $O$ , [2]

(ii) the speed with which the centre of mass of the lamina is moving. [2]

2 A particle starts from rest at  $O$  and travels in a straight line. Its acceleration is  $(3 - 2x) \text{ m s}^{-2}$ , where  $x \text{ m}$  is the displacement of the particle from  $O$ .

(i) Find the value of  $x$  for which the velocity of the particle reaches its maximum value. [1]

(ii) Find this maximum velocity. [4]

3

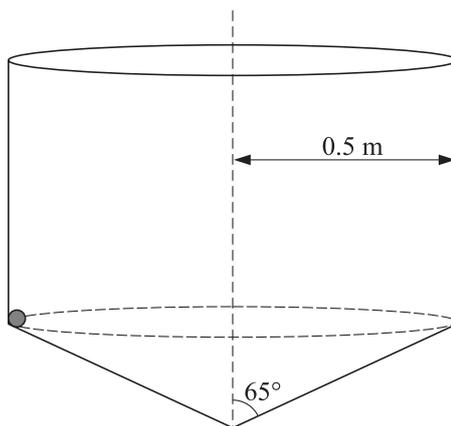


Fig. 1

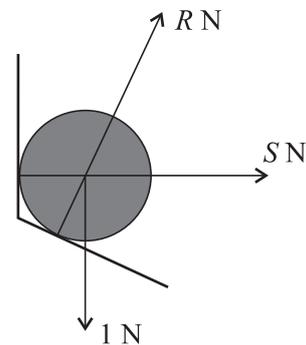
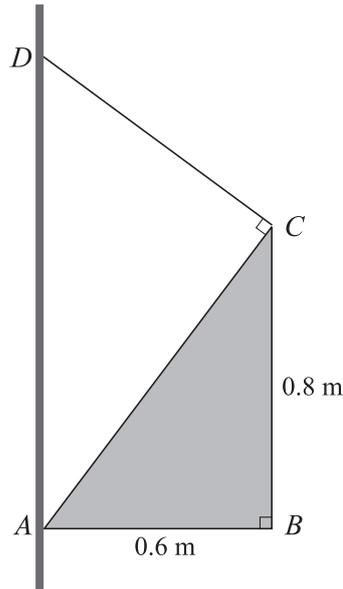


Fig. 2

A hollow container consists of a smooth circular cylinder of radius 0.5 m, and a smooth hollow cone of semi-vertical angle  $65^\circ$  and radius 0.5 m. The container is fixed with its axis vertical and with the cone below the cylinder. A steel ball of weight 1 N moves with constant speed  $2.5 \text{ m s}^{-1}$  in a horizontal circle inside the container. The ball is in contact with both the cylinder and the cone (see Fig. 1). Fig. 2 shows the forces acting on the ball, i.e. its weight and the forces of magnitudes  $R \text{ N}$  and  $S \text{ N}$  exerted by the container at the points of contact. Given that the radius of the ball is negligible compared with the radius of the cylinder, find  $R$  and  $S$ . [6]

4



A uniform triangular lamina  $ABC$  is right-angled at  $B$  and has sides  $AB = 0.6$  m and  $BC = 0.8$  m. The mass of the lamina is 4 kg. One end of a light inextensible rope is attached to the lamina at  $C$ . The other end of the rope is attached to a fixed point  $D$  on a vertical wall. The lamina is in equilibrium with  $A$  in contact with the wall at a point vertically below  $D$ . The lamina is in a vertical plane perpendicular to the wall, and  $AB$  is horizontal. The rope is taut and at right angles to  $AC$  (see diagram). Find

- (i) the tension in the rope, [4]  
 (ii) the horizontal and vertical components of the force exerted at  $A$  on the lamina by the wall. [3]

5 One end of a light elastic string, of natural length 0.5 m and modulus of elasticity 140 N, is attached to a fixed point  $O$ . A particle of mass 0.8 kg is attached to the other end of the string. The particle is released from rest at  $O$ . By considering the energy of the system, find

- (i) the speed of the particle when the extension of the string is 0.1 m, [4]  
 (ii) the extension of the string when the particle is at its lowest point. [4]

6



$A$  and  $B$  are fixed points on a smooth horizontal table. The distance  $AB$  is 2.5 m. An elastic string of natural length 0.6 m and modulus of elasticity 24 N has one end attached to the table at  $A$ , and the other end attached to a particle  $P$  of mass 0.95 kg. Another elastic string of natural length 0.9 m and modulus of elasticity 18 N has one end attached to the table at  $B$ , and the other end attached to  $P$ . The particle  $P$  is held at rest at the mid-point of  $AB$  (see diagram).

- (i) Find the tensions in the strings. [3]

The particle is released from rest.

- (ii) Find the acceleration of  $P$  immediately after its release. [2]  
 (iii)  $P$  reaches its maximum speed at the point  $C$ . Find the distance  $AC$ . [4]

- 7 A particle is projected with speed  $65 \text{ m s}^{-1}$  from a point on horizontal ground, in a direction making an angle of  $\alpha^\circ$  above the horizontal. The particle reaches the ground again after 12 s. Find
- (i) the value of  $\alpha$ , [3]
  - (ii) the greatest height reached by the particle, [2]
  - (iii) the length of time for which the direction of motion of the particle is between  $20^\circ$  above the horizontal and  $20^\circ$  below the horizontal, [5]
  - (iv) the horizontal distance travelled by the particle in the time found in part (iii). [1]

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