

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

**MATHEMATICS**

**9709/04**

Paper 4 Mechanics 1 **(M1)**

May/June 2004

**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.

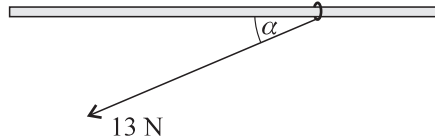
Answer **all** the questions.  
Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.  
Where a numerical value for the acceleration due to gravity is needed, use  $10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



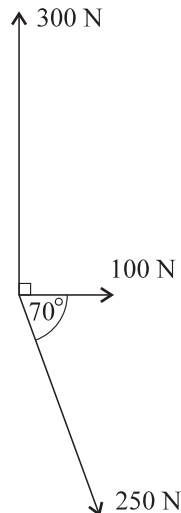
1



A ring of mass 1.1 kg is threaded on a fixed rough horizontal rod. A light string is attached to the ring and the string is pulled with a force of magnitude 13 N at an angle  $\alpha$  below the horizontal, where  $\tan \alpha = \frac{5}{12}$  (see diagram). The ring is in equilibrium.

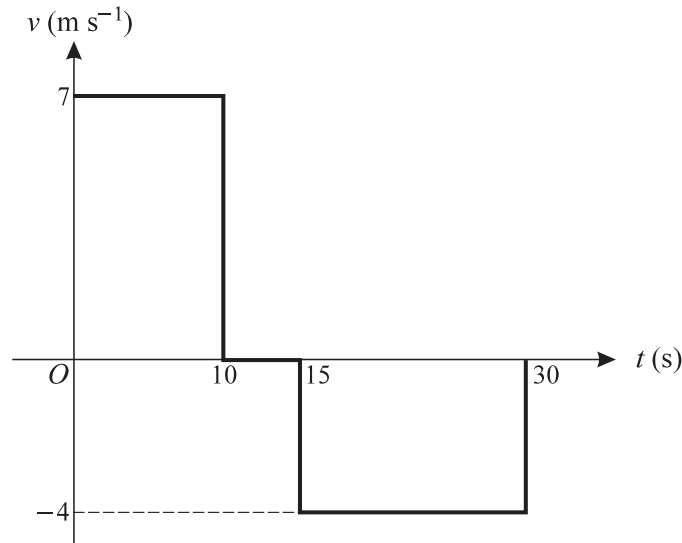
- (i) Find the frictional component of the contact force on the ring. [2]
- (ii) Find the normal component of the contact force on the ring. [2]
- (iii) Given that the equilibrium of the ring is limiting, find the coefficient of friction between the ring and the rod. [1]

2



Coplanar forces of magnitudes 250 N, 100 N and 300 N act at a point in the directions shown in the diagram. The resultant of the three forces has magnitude  $R$  N, and acts at an angle  $\alpha^\circ$  anticlockwise from the force of magnitude 100 N. Find  $R$  and  $\alpha$ . [6]

3



A boy runs from a point  $A$  to a point  $C$ . He pauses at  $C$  and then walks back towards  $A$  until reaching the point  $B$ , where he stops. The diagram shows the graph of  $v$  against  $t$ , where  $v \text{ m s}^{-1}$  is the boy's velocity at time  $t$  seconds after leaving  $A$ . The boy runs and walks in the same straight line throughout.

(i) Find the distances  $AC$  and  $AB$ . [3]

(ii) Sketch the graph of  $x$  against  $t$ , where  $x$  metres is the boy's displacement from  $A$ . Show clearly the values of  $t$  and  $x$  when the boy arrives at  $C$ , when he leaves  $C$ , and when he arrives at  $B$ . [3]

4 The top of an inclined plane is at a height of  $0.7 \text{ m}$  above the bottom. A block of mass  $0.2 \text{ kg}$  is released from rest at the top of the plane and slides a distance of  $2.5 \text{ m}$  to the bottom. Find the kinetic energy of the block when it reaches the bottom of the plane in each of the following cases:

(i) the plane is smooth, [2]

(ii) the coefficient of friction between the plane and the block is  $0.15$ . [5]

5 A particle  $P$  moves in a straight line that passes through the origin  $O$ . The velocity of  $P$  at time  $t$  seconds is  $v \text{ m s}^{-1}$ , where  $v = 20t - t^3$ . At time  $t = 0$  the particle is at rest at a point whose displacement from  $O$  is  $-36 \text{ m}$ .

(i) Find an expression for the displacement of  $P$  from  $O$  in terms of  $t$ . [3]

(ii) Find the displacement of  $P$  from  $O$  when  $t = 4$ . [1]

(iii) Find the values of  $t$  for which the particle is at  $O$ . [3]

6 A car of mass 1200 kg travels along a horizontal straight road. The power of the car's engine is 20 kW. The resistance to the car's motion is 400 N.

(i) Find the speed of the car at an instant when its acceleration is  $0.5 \text{ m s}^{-2}$ . [4]

(ii) Show that the maximum possible speed of the car is  $50 \text{ m s}^{-1}$ . [2]

The work done by the car's engine as the car travels from a point *A* to a point *B* is 1500 kJ.

(iii) Given that the car is travelling at its maximum possible speed between *A* and *B*, find the time taken to travel from *A* to *B*. [2]

7 A particle  $P_1$  is projected vertically upwards, from horizontal ground, with a speed of  $30 \text{ m s}^{-1}$ . At the same instant another particle  $P_2$  is projected vertically upwards from the top of a tower of height 25 m, with a speed of  $10 \text{ m s}^{-1}$ . Find

(i) the time for which  $P_1$  is higher than the top of the tower, [3]

(ii) the velocities of the particles at the instant when the particles are at the same height, [5]

(iii) the time for which  $P_1$  is higher than  $P_2$  and is moving upwards. [3]