

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

**MATHEMATICS**

**9709/04**

Paper 4 Mechanics 1 **(M1)**

October/November 2006

**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.

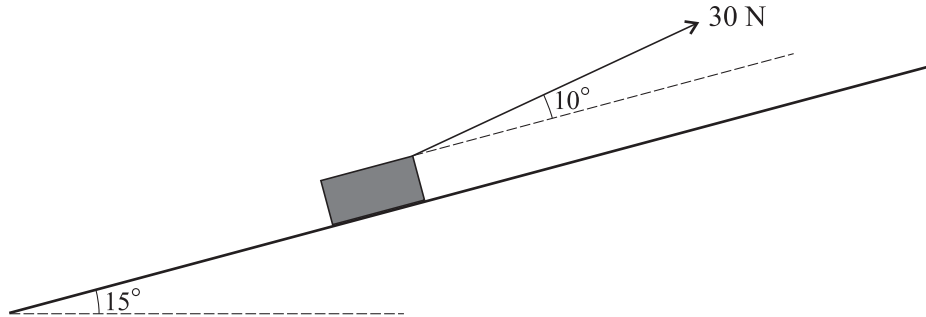
Answer **all** the questions.  
Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.  
Where a numerical value for the acceleration due to gravity is needed, use  $10 \text{ m s}^{-2}$ .  
The use of an electronic calculator is expected, where appropriate.  
You are reminded of the need for clear presentation in your answers.

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.  
At the end of the examination, fasten all your work securely together.

This document consists of 4 printed pages.



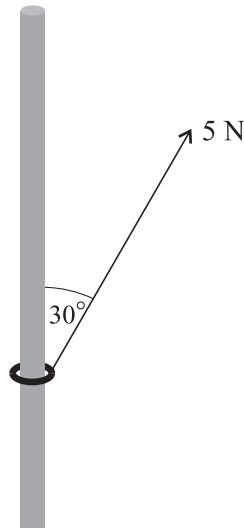
1



A box of mass 8 kg is pulled, at constant speed, up a straight path which is inclined at an angle of  $15^\circ$  to the horizontal. The pulling force is constant, of magnitude 30 N, and acts upwards at an angle of  $10^\circ$  from the path (see diagram). The box passes through the points  $A$  and  $B$ , where  $AB = 20$  m and  $B$  is above the level of  $A$ . For the motion from  $A$  to  $B$ , find

- (i) the work done by the pulling force, [2]
- (ii) the gain in potential energy of the box, [2]
- (iii) the work done against the resistance to motion of the box. [1]

2



A small ring of mass 0.6 kg is threaded on a rough rod which is fixed vertically. The ring is in equilibrium, acted on by a force of magnitude 5 N pulling upwards at  $30^\circ$  to the vertical (see diagram).

- (i) Show that the frictional force acting on the ring has magnitude 1.67 N, correct to 3 significant figures. [2]
- (ii) The ring is on the point of sliding down the rod. Find the coefficient of friction between the ring and the rod. [3]

- 3 A cyclist travels along a straight road working at a constant rate of 420 W. The total mass of the cyclist and her cycle is 75 kg. Ignoring any resistance to motion, find the acceleration of the cyclist at an instant when she is travelling at  $5 \text{ m s}^{-1}$ ,

(i) given that the road is horizontal,

(ii) given instead that the road is inclined at  $1.5^\circ$  to the horizontal and the cyclist is travelling up the slope.

[5]

- 4 The velocity of a particle  $t$  s after it starts from rest is  $v \text{ m s}^{-1}$ , where  $v = 1.25t - 0.05t^2$ . Find

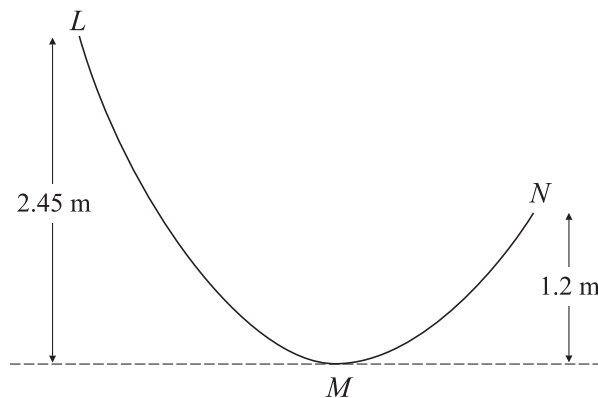
(i) the initial acceleration of the particle,

[2]

(ii) the displacement of the particle from its starting point at the instant when its acceleration is  $0.05 \text{ m s}^{-2}$ .

[5]

5



The diagram shows the vertical cross-section  $LMN$  of a fixed smooth surface.  $M$  is the lowest point of the cross-section.  $L$  is 2.45 m above the level of  $M$ , and  $N$  is 1.2 m above the level of  $M$ . A particle of mass 0.5 kg is released from rest at  $L$  and moves on the surface until it leaves it at  $N$ . Find

(i) the greatest speed of the particle,

[3]

(ii) the kinetic energy of the particle at  $N$ .

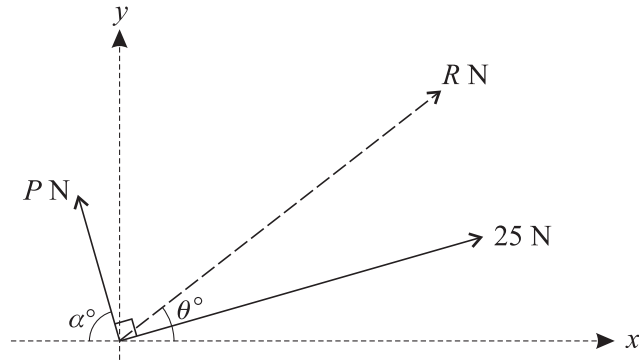
[2]

The particle is now projected from  $N$ , with speed  $v \text{ m s}^{-1}$ , along the surface towards  $M$ .

(iii) Find the least value of  $v$  for which the particle will reach  $L$ .

[2]

6



Forces of magnitudes  $P$  N and  $25$  N act at right angles to each other. The resultant of the two forces has magnitude  $R$  N and makes an angle of  $\theta^\circ$  with the  $x$ -axis (see diagram). The force of magnitude  $P$  N has components  $-2.8$  N and  $9.6$  N in the  $x$ -direction and the  $y$ -direction respectively, and makes an angle of  $\alpha^\circ$  with the negative  $x$ -axis.

(i) Find the values of  $P$  and  $R$ . [3]

(ii) Find the value of  $\alpha$ , and hence find the components of the force of magnitude  $25$  N in

(a) the  $x$ -direction,

(b) the  $y$ -direction. [4]

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

7 A particle of mass  $m$  kg moves up a line of greatest slope of a rough plane inclined at  $21^\circ$  to the horizontal. The frictional and normal components of the contact force on the particle have magnitudes  $F$  N and  $R$  N respectively. The particle passes through the point  $P$  with speed  $10 \text{ m s}^{-1}$ , and  $2$  s later it reaches its highest point on the plane.

(i) Show that  $R = 9.336m$  and  $F = 1.416m$ , each correct to 4 significant figures. [5]

(ii) Find the coefficient of friction between the particle and the plane. [1]

After the particle reaches its highest point it starts to move down the plane.

(iii) Find the speed with which the particle returns to  $P$ . [5]