



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

**MATHEMATICS**

**9709/42**

Paper 4 Mechanics 1 (M1)

**October/November 2009**

**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.



UNIVERSITY of CAMBRIDGE  
 International Examinations

1

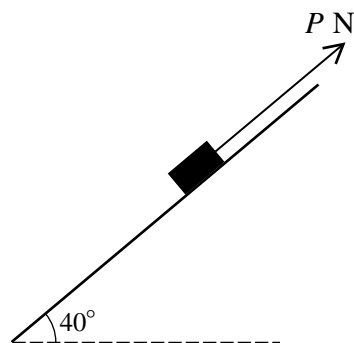


Fig. 1

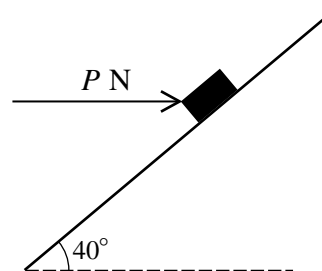


Fig. 2

A small block of weight 12 N is at rest on a smooth plane inclined at  $40^\circ$  to the horizontal. The block is held in equilibrium by a force of magnitude  $P$  N. Find the value of  $P$  when

(i) the force is parallel to the plane as in Fig. 1, [2]

(ii) the force is horizontal as in Fig. 2. [2]

2 A lorry of mass 15 000 kg moves with constant speed  $14 \text{ m s}^{-1}$  from the top to the bottom of a straight hill of length 900 m. The top of the hill is 18 m above the level of the bottom of the hill. The total work done by the resistive forces acting on the lorry, including the braking force, is  $4.8 \times 10^6 \text{ J}$ . Find

(i) the loss in gravitational potential energy of the lorry, [1]

(ii) the work done by the driving force. [1]

On reaching the bottom of the hill the lorry continues along a straight horizontal road against a constant resistance of 1600 N. There is no braking force acting. The speed of the lorry increases from  $14 \text{ m s}^{-1}$  at the bottom of the hill to  $16 \text{ m s}^{-1}$  at the point  $X$ , where  $X$  is 2500 m from the bottom of the hill.

(iii) By considering energy, find the work done by the driving force of the lorry while it travels from the bottom of the hill to  $X$ . [3]

3 A car of mass 1250 kg travels along a horizontal straight road with increasing speed. The power provided by the car's engine is constant and equal to 24 kW. The resistance to the car's motion is constant and equal to 600 N.

(i) Show that the speed of the car cannot exceed  $40 \text{ m s}^{-1}$ . [3]

(ii) Find the acceleration of the car at an instant when its speed is  $15 \text{ m s}^{-1}$ . [3]

## 3

4 A particle moves up a line of greatest slope of a rough plane inclined at an angle  $\alpha$  to the horizontal, where  $\cos \alpha = 0.96$  and  $\sin \alpha = 0.28$ .

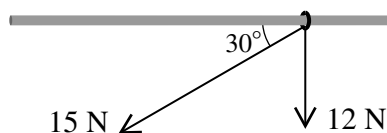
(i) Given that the normal component of the contact force acting on the particle has magnitude 1.2 N, find the mass of the particle. [2]

(ii) Given also that the frictional component of the contact force acting on the particle has magnitude 0.4 N, find the deceleration of the particle. [3]

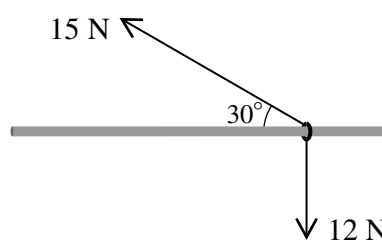
The particle comes to rest on reaching the point  $X$ .

(iii) Determine whether the particle remains at  $X$  or whether it starts to move down the plane. [2]

## 5



**Fig. 1**



**Fig. 2**

A small ring of weight 12 N 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 15 N at an angle of  $30^\circ$  to the horizontal.

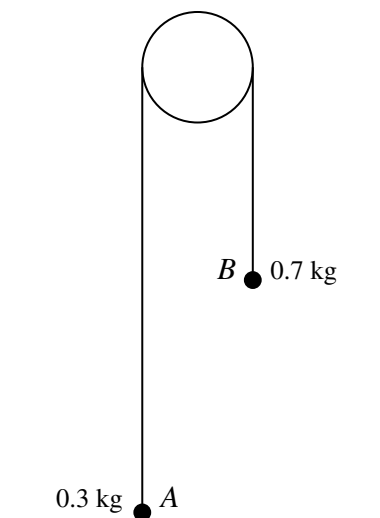
(i) When the angle of  $30^\circ$  is **below** the horizontal (see Fig. 1), the ring is in limiting equilibrium. Show that the coefficient of friction between the ring and the rod is 0.666, correct to 3 significant figures. [5]

(ii) When the angle of  $30^\circ$  is **above** the horizontal (see Fig. 2), the ring is moving with acceleration  $a \text{ m s}^{-2}$ . Find the value of  $a$ . [4]

**[Questions 6 and 7 are printed on the next page.]**

4

6



Particles  $A$  and  $B$ , of masses  $0.3\text{ kg}$  and  $0.7\text{ kg}$  respectively, are attached to the ends of a light inextensible string which passes over a smooth fixed pulley. Particle  $A$  is held on the horizontal floor and particle  $B$  hangs in equilibrium. Particle  $A$  is released and both particles start to move vertically.

- (i) Find the acceleration of the particles. [3]

The speed of the particles immediately before  $B$  hits the floor is  $1.6\text{ m s}^{-1}$ . Given that  $B$  does not rebound upwards, find

- (ii) the maximum height above the floor reached by  $A$ , [3]

- (iii) the time taken by  $A$ , from leaving the floor, to reach this maximum height. [3]

- 7 A motorcyclist starts from rest at  $A$  and travels in a straight line. For the first part of the motion, the motorcyclist's displacement  $x$  metres from  $A$  after  $t$  seconds is given by  $x = 0.6t^2 - 0.004t^3$ .

- (i) Show that the motorcyclist's acceleration is zero when  $t = 50$  and find the speed  $V\text{ m s}^{-1}$  at this time. [5]

For  $t \geq 50$ , the motorcyclist travels at constant speed  $V\text{ m s}^{-1}$ .

- (ii) Find the value of  $t$  for which the motorcyclist's average speed is  $27.5\text{ m s}^{-1}$ . [5]

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