



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 2011**

**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.

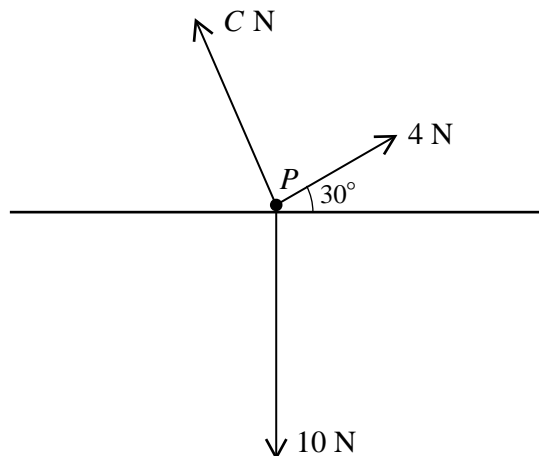
Questions carrying smaller numbers of marks are printed earlier in the paper, and questions carrying larger numbers of marks later in the paper.

This document consists of **4** printed pages.



- 1 A racing cyclist, whose mass with his cycle is 75 kg, works at a rate of 720 W while moving on a straight horizontal road. The resistance to the cyclist's motion is constant and equal to  $R$  N.
- (i) Given that the cyclist is accelerating at  $0.16 \text{ m s}^{-2}$  at an instant when his speed is  $12 \text{ m s}^{-1}$ , find the value of  $R$ . [3]
- (ii) Given that the cyclist's acceleration is positive, show that his speed is less than  $15 \text{ m s}^{-1}$ . [2]
- 2 A block of mass 6 kg is sliding down a line of greatest slope of a plane inclined at  $8^\circ$  to the horizontal. The coefficient of friction between the block and the plane is 0.2.
- (i) Find the deceleration of the block. [3]
- (ii) Given that the initial speed of the block is  $3 \text{ m s}^{-1}$ , find how far the block travels. [2]
- 3 A particle  $P$  moves in a straight line. It starts from a point  $O$  on the line with velocity  $1.8 \text{ m s}^{-1}$ . The acceleration of  $P$  at time  $t$  s after leaving  $O$  is  $0.8t^{-0.75} \text{ m s}^{-2}$ . Find the displacement of  $P$  from  $O$  when  $t = 16$ . [6]

4



A particle  $P$  has weight  $10 \text{ N}$  and is in limiting equilibrium on a rough horizontal table. The forces shown in the diagram represent the weight of  $P$ , an applied force of magnitude  $4 \text{ N}$  acting on  $P$  in a direction at  $30^\circ$  above the horizontal, and the contact force exerted on  $P$  by the table (the resultant of the frictional and normal components) of magnitude  $C \text{ N}$ .

- (i) Find the value of  $C$ . [3]
- (ii) Find the coefficient of friction between  $P$  and the table. [2]

- 5 Particles  $A$  and  $B$ , of masses  $0.9\text{ kg}$  and  $0.6\text{ kg}$  respectively, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley. The system is released from rest with the string taut, with its straight parts vertical and with the particles at the same height above the horizontal floor. In the subsequent motion,  $B$  does not reach the pulley.

(i) Find the acceleration of  $A$  and the tension in the string during the motion before  $A$  hits the floor. [4]

After  $A$  hits the floor,  $B$  continues to move vertically upwards for a further  $0.3\text{ s}$ .

(ii) Find the height of the particles above the floor at the instant that they started to move. [4]

- 6 A lorry of mass  $16\,000\text{ kg}$  climbs a straight hill  $ABCD$  which makes an angle  $\theta$  with the horizontal, where  $\sin \theta = \frac{1}{20}$ . For the motion from  $A$  to  $B$ , the work done by the driving force of the lorry is  $1200\text{ kJ}$  and the resistance to motion is constant and equal to  $1240\text{ N}$ . The speed of the lorry is  $15\text{ m s}^{-1}$  at  $A$  and  $12\text{ m s}^{-1}$  at  $B$ .

(i) Find the distance  $AB$ . [5]

For the motion from  $B$  to  $D$  the gain in potential energy of the lorry is  $2400\text{ kJ}$ .

(ii) Find the distance  $BD$ . [1]

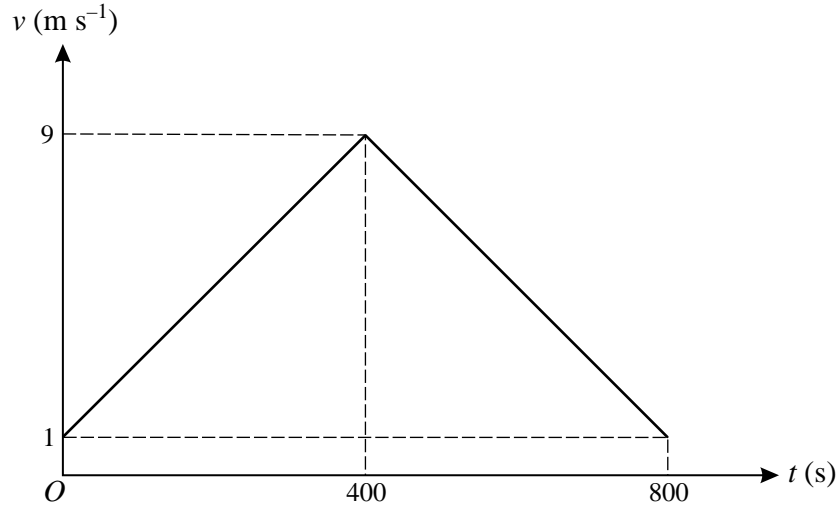
For the motion from  $B$  to  $D$  the driving force of the lorry is constant and equal to  $7200\text{ N}$ . From  $B$  to  $C$  the resistance to motion is constant and equal to  $1240\text{ N}$  and from  $C$  to  $D$  the resistance to motion is constant and equal to  $1860\text{ N}$ .

(iii) Given that the speed of the lorry at  $D$  is  $7\text{ m s}^{-1}$ , find the distance  $BC$ . [4]

[Question 7 is printed on the next page.]

- 7 A tractor travels in a straight line from a point  $A$  to a point  $B$ . The velocity of the tractor is  $v \text{ m s}^{-1}$  at time  $t \text{ s}$  after leaving  $A$ .

(i)



The diagram shows an approximate velocity-time graph for the motion of the tractor. The graph consists of two straight line segments. Use the graph to find an approximation for

- (a) the distance  $AB$ , [2]  
 (b) the acceleration of the tractor for  $0 < t < 400$  and for  $400 < t < 800$ . [2]
- (ii) The actual velocity of the tractor is given by  $v = 0.04t - 0.00005t^2$  for  $0 \leq t \leq 800$ .

- (a) Find the values of  $t$  for which the actual acceleration of the tractor is given correctly by the approximate velocity-time graph in part (i). [3]

For the interval  $0 \leq t \leq 400$ , the approximate velocity of the tractor in part (i) is denoted by  $v_1 \text{ m s}^{-1}$ .

- (b) Express  $v_1$  in terms of  $t$  and hence show that  $v_1 - v = 0.00005(t - 200)^2 - 1$ . [2]  
 (c) Deduce that  $-1 \leq v_1 - v \leq 1$ . [2]