



**ADVANCED SUBSIDIARY GCE UNIT  
MATHEMATICS (MEI)**

**Mechanics 1**

**MONDAY 21 MAY 2007**

**4761/01**

**Morning**

**Time: 1 hour 30 minutes**

Additional materials:

Answer booklet (8 pages)

Graph paper

MEI Examination Formulae and Tables (MF2)

**INSTRUCTIONS TO CANDIDATES**

- Write your name, centre number and candidate number in the spaces provided on the answer booklet.
- Answer **all** the questions.
- You are permitted to use a graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.
- The acceleration due to gravity is denoted by  $g \text{ m s}^{-2}$ . Unless otherwise instructed, when a numerical value is needed, use  $g = 9.8$ .

**INFORMATION FOR CANDIDATES**

- 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 72.

**ADVICE TO CANDIDATES**

- Read each question carefully and make sure you know what you have to do before starting your answer.
- You are advised that an answer may receive **no marks** unless you show sufficient detail of the working to indicate that a correct method is being used.

This document consists of **7** printed pages and **1** blank page.

## Section A (36 marks)

1 Fig. 1 shows four forces in equilibrium.

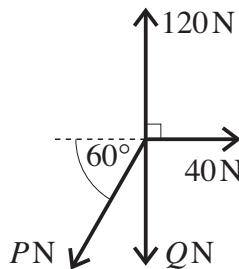


Fig. 1

(i) Find the value of  $P$ . [3]

(ii) Hence find the value of  $Q$ . [2]

2 A car passes a point A travelling at  $10 \text{ m s}^{-1}$ . Its motion over the next 45 seconds is modelled as follows.

- The car's speed increases uniformly from  $10 \text{ m s}^{-1}$  to  $30 \text{ m s}^{-1}$  over the first 10 s.
- Its speed then increases uniformly to  $40 \text{ m s}^{-1}$  over the next 15 s.
- The car then maintains this speed for a further 20 s at which time it reaches the point B.

(i) Sketch a speed-time graph to represent this motion. [3]

(ii) Calculate the distance from A to B. [3]

(iii) When it reaches the point B, the car is brought uniformly to rest in  $T$  seconds. The total distance from A is now 1700 m. Calculate the value of  $T$ . [2]

3 Fig. 3 shows a system in equilibrium. The rod is firmly attached to the floor and also to an object, P. The light string is attached to P and passes over a smooth pulley with an object Q hanging freely from its other end.

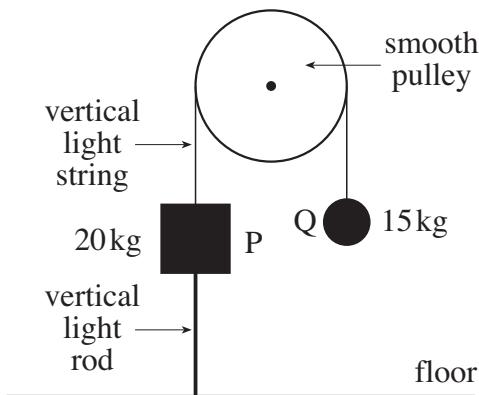


Fig. 3

(i) Why is the tension the same throughout the string? [1]

(ii) Calculate the force in the rod, stating whether it is a tension or a thrust. [3]

4 Two trucks, A and B, each of mass 10 000 kg, are pulled along a straight, horizontal track by a constant, horizontal force of  $P$  N. The coupling between the trucks is light and horizontal. This situation and the resistances to motion of the trucks are shown in Fig. 4.

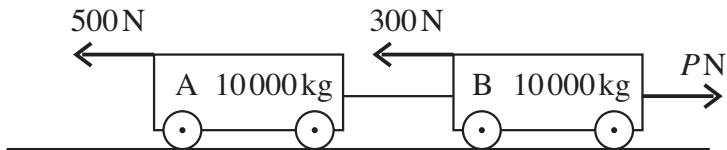


Fig. 4

The acceleration of the system is  $0.2 \text{ m s}^{-2}$  in the direction of the pulling force of magnitude  $P$ .

(i) Calculate the value of  $P$ . [3]

Truck A is now subjected to an extra resistive force of 2000 N while  $P$  does not change.

(ii) Calculate the new acceleration of the trucks. [2]

(iii) Calculate the force in the coupling between the trucks. [2]

5 A block of weight 100 N is on a rough plane that is inclined at  $35^\circ$  to the horizontal. The block is in equilibrium with a horizontal force of 40 N acting on it, as shown in Fig. 5.

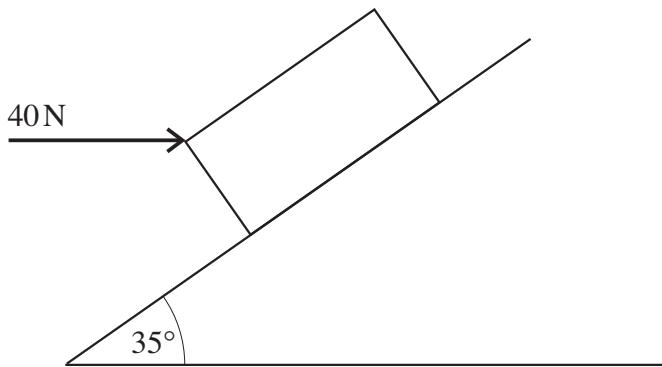


Fig. 5

Calculate the frictional force acting on the block.

[4]

6 A rock of mass 8 kg is acted on by just the two forces  $-80\mathbf{k}$  N and  $(-\mathbf{i} + 16\mathbf{j} + 72\mathbf{k})$  N, where  $\mathbf{i}$  and  $\mathbf{j}$  are perpendicular unit vectors in a horizontal plane and  $\mathbf{k}$  is a unit vector vertically upward.

(i) Show that the acceleration of the rock is  $(-\frac{1}{8}\mathbf{i} + 2\mathbf{j} - \mathbf{k})\text{ms}^{-2}$ .

[2]

The rock passes through the origin of position vectors, O, with velocity  $(\mathbf{i} - 4\mathbf{j} + 3\mathbf{k}) \text{ m s}^{-1}$  and 4 seconds later passes through the point A.

(ii) Find the position vector of A.

[3]

(iii) Find the distance OA.

[1]

(iv) Find the angle that OA makes with the horizontal.

[2]

## Section B (36 marks)

7 Fig. 7 is a sketch of part of the velocity-time graph for the motion of an insect walking in a straight line. Its velocity,  $v$  m s $^{-1}$ , at time  $t$  seconds for the time interval  $-3 \leq t \leq 5$  is given by

$$v = t^2 - 2t - 8.$$

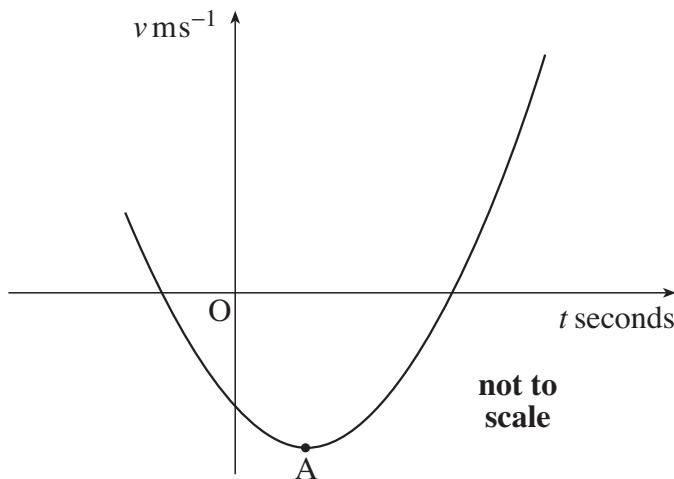


Fig. 7

(i) Write down the velocity of the insect when  $t = 0$ . [1]

(ii) Show that the insect is instantaneously at rest when  $t = -2$  and when  $t = 4$ . [2]

(iii) Determine the velocity of the insect when its acceleration is zero.  
Write down the coordinates of the point A shown in Fig. 7. [5]

(iv) Calculate the distance travelled by the insect from  $t = 1$  to  $t = 4$ . [5]

(v) Write down the distance travelled by the insect in the time interval  $-2 \leq t \leq 4$ . [1]

(vi) How far does the insect walk in the time interval  $1 \leq t \leq 5$ ? [3]

8 A ball is kicked from ground level over horizontal ground. It leaves the ground at a speed of  $25 \text{ m s}^{-1}$  and at an angle  $\theta$  to the horizontal such that  $\cos \theta = 0.96$  and  $\sin \theta = 0.28$ .

(i) Show that the height,  $y \text{ m}$ , of the ball above the ground  $t$  seconds after projection is given by  $y = 7t - 4.9t^2$ . Show also that the horizontal distance,  $x \text{ m}$ , travelled by this time is given by  $x = 24t$ . [3]

(ii) Calculate the maximum height reached by the ball. [2]

(iii) Calculate the times at which the ball is at half its maximum height.

Find the horizontal distance travelled by the ball between these times. [4]

(iv) Determine the following when  $t = 1.25$ .

(A) The vertical component of the velocity of the ball.

(B) Whether the ball is rising or falling. (You should give a reason for your answer.)

(C) The speed of the ball. [5]

(v) Show that the equation of the trajectory of the ball is

$$y = \frac{0.7x}{576} (240 - 7x).$$

Hence, or otherwise, find the range of the ball. [5]

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