RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE UNIT **4761/01**

MATHEMATICS (MEI)

Mechanics 1

MONDAY 21 MAY 2007

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 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.

Section A (36 marks)

1 Fig. 1 shows four forces in equilibrium.

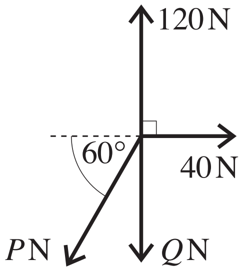

Fig. 1

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

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

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

- The car's speed increases uniformly from $10\,\mathrm{m\,s^{-1}}$ to $30\,\mathrm{m\,s^{-1}}$ over the first 10 s.
- Its speed then increases uniformly to $40\,\mathrm{m\,s^{-1}}$ 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.

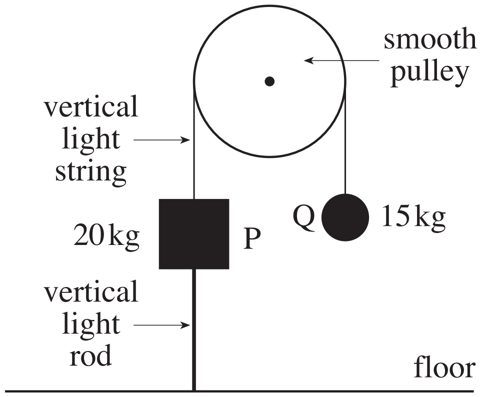

Fig. 3

(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.

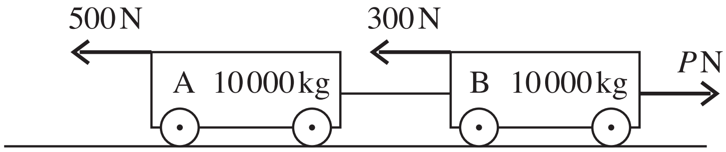

Fig. 4

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° to the horizontal. The block is in equilibrium with a horizontal force of 40 N acting on it, as shown in Fig. 5.

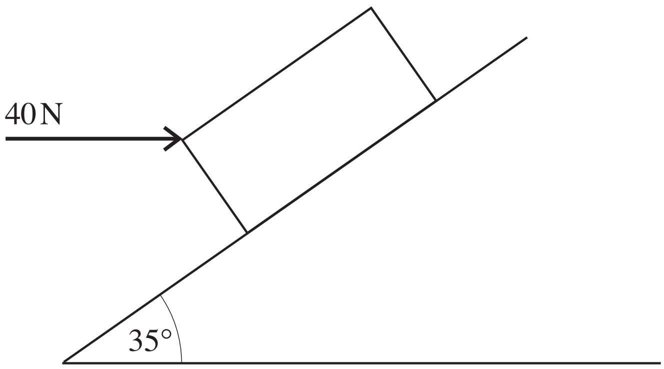

Fig. 5

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 $\left(-\frac{1}{8}\mathbf{i} + 2\mathbf{j} - \mathbf{k}\right)\mathrm{m\,s^{-2}}$. [2]

The rock passes through the origin of position vectors, O, with velocity $(\mathbf{i} - 4\mathbf{j} + 3\mathbf{k})$ 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, $v\,\mathrm{m\,s^{-1}}$, at time t seconds for the time interval $-3 \leqslant t \leqslant 5$ is given by

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

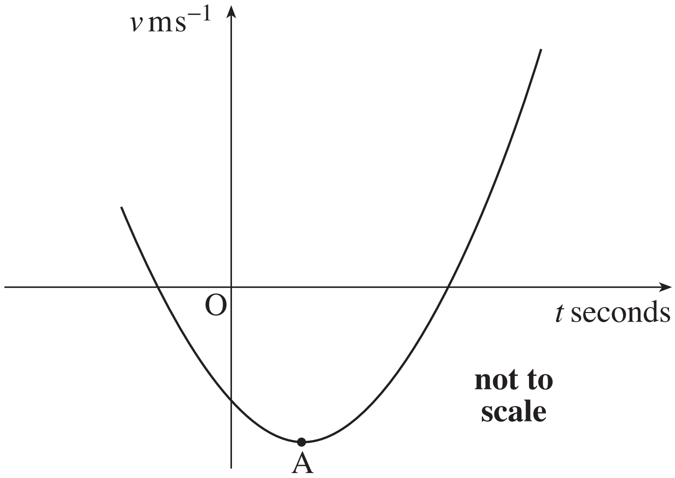

Fig. 7

(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 $-2 \leqslant t \leqslant 4$. [1]

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

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

(i) Show that the height, y 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 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]