

**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.

Section A (36 marks)

1 Fig. 1 shows four forces in equilibrium.

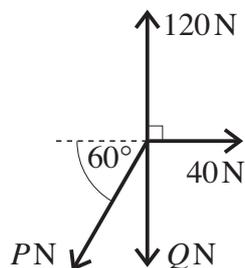


Fig. 1

(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 m s^{-1} . Its motion over the next 45 seconds is modelled as follows.

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

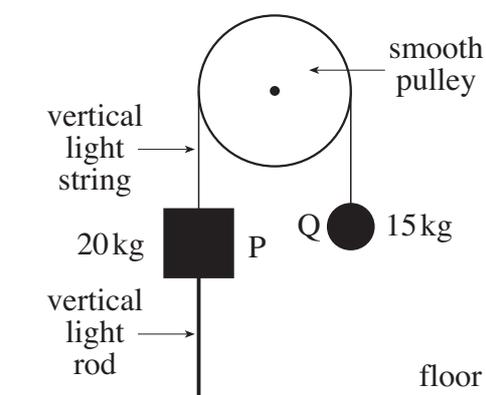


Fig. 3

- (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.

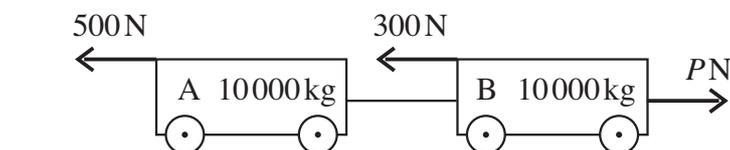


Fig. 4

The acceleration of the system is 0.2 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.

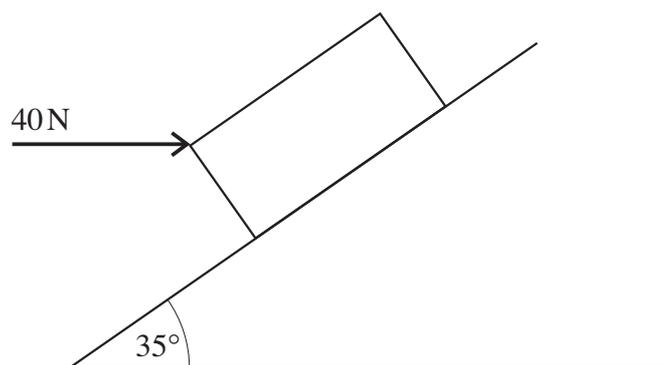


Fig. 5

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 $(-\frac{1}{8}\mathbf{i} + 2\mathbf{j} - \mathbf{k})\text{ms}^{-2}$. [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, $v \text{ m s}^{-1}$, at time t seconds for the time interval $-3 \leq t \leq 5$ is given by

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

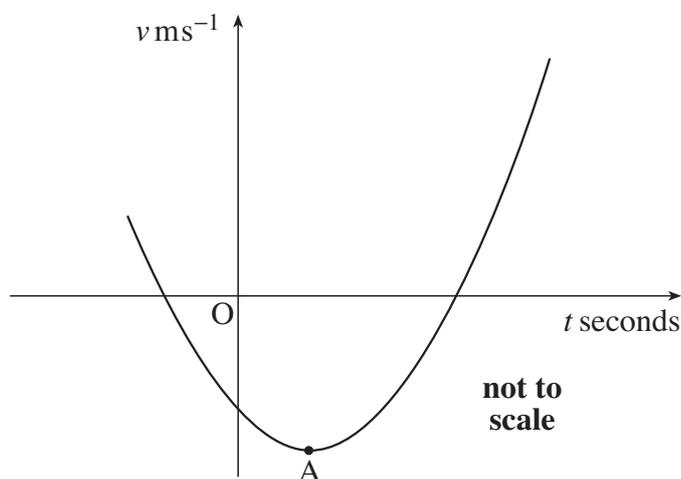


Fig. 7

- (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 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]

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