

ADVANCED SUBSIDIARY GCE
MATHEMATICS (MEI)
Mechanics 1

4761

Candidates answer on the Answer Booklet

OCR Supplied Materials:

- 8 page Answer Booklet
- Graph paper
- MEI Examination Formulae and Tables (MF2)

Other Materials Required:

None

Wednesday 21 January 2009
Afternoon

Duration: 1 hour 30 minutes



INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the spaces provided on the Answer Booklet.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- 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.
- 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.
- The total number of marks for this paper is **72**.
- This document consists of **8** pages. Any blank pages are indicated.

Section A (36 marks)

- 1 A particle is travelling in a straight line. Its velocity $v \text{ m s}^{-1}$ at time t seconds is given by

$$v = 6 + 4t \quad \text{for } 0 \leq t \leq 5.$$

- (i) Write down the initial velocity of the particle and find the acceleration for $0 \leq t \leq 5$. [2]

- (ii) Write down the velocity of the particle when $t = 5$. Find the distance travelled in the first 5 seconds. [3]

For $5 \leq t \leq 15$, the acceleration of the particle is 3 m s^{-2} .

- (iii) Find the total distance travelled by the particle during the 15 seconds. [3]

- 2 Fig. 2 shows an acceleration-time graph modelling the motion of a particle.

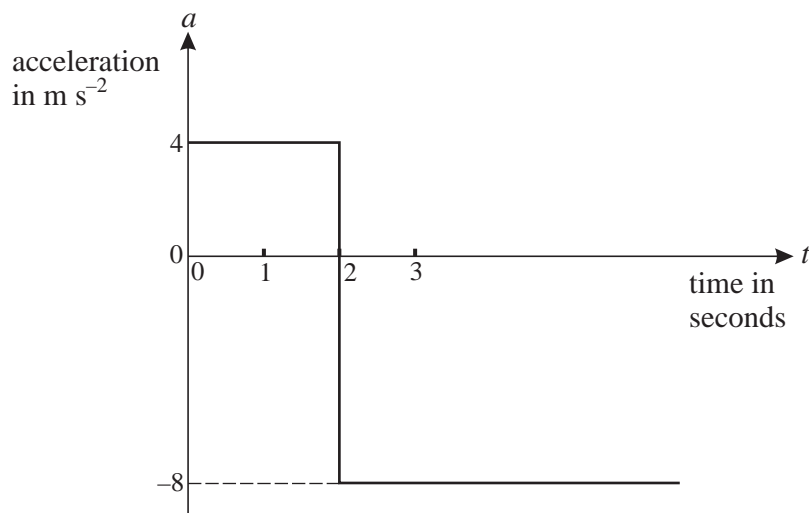


Fig. 2

At $t = 0$ the particle has a velocity of 6 m s^{-1} in the positive direction.

- (i) Find the velocity of the particle when $t = 2$. [2]

- (ii) At what time is the particle travelling in the negative direction with a speed of 6 m s^{-1} ? [2]

- 3 The resultant of the force $\begin{pmatrix} -4 \\ 8 \end{pmatrix} \text{ N}$ and the force \mathbf{F} gives an object of mass 6 kg an acceleration of $\begin{pmatrix} 2 \\ 3 \end{pmatrix} \text{ m s}^{-2}$.

- (i) Calculate \mathbf{F} . [4]

- (ii) Calculate the angle between \mathbf{F} and the vector $\begin{pmatrix} 0 \\ 1 \end{pmatrix}$. [2]

- 4 Sandy is throwing a stone at a plum tree. The stone is thrown from a point O at a speed of 35 m s^{-1} at an angle of α to the horizontal, where $\cos \alpha = 0.96$. You are *given* that, t seconds after being thrown, the stone is $(9.8t - 4.9t^2)$ m higher than O.

When descending, the stone hits a plum which is 3.675 m higher than O. Air resistance should be neglected.

Calculate the horizontal distance of the plum from O. [6]

- 5 A man of mass 75 kg is standing in a lift. He is holding a parcel of mass 5 kg by means of a light inextensible string, as shown in Fig. 5. The tension in the string is 55 N.

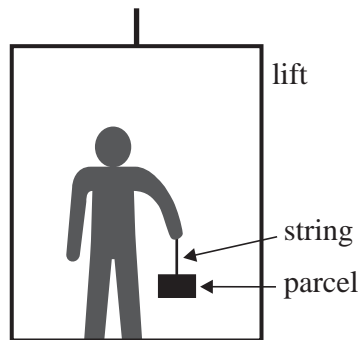


Fig. 5

- (i) Find the upward acceleration. [3]
- (ii) Find the reaction on the man of the lift floor. [2]
- 6 Small stones A and B are initially in the positions shown in Fig. 6 with B a height H m directly above A.

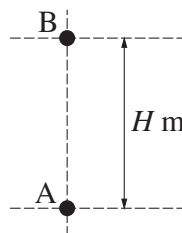


Fig. 6

At the instant when B is released from rest, A is projected vertically upwards with a speed of 29.4 m s^{-1} . Air resistance may be neglected.

The stones collide T seconds after they begin to move. At this instant they have the same speed, $V \text{ m s}^{-1}$, and A is still rising.

By considering when the speed of A upwards is the same as the speed of B downwards, or otherwise, show that $T = 1.5$ and find the values of V and H . [7]

Section B (36 marks)

- 7 An explorer is trying to pull a loaded sledge of total mass 100 kg along horizontal ground using a light rope. The only resistance to motion of the sledge is from friction between it and the ground.

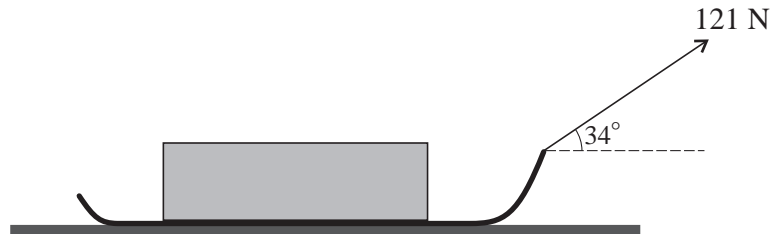


Fig. 7

Initially she pulls with a force of 121 N on the rope inclined at 34° to the horizontal, as shown in Fig. 7, but the sledge does not move.

- (i) Draw a diagram showing all the forces acting on the sledge.

Show that the frictional force between the ground and the sledge is 100 N, correct to 3 significant figures.

Calculate the normal reaction of the ground on the sledge. [7]

The sledge is given a small push to set it moving at 0.5 m s^{-1} . The explorer continues to pull on the rope with the same force and the same angle as before. The frictional force is also unchanged.

- (ii) Describe the subsequent motion of the sledge. [2]

The explorer now pulls the rope, still at an angle of 34° to the horizontal, so that the tension in it is 155 N. The frictional force is now 95 N.

- (iii) Calculate the acceleration of the sledge. [3]

In a new situation, there is no rope and the sledge slides down a uniformly rough slope inclined at 26° to the horizontal. The sledge starts from rest and reaches a speed of 5 m s^{-1} in 2 seconds.

- (iv) Calculate the frictional force between the slope and the sledge. [5]

- 8** A toy boat moves in a horizontal plane with position vector $\mathbf{r} = x\mathbf{i} + y\mathbf{j}$, where \mathbf{i} and \mathbf{j} are the standard unit vectors east and north respectively. The origin of the position vectors is at O. The displacements x and y are in metres.

First consider only the motion of the boat parallel to the x -axis. For this motion

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

The velocity of the boat in the x -direction is $v_x \text{ m s}^{-1}$.

- (i)** Find an expression in terms of t for v_x and determine when the boat instantaneously has zero speed in the x -direction. **[3]**

Now consider only the motion of the boat parallel to the y -axis. For this motion

$$v_y = (t - 2)(3t - 2),$$

where $v_y \text{ m s}^{-1}$ is the velocity of the boat in the y -direction at time t seconds.

- (ii)** Given that $y = 3$ when $t = 1$, use integration to show that $y = t^3 - 4t^2 + 4t + 2$. **[4]**

The position vector of the boat is given in terms of t by $\mathbf{r} = (8t - 2t^2)\mathbf{i} + (t^3 - 4t^2 + 4t + 2)\mathbf{j}$.

- (iii)** Find the time(s) when the boat is due north of O and also the distance of the boat from O at any such times. **[4]**
- (iv)** Find the time(s) when the boat is instantaneously at rest. Find the distance of the boat from O at any such times. **[5]**
- (v)** Plot a graph of the path of the boat for $0 \leq t \leq 2$. **[3]**