OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

MATHEMATICS (MEI)

4761

Mechanics 1

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 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

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

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

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

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

(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.

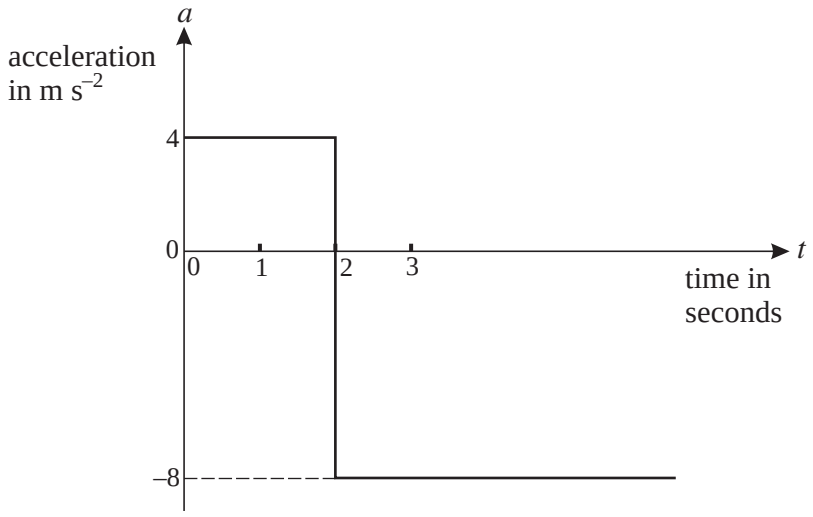

Fig. 2

At $t = 0$ the particle has a velocity of $6\,\text{m s}^{-1}$ 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 $6\,\text{m s}^{-1}$? **[2]**

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

(i) Calculate **F**. **[4]**

(ii) Calculate the angle between **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 $35\,\text{m s}^{-1}$ 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.

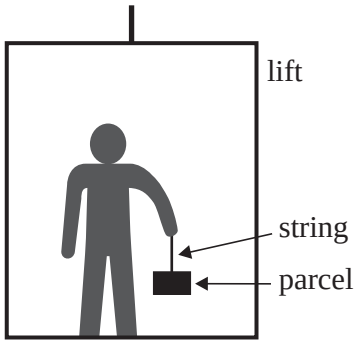

Fig. 5

(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.

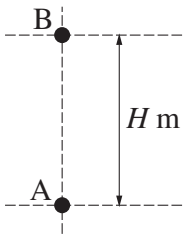

Fig. 6

At the instant when B is released from rest, A is projected vertically upwards with a speed of $29.4\,\text{m s}^{-1}$. 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.

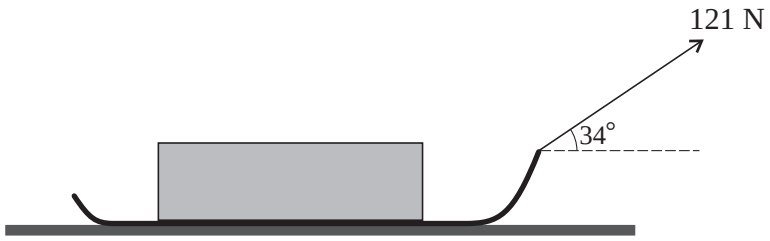

Fig. 7

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 $0.5\,\mathrm{m\,s^{-1}}$. 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 $5\,\mathrm{m\,s^{-1}}$ 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 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 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 $0 \leqslant t \leqslant 2$. **[3]**