OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE UNIT **4761/01**

MATHEMATICS (MEI)

Mechanics 1

WEDNESDAY 10 JANUARY 2007 Afternoon

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.

[Turn over

Section A (36 marks)

1 Fig. 1 is the velocity-time graph for the motion of a body. The velocity of the body is v m s^{-1} at time t seconds.

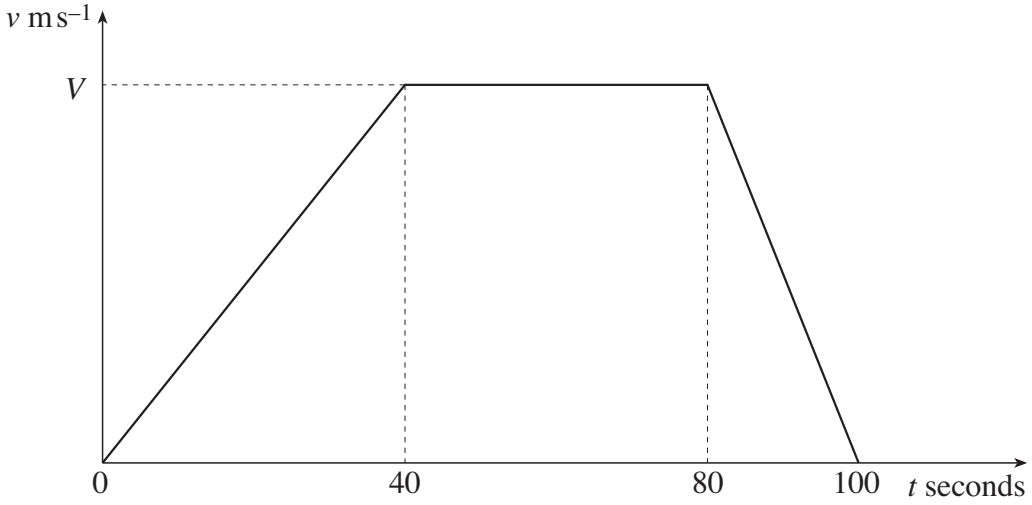

Fig. 1

The displacement of the body from $t = 0$ to $t = 100$ is 1400 m. Find the value of V. [4]

2 A particle moves along a straight line containing a point O. Its displacement, x m, from O at time t seconds is given by

$$x = 12t - t^3, \text{ where } -10 \leqslant t \leqslant 10.$$

Find the values of x for which the velocity of the particle is zero. [5]

3 A box of mass 5 kg is at rest on a rough horizontal floor.

(i) Find the value of the normal reaction of the floor on the box. [1]

The box remains at rest on the floor when a force of 10 N is applied to it at an angle of 40° to the upward vertical, as shown in Fig. 3.

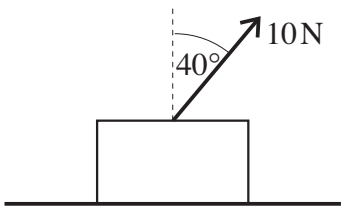

Fig. 3

(ii) Draw a diagram showing all the forces acting on the box. [2]

(iii) Calculate the new value of the normal reaction of the floor on the box and also the frictional force. [4]

4 Fig. 4 shows forces of magnitudes 20 N and 16 N inclined at 60°.

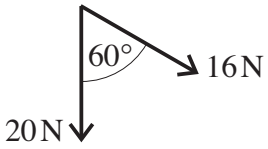

Fig. 4

(i) Calculate the component of the resultant of these two forces in the direction of the 20 N force. [1]

(ii) Calculate the magnitude of the resultant of these two forces. [3]

These are the only forces acting on a particle of mass 2 kg.

(iii) Find the magnitude of the acceleration of the particle and the angle the acceleration makes with the 20 N force. [3]

5 A block of mass 4 kg slides on a horizontal plane against a constant resistance of 14.8 N. A light, inextensible string is attached to the block and, after passing over a smooth pulley, is attached to a freely hanging sphere of mass 2 kg. The part of the string between the block and the pulley is horizontal. This situation is shown in Fig. 5.

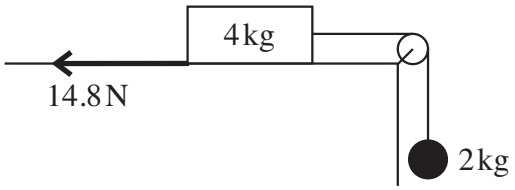

Fig. 5

The tension in the string is T N and the acceleration of the block and of the sphere is a m s^{-2}.

(i) Write down the equation of motion of the block and also the equation of motion of the sphere, each in terms of T and a. [3]

(ii) Find the values of T and a. [3]

[Turn over

6 The velocity of a model boat, $\mathbf{v}$ m s^{-1}, is given by

$$\mathbf{v} = \begin{pmatrix} -5 \\ 10 \end{pmatrix} + t \begin{pmatrix} 6 \\ -8 \end{pmatrix},$$

where t is the time in seconds and the vectors $\begin{pmatrix} 1 \\ 0 \end{pmatrix}$ and $\begin{pmatrix} 0 \\ 1 \end{pmatrix}$ are east and north respectively.

(i) Show that when $t = 2.5$ the boat is travelling south-east (i.e. on a bearing of 135°). Calculate its speed at this time. [3]

The boat is at a point O when $t = 0$.

(ii) Calculate the bearing of the boat from O when $t = 2.5$. [4]

Section B (36 marks)

7 A horizontal force of 24 N acts on a block of mass 12 kg on a horizontal plane. The block is initially at rest.

This situation is first modelled assuming the plane is smooth.

(i) Write down the acceleration of the block according to this model. [1]

The situation is now modelled assuming a constant resistance to motion of 15 N.

(ii) Calculate the acceleration of the block according to this new model. How much less distance does the new model predict that the block will travel in the first 4 seconds? [5]

The 24 N force is removed and the block slides *down* a slope at 5° to the horizontal. The speed of the block at the top of the slope is $1.5\,\mathrm{m\,s^{-1}}$, as shown in Fig. 7. The answers to parts **(iii)** and **(iv)** should be found using the assumption that the resistance to the motion of the block is still a constant 15 N.

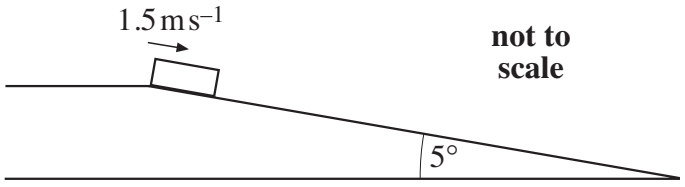

Fig. 7

(iii) Calculate the acceleration of the block in the direction of its motion. [4]

(iv) For how much time does the block slide down the slope before coming to rest and how far does it slide in that time? [4]

Measurements show that the block actually comes to rest in 3.5 seconds.

(v) Assuming that the error in the prediction is due only to the value of the resistance, calculate the true value of the resistance. [4]

[Question 8 is printed overleaf.]

[Turn over

8 In this question the value of g should be taken as $10\,\text{m s}^{-2}$.

As shown in Fig. 8, particles A and B are projected towards one another. Each particle has an initial speed of $10\,\text{m s}^{-1}$ vertically and $20\,\text{m s}^{-1}$ horizontally. Initially A and B are 70 m apart horizontally and B is 15 m higher than A. Both particles are projected over horizontal ground.

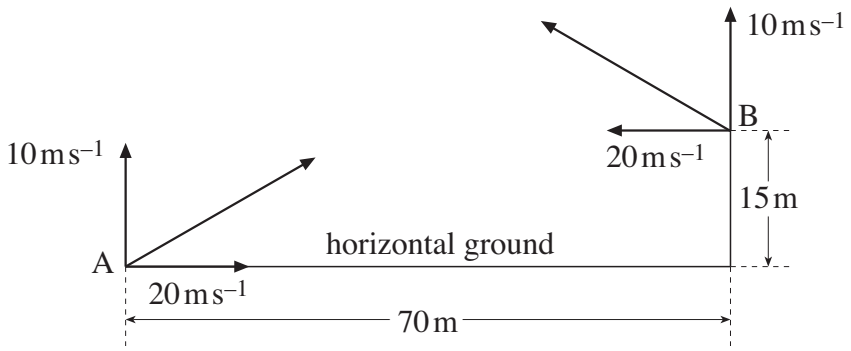

Fig. 8

(i) Show that, t seconds after projection, the height in metres of each particle above its point of projection is $10t - 5t^2$. [1]

(ii) Calculate the horizontal range of A. Deduce that A hits the horizontal ground between the initial positions of A and B. [5]

(iii) Calculate the horizontal distance travelled by B before reaching the ground. [5]

(iv) Show that the paths of the particles cross but that the particles do not collide if they are projected at the same time. [2]

In fact, particle A is projected 2 seconds after particle B.

(v) Verify that the particles collide 0.75 seconds after A is projected. [5]