OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education

MEI STRUCTURED MATHEMATICS 2607

Mechanics 1

Tuesday **5 NOVEMBER 2002** Afternoon 1 hour 20 minutes

Additional materials:
Answer booklet
Graph paper
MEI Examination Formulae and Tables (MF12)

TIME 1 hour 20 minutes

INSTRUCTIONS TO CANDIDATES

- Write your Name, Centre Number and Candidate Number in the spaces provided on the answer booklet.
- Answer **all** questions.
- You are permitted to use a graphical calculator in this paper.

INFORMATION FOR CANDIDATES

- The allocation 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.
- Final answers should be given to a degree of accuracy appropriate to the context.
- Take $g = 9.8$ m s^{-2} unless otherwise instructed.
- The total number of marks for this paper is 60.

This question paper consists of 5 printed pages and 3 blank pages.

Registered Charity 1066969
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1 **(a)** A particle is travelling along a north-south line during the time interval $0 \leqslant t \leqslant 4$, where t is in seconds. The positive direction is north.

Initially, the velocity $v\,\mathrm{m\,s^{-1}}$ is modelled by the v-t diagram, Fig. 1.

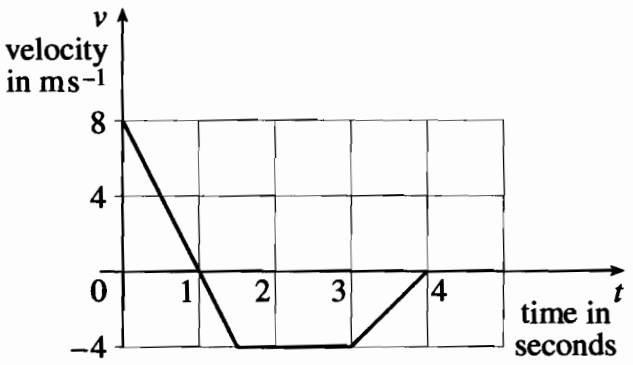


Fig. 1

(i) Calculate the distance travelled by the particle in each of the intervals

(*A*) $0 \leqslant t \leqslant 1$,

(*B*) $0 \leqslant t \leqslant 4$. [4]

(ii) Calculate the displacement of the particle from its position when $t = 0$ to its position when $t = 4$. [1]

In a different model for the motion of the particle, the displacement from its position when $t = 0$ is given by

$$s = \tfrac{2}{3}t^3 - 5t^2 + 8t.$$

(iii) Show that the models agree about the times at which the particle is instantaneously at rest.

Find also the difference in the predictions given by the two models of the displacement of the particle from its position when $t = 0$ to its position when $t = 4$.

[5]

(b) In this part of the question, **i** and **j** are the standard unit vectors in the Ox and Oy directions.

An object has initial position $(2\mathbf{i} - \mathbf{j})$ m and velocity $(-\mathbf{i} + 4\mathbf{j})\,\mathrm{m\,s^{-1}}$. It has a constant acceleration of $(2\mathbf{i} + 5\mathbf{j})\,\mathrm{m\,s^{-2}}$.

Calculate the object's velocity and position after four seconds. [4]

[Total 14]

2 **(a)** As shown in Fig. 2.1, an object of mass m kg at B is held in equilibrium by two light strings AB and BC. String AB is horizontal and fixed at A, string BC is at 60° to the horizontal and is fixed at C. The tension in string BC is 10 N.

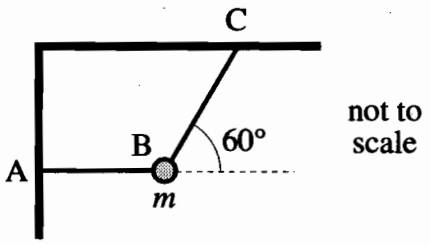


Fig. 2.1

(i) Draw a diagram showing all the forces acting on the object at B.

Calculate the tension in the string AB. [3]

(ii) Calculate the value of m. [3]

(b) The unit vectors **i** and **j** are in the directions east and north in a horizontal plane, as shown in Fig. 2.2.

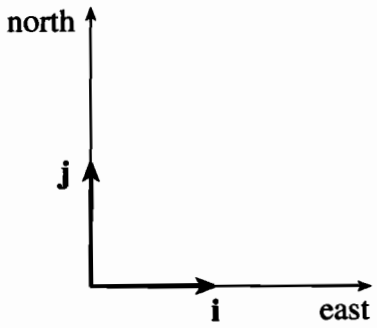


Fig. 2.2

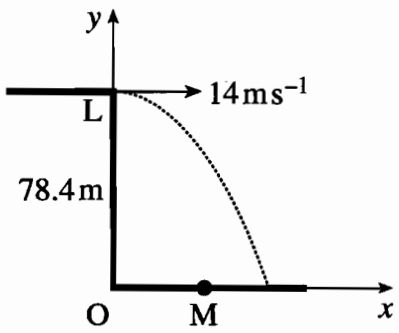
(i) Show that $k\mathbf{i} + k\mathbf{j}$, where k is a positive constant, is a vector of magnitude $k\sqrt{2}$ in the direction north-east. [2]

The vector $\mathbf{V} = (5\mathbf{i} - \mathbf{j}) + q(\mathbf{i} + 4\mathbf{j})$ is in the direction north-east.

(ii) Find the constant q and also the magnitude of **V**. [6]

[Total 14]

3 In this question, air resistance should be neglected.



not to scale

Fig. 3

Fig. 3 shows a small stone being projected horizontally at a speed of 14 m s^{-1} from the point L at the top of a vertical cliff. The cliff is 78.4 m above horizontal ground. Coordinate axes are drawn through the origin O on the horizontal ground vertically below the point of projection.

(i) Show that, t seconds after projection, the height, y m, of the stone, is given by $y = 78.4 - 4.9t^2$. Write down an expression in terms of t for the horizontal distance, x m, of the stone from O. [4]

(ii) Calculate the time it takes the stone to reach the ground.

Calculate also the horizontal distance travelled by the stone. [3]

(iii) Show that the equation of the trajectory of the stone is $40y = 3136 - x^2$. [3]

On another occasion the stone is projected from L as before. At the same time, a second small stone is projected vertically upwards at speed u m s^{-1} from a point M on the horizontal ground 35 m from O. The stones collide.

(iv) Show that the collision takes place just less than 48 m above the ground, 2.5 seconds after projection. [3]

(v) Calculate the value of u. [3]

[Total 16]

4 A model truck of mass 5 kg is being pulled by a light string along a straight path. The resistance to its motion is 8 N.

In one situation, the string and the path are horizontal, as shown in Fig. 4.1.

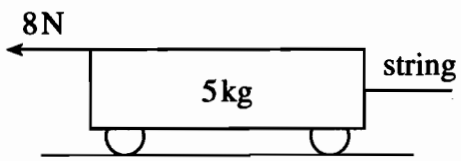


Fig. 4.1

(i) Given that the acceleration of the truck is 4 m s^{-2}, calculate the tension in the string. [3]

In another situation, the path is horizontal and the string is inclined at 30° to the horizontal, as shown in Fig. 4.2.

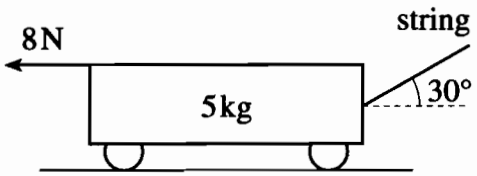


Fig. 4.2

(ii) Given that the tension in the string is 40 N, calculate the acceleration of the truck. [3]

A second truck is attached to the first by a light, rigid coupling. The mass of the second truck is 2 kg and the resistance to its motion is 6 N. The two trucks are pulled up a slope at 10° to the horizontal, as shown in Fig. 4.3, with the coupling and the pulling string both parallel to the slope.

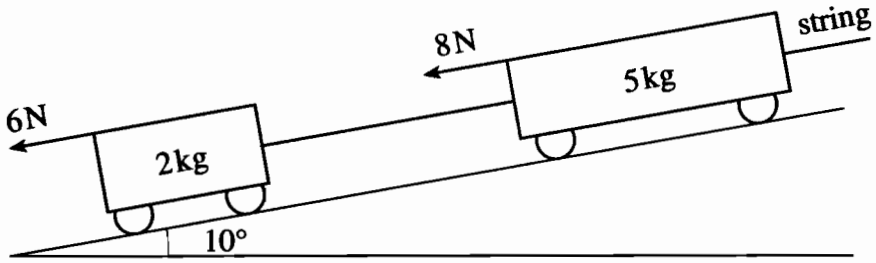


Fig. 4.3

(iii) In a case where the acceleration of the two trucks is 2.5 m s^{-2}, show that the tension in the string is 43.4 N, correct to three significant figures.

Calculate also the tension in the coupling. [7]

(iv) Show that, while the trucks are moving up the slope, the coupling remains in tension whatever the tension in the string. [3]

[Total 16]