

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 27 January 2010
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 ring is moving up and down a vertical pole. The displacement, s m, of the ring above a mark on the pole is modelled by the displacement-time graph shown in Fig. 1. The three sections of the graph are straight lines.

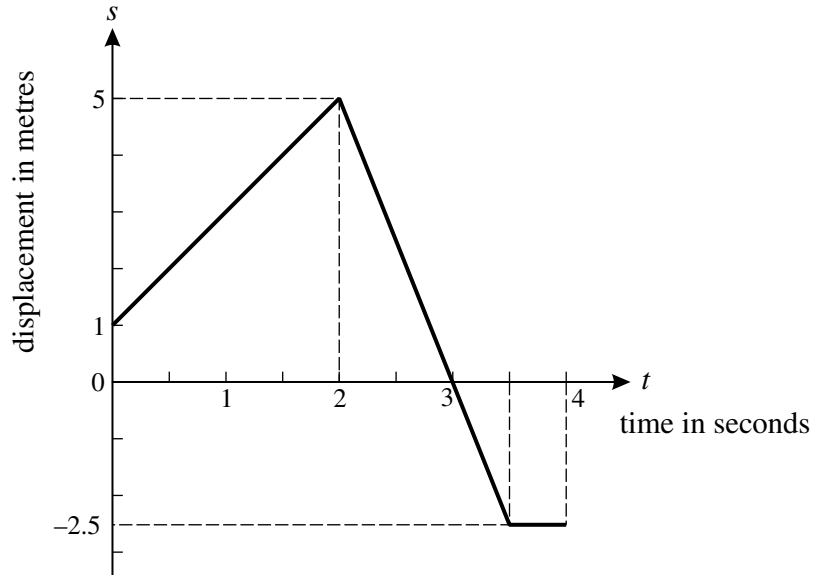


Fig. 1

- (i) Calculate the velocity of the ring in the interval $0 < t < 2$ and in the interval $2 < t < 3.5$. [2]
- (ii) Sketch a velocity-time graph for the motion of the ring during the 4 seconds. [2]
- (iii) State the direction of motion of the ring when
- (A) $t = 1$,
- (B) $t = 2.75$,
- (C) $t = 3.25$. [1]
- 2 A particle of mass 5 kg has constant acceleration. Initially, the particle is at $\begin{pmatrix} -1 \\ 2 \end{pmatrix}$ m with velocity $\begin{pmatrix} 2 \\ -3 \end{pmatrix}$ m s⁻¹; after 4 seconds the particle has velocity $\begin{pmatrix} 12 \\ 9 \end{pmatrix}$ m s⁻¹.
- (i) Calculate the acceleration of the particle. [2]
- (ii) Calculate the position of the particle at the end of the 4 seconds. [3]
- (iii) Calculate the force acting on the particle. [2]

- 3 In this question, \mathbf{i} is a horizontal unit vector and \mathbf{j} is a unit vector pointing vertically upwards.

A force \mathbf{F} is $-\mathbf{i} + 5\mathbf{j}$.

- (i) Calculate the magnitude of \mathbf{F} .

Calculate also the angle between \mathbf{F} and the upward vertical.

[4]

Force \mathbf{G} is $2a\mathbf{i} + a\mathbf{j}$ and force \mathbf{H} is $-2\mathbf{i} + 3b\mathbf{j}$, where a and b are constants. The force \mathbf{H} is the resultant of forces $4\mathbf{F}$ and \mathbf{G} .

- (ii) Find \mathbf{G} and \mathbf{H} .

[4]

- 4 A box of mass 2.5 kg is on a smooth horizontal table, as shown in Fig. 4. A light string AB is attached to the table at A and the box at B. AB is at an angle of 50° to the vertical. Another light string is attached to the box at C; this string is inclined at 15° above the horizontal and the tension in it is 20 N. The box is in equilibrium.

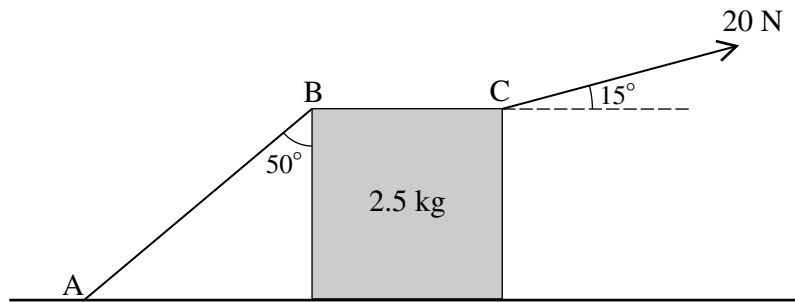


Fig. 4

- (i) Calculate the horizontal component of the force exerted on the box by the string at C. [1]

- (ii) Calculate the tension in the string AB. [2]

- (iii) Calculate the normal reaction of the table on the box. [4]

The string at C is replaced by one inclined at 15° below the horizontal with the same tension of 20 N.

- (iv) Explain why this has no effect on the tension in string AB. [1]

- 5 The velocity, $v \text{ m s}^{-1}$, of a particle moving along a straight line is given by

$$v = 3t^2 - 12t + 14,$$

where t is the time in seconds.

- (i) Find an expression for the acceleration of the particle at time t . [2]

- (ii) Find the displacement of the particle from its position when $t = 1$ to its position when $t = 3$. [4]

- (iii) You are given that v is always positive. Explain how this tells you that the distance travelled by the particle between $t = 1$ and $t = 3$ has the same value as the displacement between these times. [2]

Section B (36 marks)

6

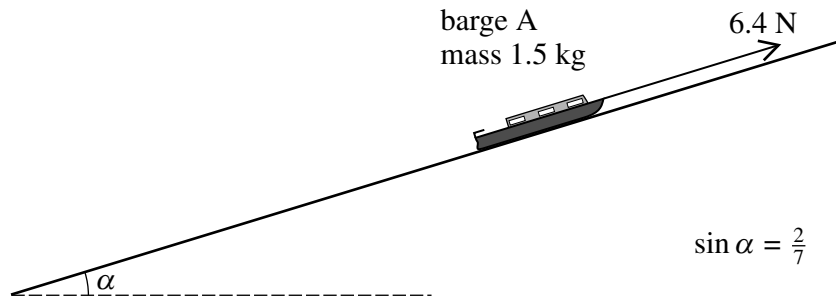


Fig. 6.1

Fig. 6.1 shows a toy barge A of mass 1.5 kg on a rough plane. The plane is at an angle α to the horizontal where $\sin \alpha = \frac{2}{7}$.

- (i) Show that the component of the weight of the barge down the slope is 4.2 N. [2]

The barge is held in equilibrium by a force of 6.4 N acting up and parallel to the plane.

- (ii) Determine the frictional force on the barge and state whether it acts up or down the plane. [2]

The force of 6.4 N is removed and the barge now slides down the plane with acceleration 1.2 m s^{-2} .

- (iii) Calculate the new frictional force on the barge. [4]

- (iv) Determine how far the barge travels while its speed increases from 0.8 m s^{-1} to 2 m s^{-1} . [3]

Fig. 6.2 shows barge A on the same slope with a second barge B of mass 2 kg attached to it by means of a light rigid coupling parallel to the plane. The frictional force on barge B is 0.7 N and the frictional force on barge A is now 2.3 N. At one stage of the motion the two barges are being pulled up the plane by a force of 10 N parallel to the plane.

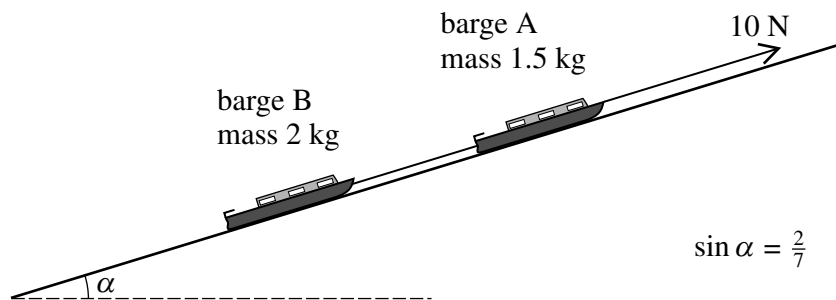


Fig. 6.2

- (v) Draw diagrams showing the forces acting on each barge.

Calculate the acceleration of the barges and clearly indicate its direction.

Find the force in the coupling, stating whether this is a tension or a thrust (compression). [7]

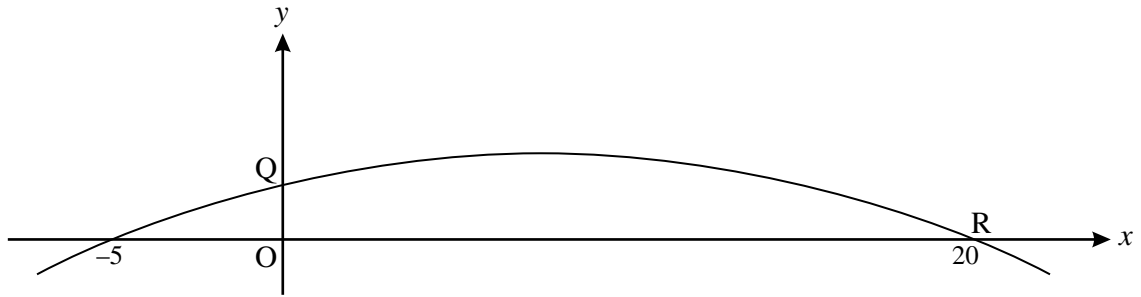


Fig. 7

Fig. 7 shows the graph of $y = \frac{1}{100}(100 + 15x - x^2)$.

For $0 \leq x \leq 20$, this graph shows the trajectory of a small stone projected from the point Q where y m is the height of the stone above horizontal ground and x m is the horizontal displacement of the stone from O. The stone hits the ground at the point R.

- (i) Write down the height of Q above the ground. [1]
- (ii) Find the horizontal distance from O of the highest point of the trajectory and show that this point is 1.5625 m above the ground. [5]
- (iii) Show that the time taken for the stone to fall from its highest point to the ground is 0.565 seconds, correct to 3 significant figures. [3]
- (iv) Show that the horizontal component of the velocity of the stone is 22.1 m s^{-1} , correct to 3 significant figures. Deduce the time of flight from Q to R. [5]
- (v) Calculate the speed at which the stone hits the ground. [4]

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