

**ADVANCED SUBSIDIARY GCE  
MATHEMATICS (MEI)**

Mechanics 1

**4761**

**QUESTION PAPER**

Candidates answer on the printed answer book.

**OCR supplied materials:**

- Printed answer book 4761
- MEI Examination Formulae and Tables (MF2)

**Other materials required:**

- Scientific or graphical calculator

**Wednesday 26 January 2011**

**Afternoon**

**Duration:** 1 hour 30 minutes

**INSTRUCTIONS TO CANDIDATES**

These instructions are the same on the printed answer book and the question paper.

- The question paper will be found in the centre of the printed answer book.
- Write your name, centre number and candidate number in the spaces provided on the printed answer book. Please write clearly and in capital letters.
- **Write your answer to each question in the space provided in the printed answer book.** Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure 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 scientific or 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**

This information is the same on the printed answer book and the question paper.

- The number of marks is given in brackets [ ] at the end of each question or part question on the question paper.
- 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**.
- The printed answer book consists of **12** pages. The question paper consists of **8** pages. Any blank pages are indicated.

**INSTRUCTION TO EXAMS OFFICER / INVIGILATOR**

- Do **not** send this question paper for marking; it should be retained in the centre or destroyed.

## Section A (36 marks)

- 1 An object C is moving along a vertical straight line. Fig. 1 shows the velocity-time graph for part of its motion. Initially C is moving upwards at  $14 \text{ m s}^{-1}$  and after 10 s it is moving downwards at  $6 \text{ m s}^{-1}$ .

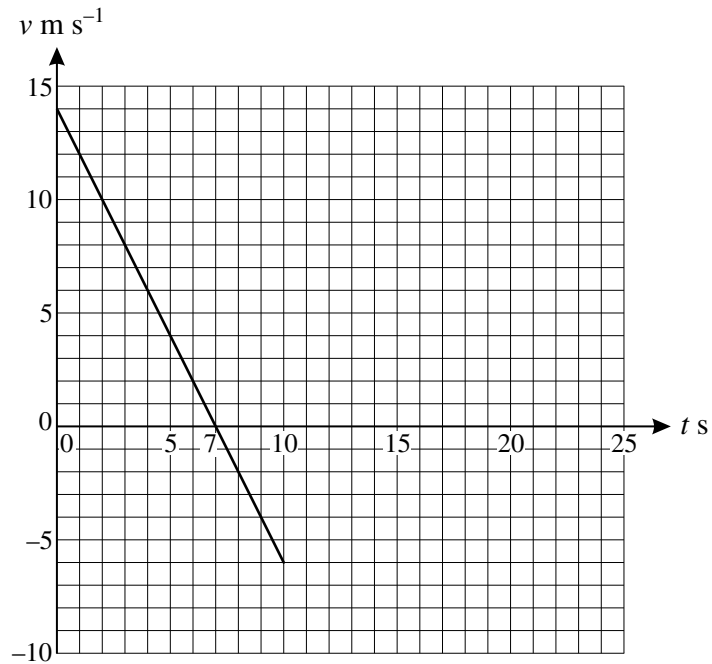


Fig. 1

C then moves as follows.

- In the interval  $10 \leq t \leq 15$ , the velocity of C is constant at  $6 \text{ m s}^{-1}$  downwards.
- In the interval  $15 \leq t \leq 20$ , the velocity of C increases uniformly so that C has zero velocity at  $t = 20$ .

- (i) Complete the velocity-time graph for the motion of C in the time interval  $0 \leq t \leq 20$ . [2]
- (ii) Calculate the acceleration of C in the time interval  $0 < t < 10$ . [2]
- (iii) Calculate the displacement of C from  $t = 0$  to  $t = 20$ . [4]

- 2 Fig. 2 shows two forces acting at A. The figure also shows the perpendicular unit vectors  $\mathbf{i}$  and  $\mathbf{j}$  which are respectively horizontal and vertically upwards.

The resultant of the two forces is  $\mathbf{F}$  N.

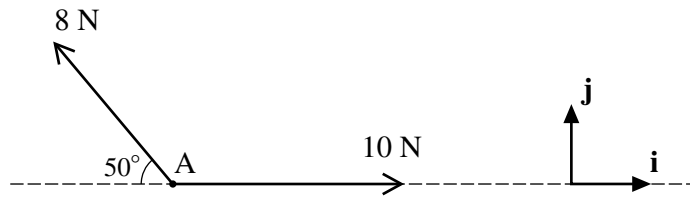


Fig. 2

- (i) Find  $\mathbf{F}$  in terms of  $\mathbf{i}$  and  $\mathbf{j}$ , giving your answer correct to three significant figures. [3]
- (ii) Calculate the magnitude of  $\mathbf{F}$  and the angle that  $\mathbf{F}$  makes with the upward vertical. [3]

- 3 Two cars, P and Q, are being crashed as part of a film 'stunt'.

At the start

- P is travelling directly towards Q with a speed of  $8 \text{ m s}^{-1}$ ,
- Q is instantaneously at rest and has an acceleration of  $4 \text{ m s}^{-2}$  directly towards P.

P continues with the same velocity and Q continues with the same acceleration. The cars collide  $T$  seconds after the start.

- (i) Find expressions in terms of  $T$  for how far each of the cars has travelled since the start. [2]

At the start, P is 90 m from Q.

- (ii) Show that  $T^2 + 4T - 45 = 0$  and hence find  $T$ . [5]

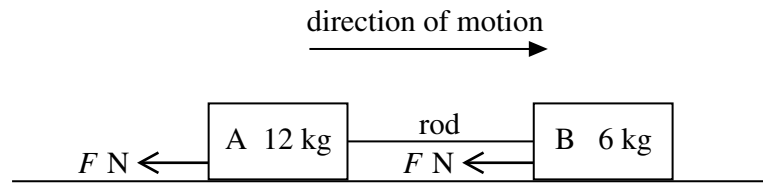
- 4 At time  $t$  seconds, a particle has position with respect to an origin O given by the vector

$$\mathbf{r} = \begin{pmatrix} 8t \\ 10t^2 - 2t^3 \end{pmatrix},$$

where  $\begin{pmatrix} 1 \\ 0 \end{pmatrix}$  and  $\begin{pmatrix} 0 \\ 1 \end{pmatrix}$  are perpendicular unit vectors east and north respectively and distances are in metres.

- (i) When  $t = 1$ , the particle is at P. Find the bearing of P from O. [2]
- (ii) Find the velocity of the particle at time  $t$  and show that it is never zero. [3]
- (iii) Determine the time(s), if any, when the acceleration of the particle is zero. [3]

- 5 Fig. 5 shows two boxes, A of mass 12 kg and B of mass 6 kg, sliding in a straight line on a rough horizontal plane. The boxes are connected by a light rigid rod which is parallel to the line of motion. The only forces acting on the boxes in the line of motion are those due to the rod and a constant force of  $F$  N on each box.



**Fig. 5**

The boxes have an initial speed of  $1.5 \text{ m s}^{-1}$  and come to rest after sliding a distance of 0.375 m.

- (i) Calculate the deceleration of the boxes and the value of  $F$ . [4]
- (ii) Calculate the magnitude of the force in the rod and state, with a reason, whether it is a tension or a thrust (compression). [3]

## Section B (36 marks)

- 6 A toy sledge of mass 4 kg is being pulled in a straight line by a light string. The resistance to its motion is 6 N.

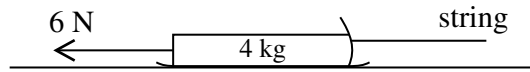


Fig. 6.1

At one time, the string is horizontal and the sledge is on horizontal ground, as shown in Fig. 6.1. The acceleration of the sledge is  $3 \text{ m s}^{-2}$  forwards.

- (i) Calculate the tension in the string. [3]

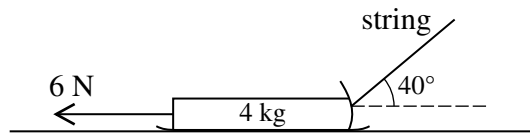


Fig. 6.2

At another time, the sledge is again on horizontal ground but the string is now at  $40^\circ$  to the horizontal, as shown in Fig. 6.2. The tension in the string is 25 N.

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

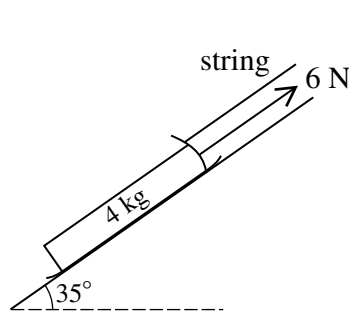


Fig. 6.3

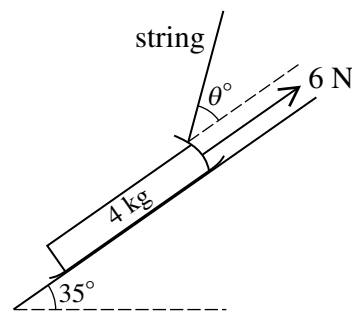


Fig. 6.4

In another situation the sledge is on a slope inclined at  $35^\circ$  to the horizontal, as shown in Fig. 6.3. It is held in equilibrium by the light string parallel to the slope. The resistance to motion of 6 N acts up the slope.

- (iii) Calculate the tension in the string. [3]

The sledge is now held in equilibrium with the light string inclined at  $\theta^\circ$  to the slope, as shown in Fig. 6.4. The tension in the string is 25 N and the resistance to motion remains 6 N acting up the slope.

- (iv) (A) Show all the forces acting on the sledge. [2]  
 (B) Calculate the angle  $\theta$ . [3]  
 (C) Calculate the normal reaction of the slope on the sledge. [3]

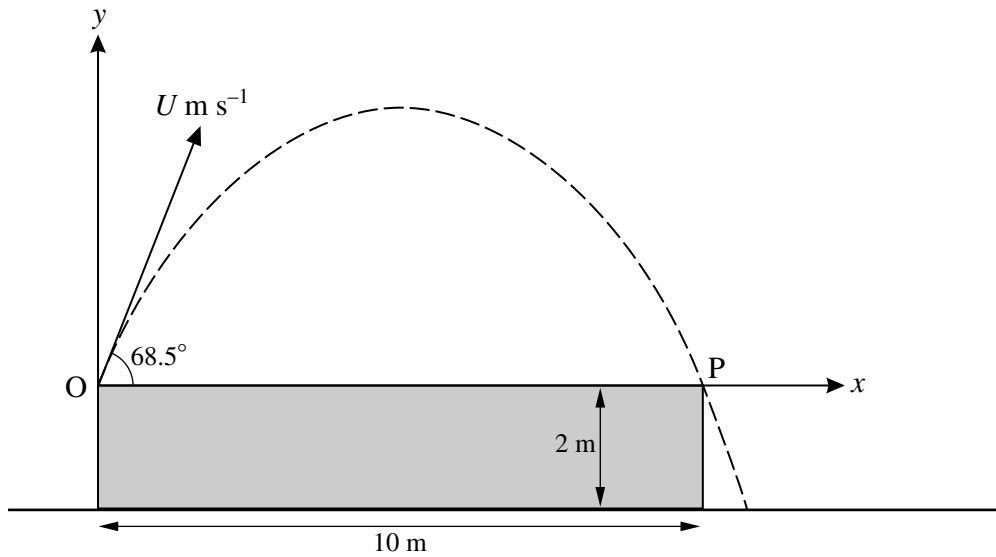


Fig. 7

Fig. 7 shows a platform 10 m long and 2 m high standing on horizontal ground. A small ball projected from the surface of the platform at one end, O, just misses the other end, P. The ball is projected at  $68.5^\circ$  to the horizontal with a speed of  $U \text{ m s}^{-1}$ . Air resistance may be neglected.

At time  $t$  seconds after projection, the horizontal and vertical displacements of the ball from O are  $x$  m and  $y$  m.

(i) Obtain expressions, in terms of  $U$  and  $t$ , for

(A)  $x$ ,

(B)  $y$ .

[3]

(ii) The ball takes  $T$  s to travel from O to P.

Show that  $T = \frac{U \sin 68.5^\circ}{4.9}$  and write down a second equation connecting  $U$  and  $T$ .

[4]

(iii) Hence show that  $U = 12.0$  (correct to three significant figures).

[3]

(iv) Calculate the horizontal distance of the ball from the platform when the ball lands on the ground.

[5]

(v) Use the expressions you found in part (i) to show that the cartesian equation of the trajectory of the ball in terms of  $U$  is

$$y = x \tan 68.5^\circ - \frac{4.9x^2}{U^2(\cos 68.5^\circ)^2}.$$

Use this equation to show again that  $U = 12.0$  (correct to three significant figures).

[4]

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