

**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

**Tuesday 15 June 2010  
Morning**

**Duration: 1 hour 30 minutes**

**INSTRUCTIONS TO CANDIDATES**

These instructions are the same on the Printed Answer Book and the Question Paper.

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the spaces provided on the Printed Answer Book.
- **The questions are on the inserted Question Paper.**
- **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 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**

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 egg falls from rest a distance of 75 cm to the floor.

Neglecting air resistance, at what speed does it hit the floor? [3]

- 2 Fig. 2 shows a sack of rice of weight 250 N hanging in equilibrium supported by a light rope AB. End A of the rope is attached to the sack. The rope passes over a small smooth fixed pulley.

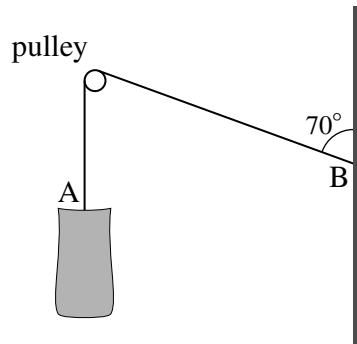


Fig. 2

Initially, end B of the rope is attached to a vertical wall as shown in Fig. 2.

- (i) Calculate the horizontal and the vertical forces acting on the wall due to the rope. [3]

End B of the rope is now detached from the wall and attached instead to the top of the sack. The sack is in equilibrium with both sections of the rope vertical.

- (ii) Calculate the tension in the rope. [1]

- 3 The three forces  $\begin{pmatrix} -1 \\ 14 \\ -8 \end{pmatrix}$  N,  $\begin{pmatrix} 3 \\ -9 \\ 10 \end{pmatrix}$  N and  $\mathbf{F}$  N act on a body of mass 4 kg in deep space and give it an acceleration of  $\begin{pmatrix} -1 \\ 2 \\ 4 \end{pmatrix}$  m s<sup>-2</sup>.

- (i) Calculate  $\mathbf{F}$ . [4]

At one instant the velocity of the body is  $\begin{pmatrix} -3 \\ 3 \\ 6 \end{pmatrix}$  m s<sup>-1</sup>.

- (ii) Calculate the velocity and also the speed of the body 3 seconds later. [4]

- 4 As shown in Fig. 4, boxes P and Q are descending vertically supported by a parachute. Box P has mass 75 kg. Box Q has mass 25 kg and hangs from box P by means of a light vertical wire. Air resistance on the boxes should be neglected.

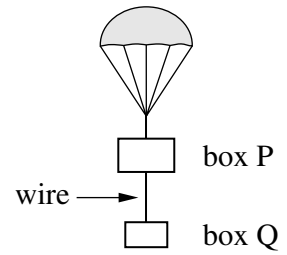


Fig. 4

- (i) Draw a labelled diagram showing all the forces acting on box P and another diagram showing all the forces acting on box Q. [2]
- (ii) Write down separate equations of motion for box P and for box Q. [3]
- (iii) Calculate the tension in the wire. [2]

- 5 In this question the unit vectors  $\mathbf{i}$  and  $\mathbf{j}$  are pointing east and north respectively.

- (i) Calculate the bearing of the vector  $-4\mathbf{i} - 6\mathbf{j}$ . [2]

The vector  $-4\mathbf{i} - 6\mathbf{j} + k(3\mathbf{i} - 2\mathbf{j})$  is in the direction  $7\mathbf{i} - 9\mathbf{j}$ .

- (ii) Find  $k$ . [4]

- 6 A small ball is kicked off the edge of a jetty over a calm sea. Air resistance is negligible. Fig. 6 shows
- the point of projection, O,
  - the initial horizontal and vertical components of velocity,
  - the point A on the jetty vertically below O and at sea level,
  - the height, OA, of the jetty above the sea.

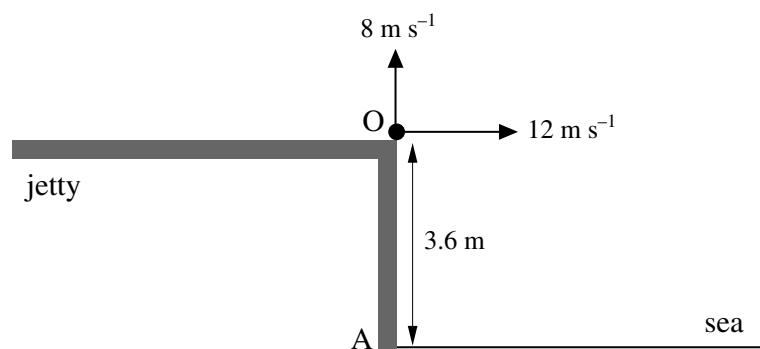


Fig. 6

The time elapsed after the ball is kicked is  $t$  seconds.

- (i) Find an expression in terms of  $t$  for the height of the ball above O at time  $t$ . Find also an expression for the horizontal distance of the ball from O at this time. [3]
- (ii) Determine how far the ball lands from A. [5]

## Section B (36 marks)

- 7 A point P on a piece of machinery is moving in a vertical straight line. The displacement of P above ground level at time  $t$  seconds is  $y$  metres. The displacement-time graph for the motion during the time interval  $0 \leq t \leq 4$  is shown in Fig. 7.

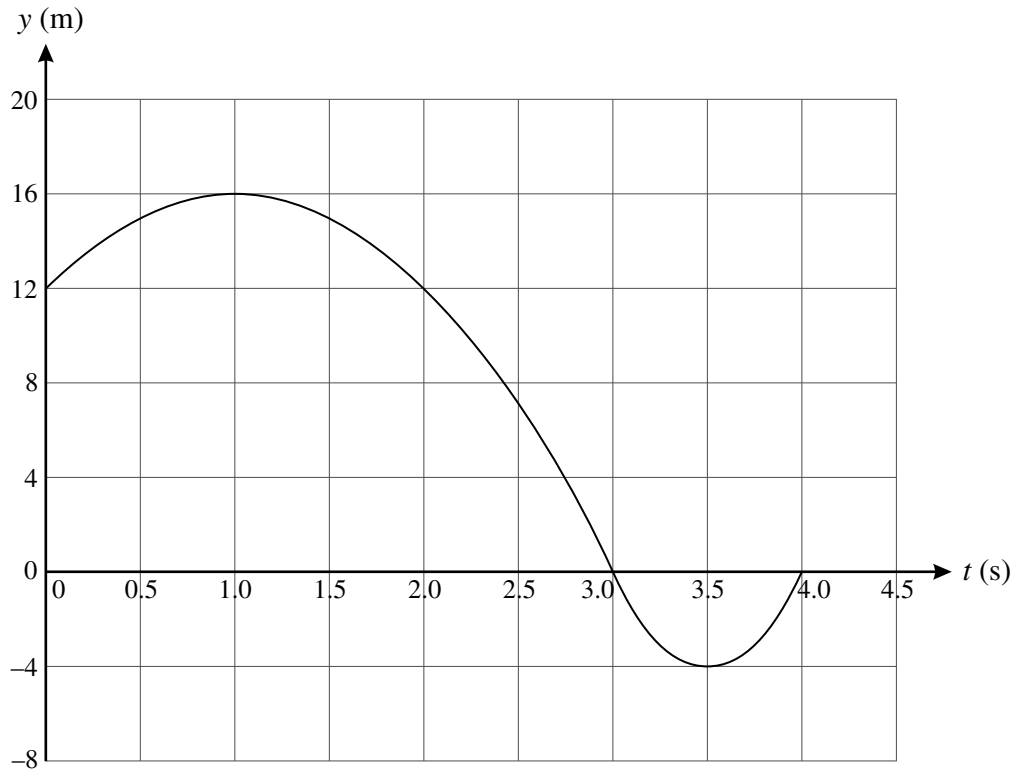


Fig. 7

- (i) Using the graph, determine for the time interval  $0 \leq t \leq 4$
- (A) the greatest displacement of P above its position when  $t = 0$ ,
  - (B) the greatest distance of P from its position when  $t = 0$ ,
  - (C) the time interval in which P is moving downwards,
  - (D) the times when P is instantaneously at rest.
- [6]

The displacement of P in the time interval  $0 \leq t \leq 3$  is given by  $y = -4t^2 + 8t + 12$ .

- (ii) Use calculus to find expressions in terms of  $t$  for the velocity and for the acceleration of P in the interval  $0 \leq t \leq 3$ . [3]
- (iii) At what times does P have a speed of  $4 \text{ m s}^{-1}$  in the interval  $0 \leq t \leq 3$ ? [2]

In the time interval  $3 \leq t \leq 4$ , P has a constant acceleration of  $32 \text{ m s}^{-2}$ . There is no sudden change in velocity when  $t = 3$ .

- (iv) Find an expression in terms of  $t$  for the displacement of P in the interval  $3 \leq t \leq 4$ . [5]

- 8 A cylindrical tub of mass 250 kg is on a horizontal floor. Resistance to its motion other than that due to friction is negligible.

The first attempt to move the tub is by pulling it with a force of 150 N in the  $\mathbf{i}$  direction, as shown in Fig. 8.1.

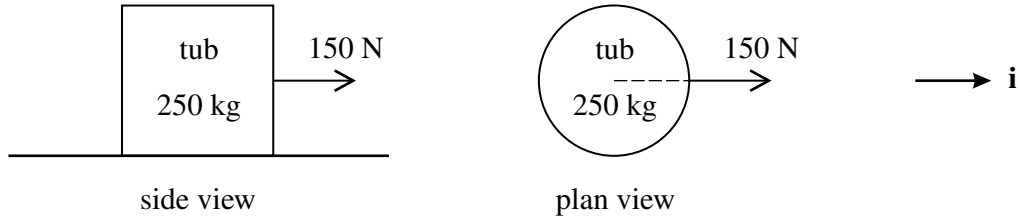


Fig. 8.1

- (i) Calculate the acceleration of the tub if friction is ignored. [2]

In fact, there is friction and the tub does not move.

- (ii) Write down the magnitude and direction of the frictional force opposing the pull. [2]

Two more forces are now added to the 150 N force in a second attempt to move the tub, as shown in Fig. 8.2.

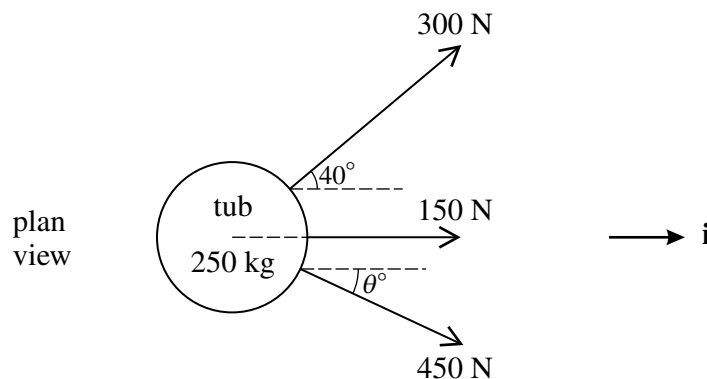


Fig. 8.2

Angle  $\theta$  is acute and chosen so that the resultant of the three forces is in the  $\mathbf{i}$  direction.

- (iii) Determine the value of  $\theta$  and the resultant of the three forces. [6]

With this resultant force, the tub moves with constant acceleration and travels 1 metre from rest in 2 seconds.

- (iv) Show that the magnitude of the friction acting on the tub is 661 N, correct to 3 significant figures. [5]

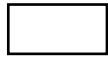
When the speed of the tub is  $1.8 \text{ m s}^{-1}$ , it comes to a part of the floor where the friction on the tub is 200 N greater. The pulling forces stay the same.

- (v) Find the velocity of the tub when it has moved a further 1.65 m. [5]

**4 (i)**



box P



box Q

**4 (ii)**

**4 (iii)**