

**ADVANCED SUBSIDIARY GCE  
MATHEMATICS (MEI)**

Mechanics 1

**FRIDAY 23 MAY 2008**

**4761/01**

Morning

Time: 1 hour 30 minutes

**Additional materials (enclosed):** None

**Additional materials (required):**

Answer Booklet (8 pages)

Graph paper

MEI Examination Formulae and Tables (MF2)

**INSTRUCTIONS TO CANDIDATES**

- Write your name in capital letters, your Centre Number and Candidate Number in the spaces provided on the Answer Booklet.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- 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  $g \text{ m s}^{-2}$ . 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.
- The total number of marks for this paper is **72**.
- 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.

This document consists of **6** printed pages and **2** blank pages.

## Section A (36 marks)

- 1 Fig. 1.1 shows a circular cylinder of mass 100 kg being raised by a light, inextensible vertical wire AB. There is negligible air resistance.

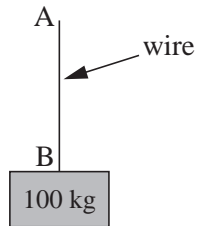


Fig. 1.1

- (i) Calculate the acceleration of the cylinder when the tension in the wire is 1000 N. [3]
- (ii) Calculate the tension in the wire when the cylinder has an upward acceleration of  $0.8 \text{ m s}^{-2}$ . [2]

The cylinder is now raised inside a fixed smooth vertical tube that prevents horizontal motion but provides negligible resistance to the upward motion of the cylinder. When the wire is inclined at  $30^\circ$  to the vertical, as shown in Fig. 1.2, the cylinder again has an upward acceleration of  $0.8 \text{ m s}^{-2}$ .

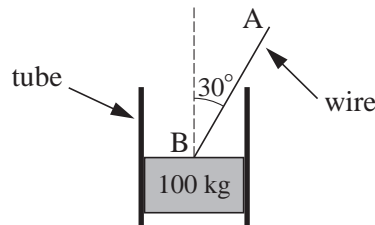


Fig. 1.2

- (iii) Calculate the new tension in the wire. [3]
- 2 A particle has a position vector  $\mathbf{r}$ , where  $\mathbf{r} = 4\mathbf{i} - 5\mathbf{j}$  and  $\mathbf{i}$  and  $\mathbf{j}$  are unit vectors in the directions east and north respectively.
- (i) Sketch  $\mathbf{r}$  on a diagram showing  $\mathbf{i}$  and  $\mathbf{j}$  and the origin O. [1]
- (ii) Calculate the magnitude of  $\mathbf{r}$  and its direction as a bearing. [4]
- (iii) Write down the vector that has the same direction as  $\mathbf{r}$  and three times its magnitude. [1]

- 3 An object of mass 5 kg has a constant acceleration of  $\begin{pmatrix} -1 \\ 2 \end{pmatrix} \text{ m s}^{-2}$  for  $0 \leq t \leq 4$ , where  $t$  is the time in seconds.

(i) Calculate the force acting on the object. [2]

When  $t = 0$ , the object has position vector  $\begin{pmatrix} -2 \\ 3 \end{pmatrix} \text{ m}$  and velocity  $\begin{pmatrix} 4 \\ 5 \end{pmatrix} \text{ m s}^{-1}$ .

(ii) Find the position vector of the object when  $t = 4$ . [3]

4

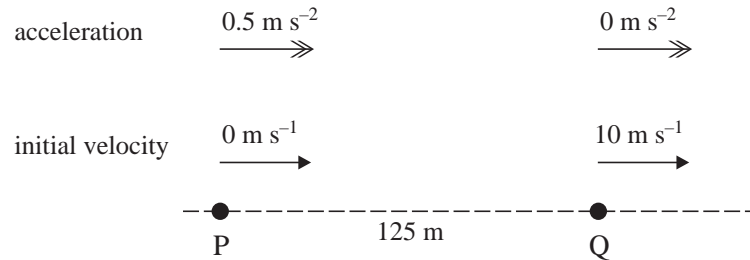


Fig. 4

Particles P and Q move in the same straight line. Particle P starts from rest and has a constant acceleration towards Q of  $0.5 \text{ m s}^{-2}$ . Particle Q starts 125 m from P at the same time and has a constant speed of  $10 \text{ m s}^{-1}$  away from P. The initial values are shown in Fig. 4.

(i) Write down expressions for the distances travelled by P and by Q at time  $t$  seconds after the start of the motion. [2]

(ii) How much time does it take for P to catch up with Q and how far does P travel in this time? [5]

- 5 Boxes A and B slide on a smooth, horizontal plane. Box A has a mass of 4 kg and box B a mass of 5 kg. They are connected by a light, inextensible, horizontal wire. Horizontal forces of 9 N and 135 N act on A and B in the directions shown in Fig. 5.

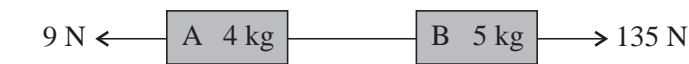


Fig. 5

Calculate the tension in the wire joining the boxes. [4]

- 6 In this question take  $g = 10$ .

A golf ball is hit from ground level over horizontal ground. The initial velocity of the ball is  $40 \text{ m s}^{-1}$  at an angle  $\alpha$  to the horizontal, where  $\sin \alpha = 0.6$  and  $\cos \alpha = 0.8$ . Air resistance may be neglected.

(i) Find an expression for the height of the ball above the ground  $t$  seconds after projection. [2]

(ii) Calculate the horizontal range of the ball. [4]

## Section B (36 marks)

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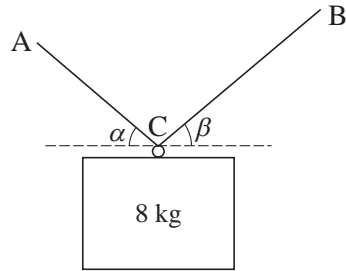


Fig. 7.1

A box of mass 8 kg is supported by a continuous light string ACB that is fixed at A and at B and passes through a smooth ring on the box at C, as shown in Fig. 7.1. The box is in equilibrium and the tension in the string section AC is 60 N.

- (i) What information in the question indicates that the tension in the string section CB is also 60 N? [2]
- (ii) Show that the string sections AC and CB are equally inclined to the horizontal (so that  $\alpha = \beta$  in Fig. 7.1). [2]
- (iii) Calculate the angle of the string sections AC and CB to the horizontal. [5]

In a different situation the same box is supported by two separate light strings, PC and QC, that are tied to the box at C. There is also a horizontal force of 10 N acting at C. This force and the angles between these strings and the horizontal are shown in Fig. 7.2. The box is in equilibrium.

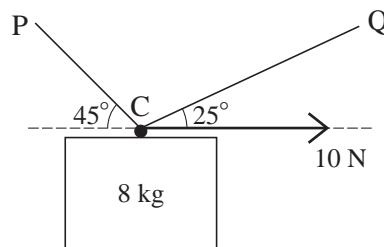


Fig. 7.2

- (iv) Calculate the tensions in the two strings. [8]

8 The displacement,  $x$  m, from the origin O of a particle on the  $x$ -axis is given by

$$x = 10 + 36t + 3t^2 - 2t^3,$$

where  $t$  is the time in seconds and  $-4 \leq t \leq 6$ .

- (i) Write down the displacement of the particle when  $t = 0$ . [1]
- (ii) Find an expression in terms of  $t$  for the velocity,  $v \text{ m s}^{-1}$ , of the particle. [2]
- (iii) Find an expression in terms of  $t$  for the acceleration of the particle. [2]
- (iv) Find the maximum value of  $v$  in the interval  $-4 \leq t \leq 6$ . [3]
- (v) Show that  $v = 0$  only when  $t = -2$  and when  $t = 3$ . Find the values of  $x$  at these times. [5]
- (vi) Calculate the *distance* travelled by the particle from  $t = 0$  to  $t = 4$ . [3]
- (vii) Determine how many times the particle passes through O in the interval  $-4 \leq t \leq 6$ . [3]