



**ADVANCED GCE**  
**MATHEMATICS (MEI)**  
 Mechanics 3

**4763**

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 **4** pages. Any blank pages are indicated.

- 1 (a) (i) Write down the dimensions of density, kinetic energy and power. [3]

A sphere of radius  $r$  is moved at constant velocity  $v$  through a fluid.

- (ii) In a viscous fluid, the power required is  $6\pi\eta rv^2$ , where  $\eta$  is the viscosity of the fluid.

Find the dimensions of viscosity. [3]

- (iii) In a non-viscous fluid, the power required is  $k\rho^\alpha r^\beta v^\gamma$ , where  $\rho$  is the density of the fluid and  $k$  is a dimensionless constant.

Use dimensional analysis to find  $\alpha$ ,  $\beta$  and  $\gamma$ . [6]

- (b) A rock of mass 5.5 kg is connected to a fixed point O by a light elastic rope with natural length 1.2 m. The rock is released from rest in a position 2 m vertically below O, and it next comes to instantaneous rest when it is 1.5 m vertically above O.

Find the stiffness of the rope. [6]

- 2 (a) A uniform solid hemisphere of volume  $\frac{2}{3}\pi a^3$  is formed by rotating the region bounded by the  $x$ -axis, the  $y$ -axis and the curve  $y = \sqrt{a^2 - x^2}$  for  $0 \leq x \leq a$ , through  $2\pi$  radians about the  $x$ -axis.

Show that the  $x$ -coordinate of the centre of mass of the hemisphere is  $\frac{3}{8}a$ . [5]

- (b) A uniform lamina is bounded by the  $x$ -axis, the line  $x = 1$ , and the curve  $y = 2 - \sqrt{x}$  for  $1 \leq x \leq 4$ . Its corners are A (1, 1), B (1, 0) and C (4, 0).

- (i) Find the coordinates of the centre of mass of the lamina. [9]

The lamina is suspended with AB vertical and BC horizontal by light vertical strings attached to A and C, as shown in Fig. 2. The weight of the lamina is  $W$ .

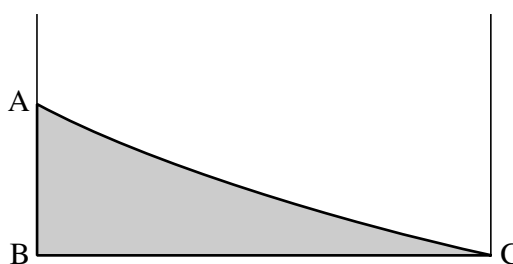


Fig. 2

- (ii) Find the tensions in the two strings in terms of  $W$ . [4]

3

- 3 A particle P of mass 0.6 kg is connected to a fixed point O by a light inextensible string of length 1.25 m. When it is 1.25 m vertically below O, P is set in motion with horizontal velocity  $6 \text{ m s}^{-1}$  and then moves in part of a vertical circle with centre O and radius 1.25 m. When OP makes an angle  $\theta$  with the downward vertical, the speed of P is  $v \text{ m s}^{-1}$ , as shown in Fig. 3.1.

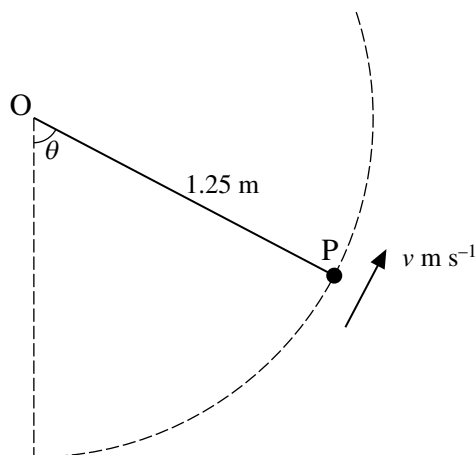


Fig. 3.1

- (i) Show that  $v^2 = 11.5 + 24.5 \cos \theta$ . [3]
- (ii) Find the tension in the string in terms of  $\theta$ . [4]
- (iii) Find the speed of P at the instant when the string becomes slack. [4]

A second light inextensible string, of length 0.35 m, is attached to P, and the other end of this string is attached to a point C which is 1.2 m vertically below O. The particle P now moves in a horizontal circle with centre C and radius 0.35 m, as shown in Fig. 3.2. The speed of P is  $1.4 \text{ m s}^{-1}$ .

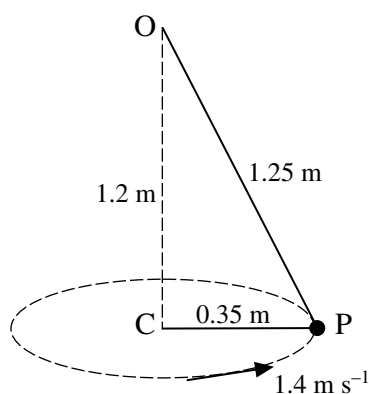


Fig. 3.2

- (iv) Find the tension in the string OP and the tension in the string CP. [7]

[Question 4 is printed overleaf.]

- 4 Fig. 4 shows a smooth plane inclined at an angle of  $30^\circ$  to the horizontal. Two fixed points A and B on the plane are 4.55 m apart with B higher than A on a line of greatest slope. A particle P of mass 0.25 kg is in contact with the plane and is connected to A and to B by two light elastic strings. The string AP has natural length 1.5 m and modulus of elasticity 7.35 N; the string BP has natural length 2.5 m and modulus of elasticity 7.35 N. The particle P moves along part of the line AB, with both strings taut throughout the motion.

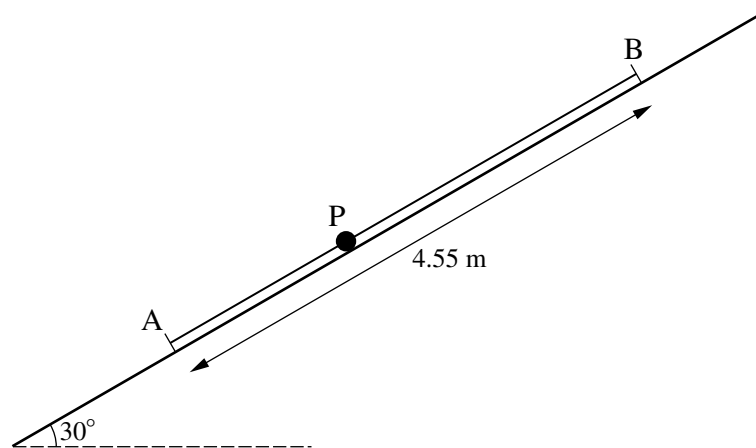


Fig. 4

- (i) Show that, when  $AP = 1.55$  m, the acceleration of P is zero. [5]
- (ii) Taking  $AP = (1.55 + x)$  m, write down the tension in the string AP, in terms of  $x$ , and show that the tension in the string BP is  $(1.47 - 2.94x)$  N. [3]
- (iii) Show that the motion of P is simple harmonic, and find its period. [5]
- The particle P is released from rest with  $AP = 1.5$  m.
- (iv) Find the time after release when P is first moving *down* the plane with speed  $0.2 \text{ m s}^{-1}$ . [5]

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