

**ADVANCED GCE**  
**MATHEMATICS**  
Mechanics 2

**4729**

Candidates answer on the Answer Booklet

**OCR Supplied Materials:**

- 8 page Answer Booklet
- List of Formulae (MF1)

**Other Materials Required:**

None

**Friday 9 January 2009**  
**Morning**

**Duration:** 1 hour 30 minutes



**INSTRUCTIONS TO CANDIDATES**

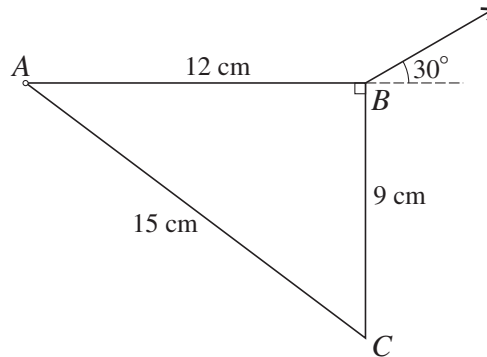
- Write your name clearly in capital letters, your Centre Number and Candidate Number in the spaces provided on the Answer Booklet.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Give non-exact numerical answers correct to 3 significant figures unless a different degree of accuracy is specified in the question or is clearly appropriate.
- The acceleration due to gravity is denoted by  $g \text{ m s}^{-2}$ . Unless otherwise instructed, when a numerical value is needed, use  $g = 9.8$ .
- You are permitted to use a graphical calculator in this paper.

**INFORMATION FOR CANDIDATES**

- The number of marks is given in brackets [ ] at the end of each question or part question.
- **You are reminded of the need for clear presentation in your answers.**
- The total number of marks for this paper is **72**.
- This document consists of **4** pages. Any blank pages are indicated.

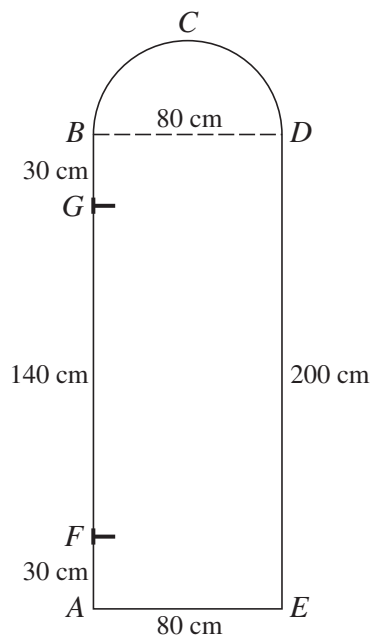
- 1 A stone is projected from a point on level ground with speed  $20 \text{ m s}^{-1}$  at an angle of elevation of  $\theta^\circ$  above the horizontal. When the stone is at its greatest height it just passes over the top of a tree that is 17 m high. Calculate  $\theta$ . [4]

2



A uniform right-angled triangular lamina  $ABC$  with sides  $AB = 12 \text{ cm}$ ,  $BC = 9 \text{ cm}$  and  $AC = 15 \text{ cm}$  is freely suspended from a hinge at its vertex  $A$ . The lamina has mass 2 kg and is held in equilibrium with  $AB$  horizontal by means of a string attached to  $B$ . The string is at an angle of  $30^\circ$  to the horizontal (see diagram). Calculate the tension in the string. [4]

3



A door is modelled as a lamina  $ABCDE$  consisting of a uniform rectangular section  $ABDE$  of weight 60 N and a uniform semicircular section  $BCD$  of weight 10 N and radius 40 cm.  $AB$  is 200 cm and  $AE$  is 80 cm. The door is freely hinged at  $F$  and  $G$ , where  $G$  is 30 cm below  $B$  and  $F$  is 30 cm above  $A$  (see diagram).

- (i) Find the magnitudes and directions of the horizontal components of the forces on the door at each of  $F$  and  $G$ . [4]
- (ii) Calculate the distance from  $AE$  to the centre of mass of the door. [6]

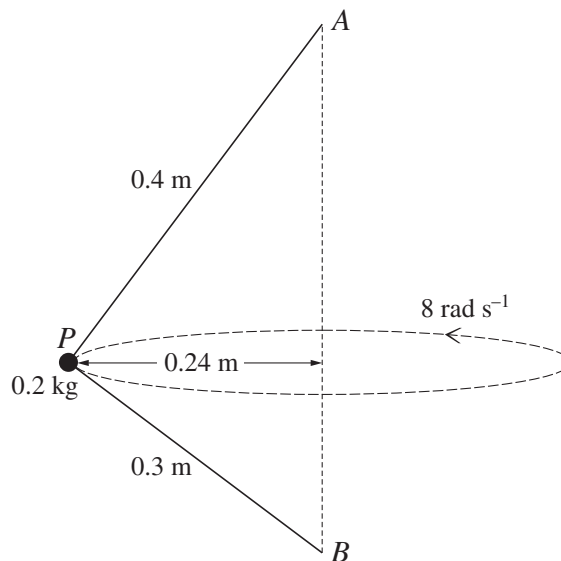
- 4 A car of mass 800 kg experiences a resistance of magnitude  $kv^2$  N, where  $k$  is a constant and  $v$  m s<sup>-1</sup> is the car's speed. The car's engine is working at a constant rate of  $P$  W. At an instant when the car is travelling on a horizontal road with speed 20 m s<sup>-1</sup> its acceleration is 0.75 m s<sup>-2</sup>. At an instant when the car is ascending a hill of constant slope 12° to the horizontal with speed 10 m s<sup>-1</sup> its acceleration is 0.25 m s<sup>-2</sup>.

(i) Show that  $k = 0.900$ , correct to 3 decimal places, and find  $P$ . [7]

The power is increased to  $1.5P$  W.

(ii) Calculate the maximum steady speed of the car on a horizontal road. [3]

5



A particle  $P$  of mass 0.2 kg is attached to one end of each of two light inextensible strings, one of length 0.4 m and one of length 0.3 m. The other end of the longer string is attached to a fixed point  $A$ , and the other end of the shorter string is attached to a fixed point  $B$ , which is vertically below  $A$ . The particle moves in a horizontal circle of radius 0.24 m at a constant angular speed of 8 rad s<sup>-1</sup> (see diagram). Both strings are taut, the tension in  $AP$  is  $S$  N and the tension in  $BP$  is  $T$  N.

(i) By resolving vertically, show that  $4S = 3T + 9.8$ . [4]

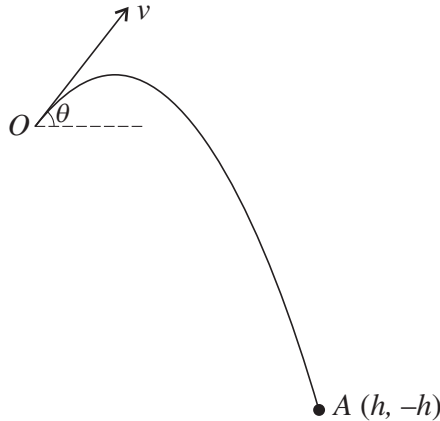
(ii) Find another equation connecting  $S$  and  $T$  and hence calculate the tensions, correct to 1 decimal place. [8]

[Questions 6 and 7 are printed overleaf.]

- 6 A particle is projected from a point  $O$  with speed  $v \text{ m s}^{-1}$  at an angle of elevation  $\theta$  above the horizontal and it moves freely under gravity. The horizontal and upward vertical displacements of the particle from  $O$  at any subsequent time,  $t$  seconds, are  $x \text{ m}$  and  $y \text{ m}$  respectively.

(i) Express  $x$  and  $y$  in terms of  $\theta$  and  $t$ , and hence show that

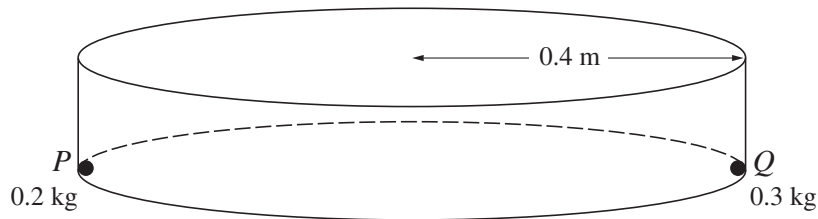
$$y = x \tan \theta - \frac{4.9x^2}{v^2 \cos^2 \theta}. \quad [4]$$



The particle subsequently passes through the point  $A$  with coordinates  $(h, -h)$  as shown in the diagram. It is given that  $v = 14$  and  $\theta = 30^\circ$ .

- (ii) Calculate  $h$ . [4]
- (iii) Calculate the direction of motion of the particle at  $A$ . [5]
- (iv) Calculate the speed of the particle at  $A$ . [2]

7



Two small spheres,  $P$  and  $Q$ , are free to move on the inside of a smooth hollow cylinder, in such a way that they remain in contact with both the curved surface and the base of the cylinder. The mass of  $P$  is  $0.2 \text{ kg}$ , the mass of  $Q$  is  $0.3 \text{ kg}$  and the radius of the cylinder is  $0.4 \text{ m}$ .  $P$  and  $Q$  are stationary at opposite ends of a diameter of the base of the cylinder (see diagram). The coefficient of restitution between  $P$  and  $Q$  is  $0.5$ .  $P$  is given an impulse of magnitude  $0.8 \text{ N s}$  in a tangential direction.

- (i) Calculate the speeds of the particles after  $P$ 's first impact with  $Q$ . [8]

$Q$  subsequently catches up with  $P$  and there is a second impact.

- (ii) Calculate the speeds of the particles after this second impact. [7]
- (iii) Calculate the magnitude of the force exerted on  $Q$  by the curved surface of the cylinder after the second impact. [2]