ADVANCED GCE

MATHEMATICS **4729**

Mechanics 2

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

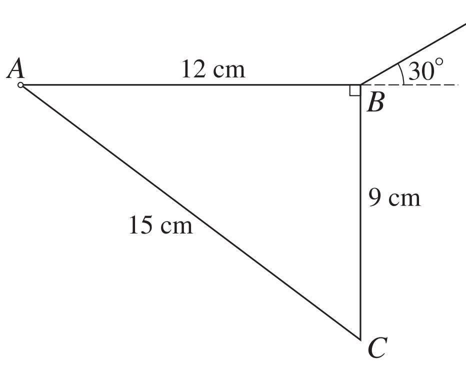
- Write your name clearly in capital letters, your Centre Number and Candidate Number in the spaces provided on the Answer Booklet.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- 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 $g\,\mathrm{m\,s^{-2}}$. 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.

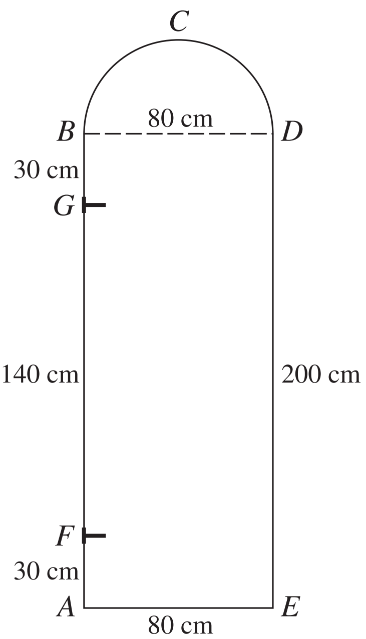
1 A stone is projected from a point on level ground with speed $20\,\text{m}\,\text{s}^{-1}$ at an angle of elevation of $\theta°$ above the horizontal. When the stone is at its greatest height it just passes over the top of a tree that is 17 m high. Calculate θ. **[4]**

2



A uniform right-angled triangular lamina ABC with sides $AB = 12$ cm, $BC = 9$ cm and $AC = 15$ 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° 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]**

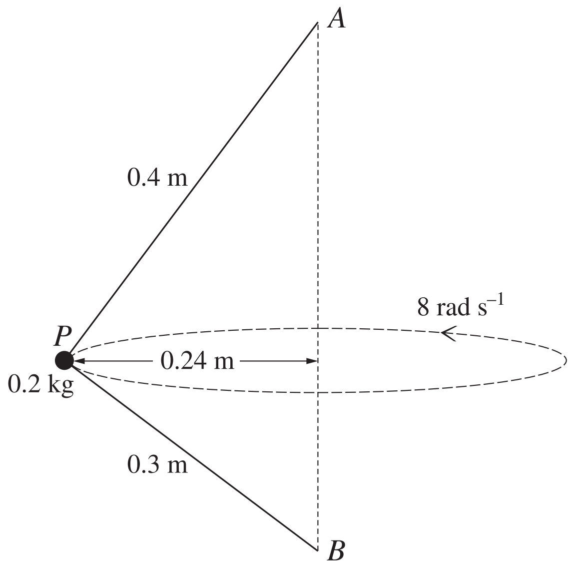
4 A car of mass 800 kg experiences a resistance of magnitude kv^2 N, where k is a constant and v m s^{-1} is the car's speed. The car's engine is working at a constant rate of P W. At an instant when the car is travelling on a horizontal road with speed 20 m s^{-1} its acceleration is 0.75 m s^{-2}.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

(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^{-1} (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]**

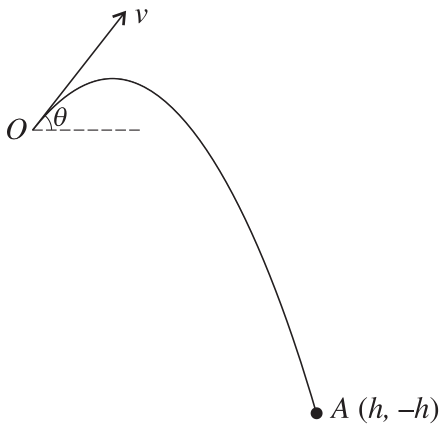
[Questions 6 and 7 are printed overleaf.]

Turn over

6 A particle is projected from a point O with speed $v\,\mathrm{m\,s^{-1}}$ at an angle of elevation θ 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 m and y m respectively.

(i) Express x and y in terms of θ and t, and hence show that

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



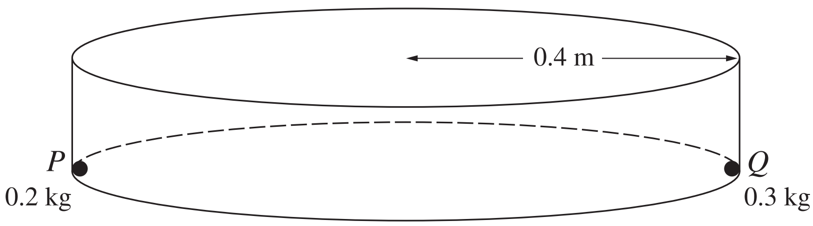
The particle subsequently passes through the point A with coordinates $(h, -h)$ as shown in the diagram. It is given that $v = 14$ and $\theta = 30°$.

(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 kg, the mass of Q is 0.3 kg and the radius of the cylinder is 0.4 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 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]**