

**OXFORD CAMBRIDGE AND RSA EXAMINATIONS****Advanced Subsidiary General Certificate of Education  
Advanced General Certificate of Education****MATHEMATICS****4729**

Mechanics 2

Wednesday

**22 JUNE 2005**

Afternoon

1 hour 30 minutes

Additional materials:

Answer booklet

Graph paper

List of Formulae (MF1)

**TIME** 1 hour 30 minutes**INSTRUCTIONS TO CANDIDATES**

- Write your name, centre number and candidate number in the spaces provided on the answer booklet.
- Answer **all** the questions.
- 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.

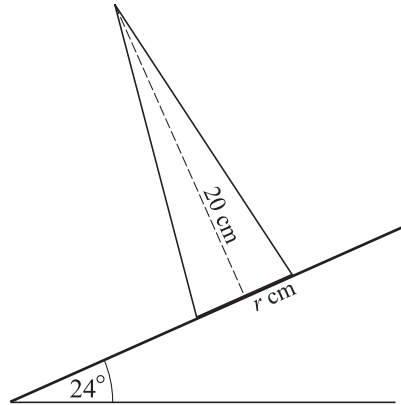
**INFORMATION FOR CANDIDATES**

- The number of marks is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is 72.
- Questions carrying smaller numbers of marks are printed earlier in the paper, and questions carrying larger numbers of marks later in the paper.
- **You are reminded of the need for clear presentation in your answers.**

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**This question paper consists of 4 printed pages.**

1



A uniform solid cone has vertical height 20 cm and base radius  $r$  cm. It is placed with its axis vertical on a rough horizontal plane. The plane is slowly tilted until the cone topples when the angle of inclination is  $24^\circ$  (see diagram).

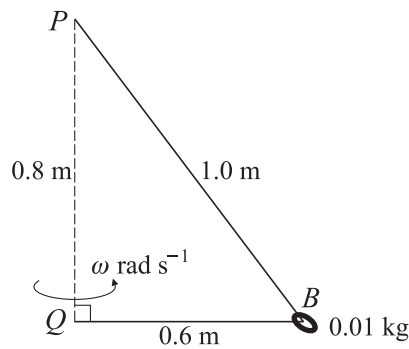
(i) Find  $r$ , correct to 1 decimal place. [4]

A uniform solid cone of vertical height 20 cm and base radius 2.5 cm is placed on the plane which is inclined at an angle of  $24^\circ$ .

(ii) State, with justification, whether this cone will topple. [1]

2 A particle is projected horizontally with a speed of  $6 \text{ m s}^{-1}$  from a point 10 m above horizontal ground. The particle moves freely under gravity. Calculate the speed and direction of motion of the particle at the instant it hits the ground. [6]

3



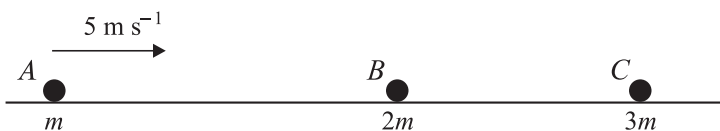
One end of a light inextensible string of length 1.6 m is attached to a point  $P$ . The other end is attached to the point  $Q$ , vertically below  $P$ , where  $PQ = 0.8 \text{ m}$ . A small smooth bead  $B$ , of mass  $0.01 \text{ kg}$ , is threaded on the string and moves in a horizontal circle, with centre  $Q$  and radius  $0.6 \text{ m}$ .  $QB$  rotates with constant angular speed  $\omega \text{ rad s}^{-1}$  (see diagram).

(i) Show that the tension in the string is  $0.1225 \text{ N}$ . [3]

(ii) Find  $\omega$ . [3]

(iii) Calculate the kinetic energy of the bead. [2]

4



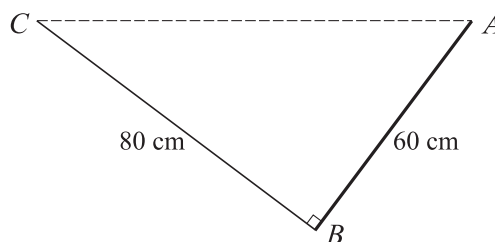
Three smooth spheres  $A$ ,  $B$  and  $C$ , of equal radius and of masses  $m$  kg,  $2m$  kg and  $3m$  kg respectively, lie in a straight line and are free to move on a smooth horizontal table. Sphere  $A$  is moving with speed  $5 \text{ m s}^{-1}$  when it collides directly with sphere  $B$  which is stationary. As a result of the collision  $B$  starts to move with speed  $2 \text{ m s}^{-1}$ .

- (i) Find the coefficient of restitution between  $A$  and  $B$ . [4]
- (ii) Find, in terms of  $m$ , the magnitude of the impulse that  $A$  exerts on  $B$ , and state the direction of this impulse. [2]

Sphere  $B$  subsequently collides with sphere  $C$  which is stationary. As a result of this impact  $B$  and  $C$  coalesce.

- (iii) Show that there will be another collision. [3]

5



A uniform rod  $AB$  of length  $60 \text{ cm}$  and weight  $15 \text{ N}$  is freely suspended from its end  $A$ . The end  $B$  of the rod is attached to a light inextensible string of length  $80 \text{ cm}$  whose other end is fixed to a point  $C$  which is at the same horizontal level as  $A$ . The rod is in equilibrium with the string at right angles to the rod (see diagram).

- (i) Show that the tension in the string is  $4.5 \text{ N}$ . [4]
- (ii) Find the magnitude and direction of the force acting on the rod at  $A$ . [6]

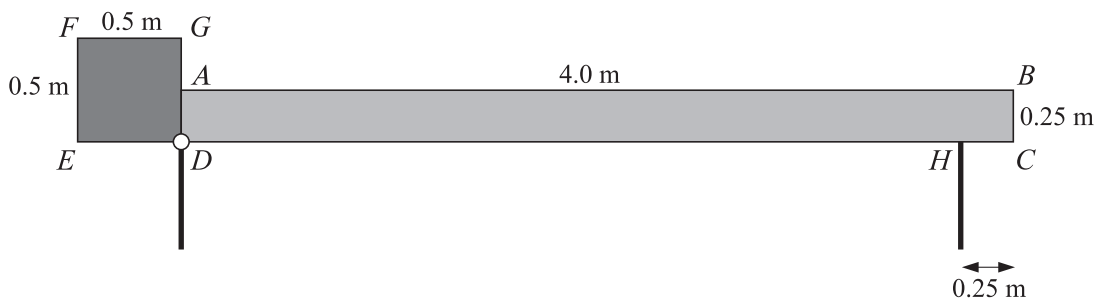
6 A car of mass  $700 \text{ kg}$  is travelling up a hill which is inclined at a constant angle of  $5^\circ$  to the horizontal. At a certain point  $P$  on the hill the car's speed is  $20 \text{ m s}^{-1}$ . The point  $Q$  is  $400 \text{ m}$  further up the hill from  $P$ , and at  $Q$  the car's speed is  $15 \text{ m s}^{-1}$ .

- (i) Calculate the work done by the car's engine as the car moves from  $P$  to  $Q$ , assuming that any resistances to the car's motion may be neglected. [4]

Assume instead that the resistance to the car's motion between  $P$  and  $Q$  is a constant force of magnitude  $200 \text{ N}$ .

- (ii) Given that the acceleration of the car at  $Q$  is zero, show that the power of the engine as the car passes through  $Q$  is  $12.0 \text{ kW}$ , correct to 3 significant figures. [3]
- (iii) Given that the power of the car's engine at  $P$  is the same as at  $Q$ , calculate the car's retardation at  $P$ . [3]

7



A barrier is modelled as a uniform rectangular plank of wood,  $ABCD$ , rigidly joined to a uniform square metal plate,  $DEFG$ . The plank of wood has mass  $50 \text{ kg}$  and dimensions  $4.0 \text{ m}$  by  $0.25 \text{ m}$ . The metal plate has mass  $80 \text{ kg}$  and side  $0.5 \text{ m}$ . The plank and plate are joined in such a way that  $CDE$  is a straight line (see diagram). The barrier is smoothly pivoted at the point  $D$ . In the closed position, the barrier rests on a thin post at  $H$ . The distance  $CH$  is  $0.25 \text{ m}$ .

- (i) Calculate the contact force at  $H$  when the barrier is in the closed position. [3]

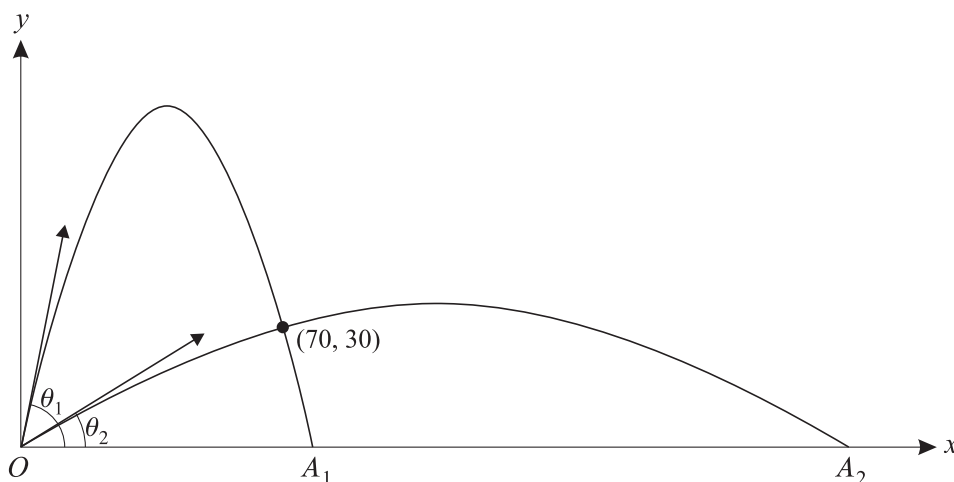
In the open position, the centre of mass of the barrier is vertically above  $D$ .

- (ii) Calculate the angle between  $AB$  and the horizontal when the barrier is in the open position. [8]

8 A particle is projected with speed  $49 \text{ m s}^{-1}$  at an angle of elevation  $\theta$  from a point  $O$  on a horizontal plane, and moves freely under gravity. The horizontal and upward vertical displacements of the particle from  $O$  at time  $t$  seconds after projection are  $x \text{ m}$  and  $y \text{ m}$  respectively.

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

$$y = x \tan \theta - \frac{x^2(1 + \tan^2 \theta)}{490}. \quad [4]$$



The particle passes through the point where  $x = 70$  and  $y = 30$ . The two possible values of  $\theta$  are  $\theta_1$  and  $\theta_2$ , and the corresponding points where the particle returns to the plane are  $A_1$  and  $A_2$  respectively (see diagram).

- (ii) Find  $\theta_1$  and  $\theta_2$ . [4]

- (iii) Calculate the distance between  $A_1$  and  $A_2$ . [5]