

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

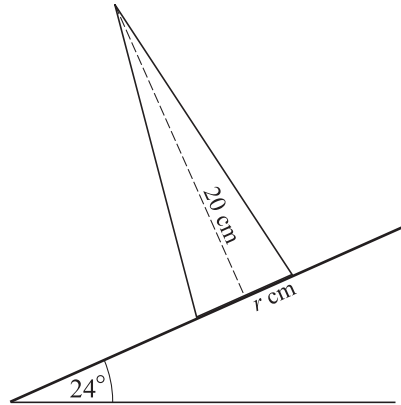
- Write your name, centre number and candidate number in the spaces provided on the answer booklet.
- Answer **all** the questions.
- Give non-exact numerical answers correct to 3 significant figures unless a different degree of accuracy is specified in the question or is clearly appropriate.
- The acceleration 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.**

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° (see diagram).

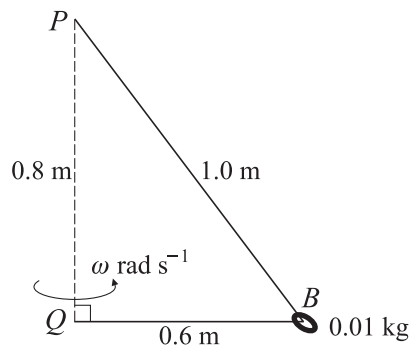
(i) Find r , correct to 1 decimal place. [4]

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° .

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

2 A particle is projected horizontally with a speed of 6 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



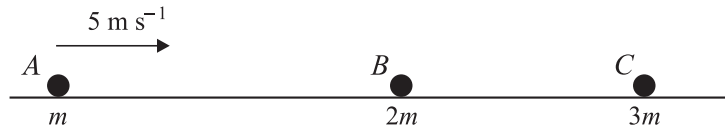
One end of a light inextensible string of length 1.6 m is attached to a point P . The other end is attached to the point Q , vertically below P , where $PQ = 0.8$ m. A small smooth bead B , of mass 0.01 kg, is threaded on the string and moves in a horizontal circle, with centre Q and radius 0.6 m. QB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

(i) Show that the tension in the string is 0.1225 N. [3]

(ii) Find ω . [3]

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

4



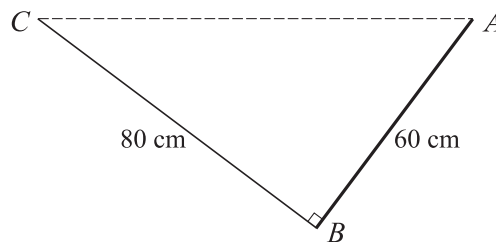
Three smooth spheres A , B and C , of equal radius and of masses m kg, $2m$ kg and $3m$ kg respectively, lie in a straight line and are free to move on a smooth horizontal table. Sphere A is moving with speed 5 m s^{-1} when it collides directly with sphere B which is stationary. As a result of the collision B starts to move with speed 2 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 cm and weight 15 N is freely suspended from its end A . The end B of the rod is attached to a light inextensible string of length 80 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 N . [4]
- (ii) Find the magnitude and direction of the force acting on the rod at A . [6]

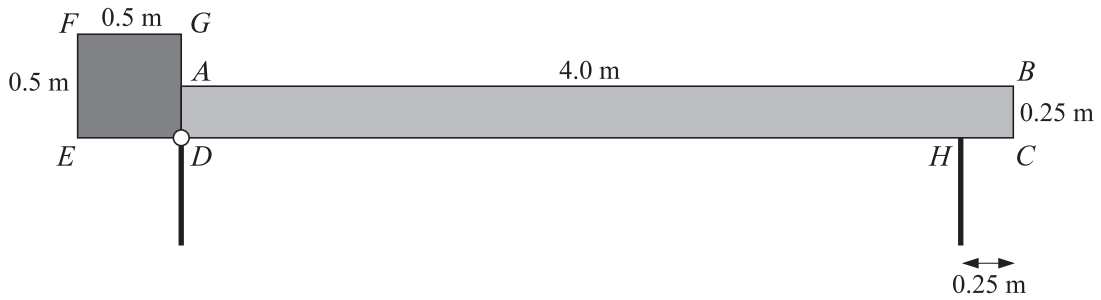
6 A car of mass 700 kg is travelling up a hill which is inclined at a constant angle of 5° to the horizontal. At a certain point P on the hill the car's speed is 20 m s^{-1} . The point Q is 400 m further up the hill from P , and at Q the car's speed is 15 m s^{-1} .

- (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 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 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 kg and dimensions 4.0 m by 0.25 m. The metal plate has mass 80 kg and side 0.5 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 m.

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

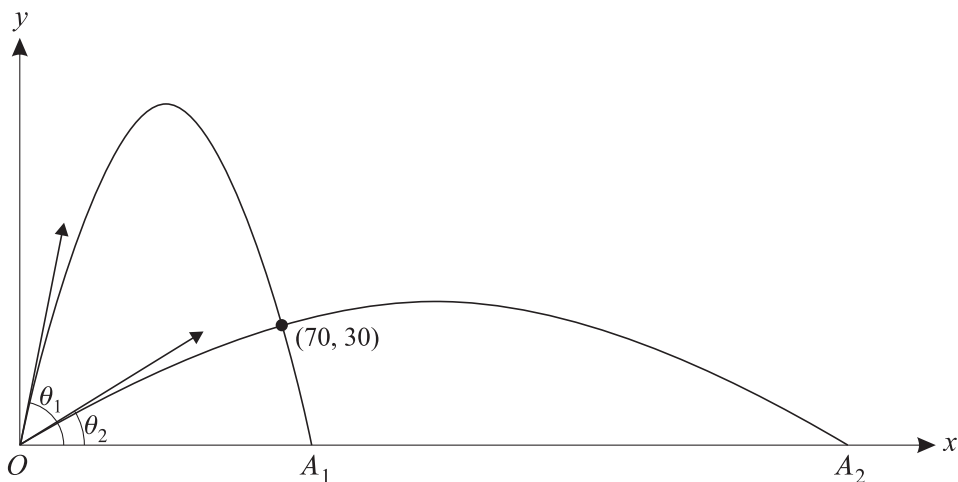
In the open position, the centre of mass of the barrier is vertically above D .

- (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 m s^{-1} at an angle of elevation θ 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 m and y m respectively.

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

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



The particle passes through the point where $x = 70$ and $y = 30$. The two possible values of θ are θ_1 and θ_2 , and the corresponding points where the particle returns to the plane are A_1 and A_2 respectively (see diagram).

- (ii) Find θ_1 and θ_2 . [4]

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