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

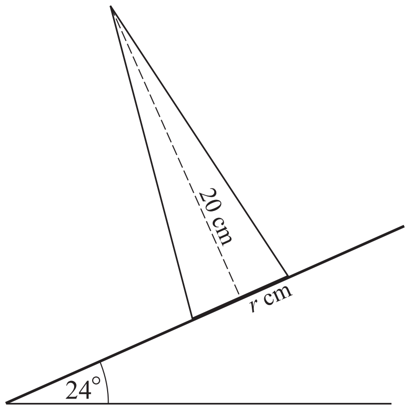
- Write your name, centre number and candidate number in the spaces provided on the answer booklet.
- Answer **all** the questions.
- Give non-exact numerical answers correct to 3 significant figures unless a different degree of accuracy is specified in the question or is clearly appropriate.
- The acceleration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

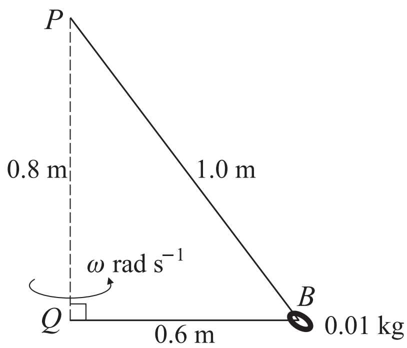
(i) Find r, correct to 1 decimal place. [4]

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



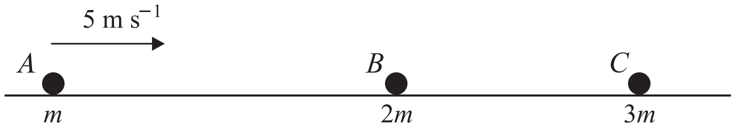
One end of a light inextensible string of length 1.6 m is attached to a point P. The other end is attached to the point Q, vertically below P, where $PQ = 0.8$ m. A small smooth bead B, of mass 0.01 kg, is threaded on the string and moves in a horizontal circle, with centre Q and radius 0.6 m. QB rotates 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 $5\ \mathrm{m\,s^{-1}}$ when it collides directly with sphere B which is stationary. As a result of the collision B starts to move with speed $2\ \mathrm{m\,s^{-1}}$.

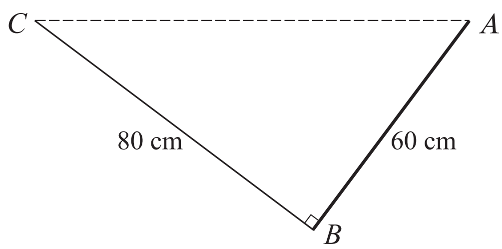
(i) Find the coefficient of restitution between A and B. [4]

(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 $20\ \mathrm{m\,s^{-1}}$. The point Q is 400 m further up the hill from P, and at Q the car's speed is $15\ \mathrm{m\,s^{-1}}$.

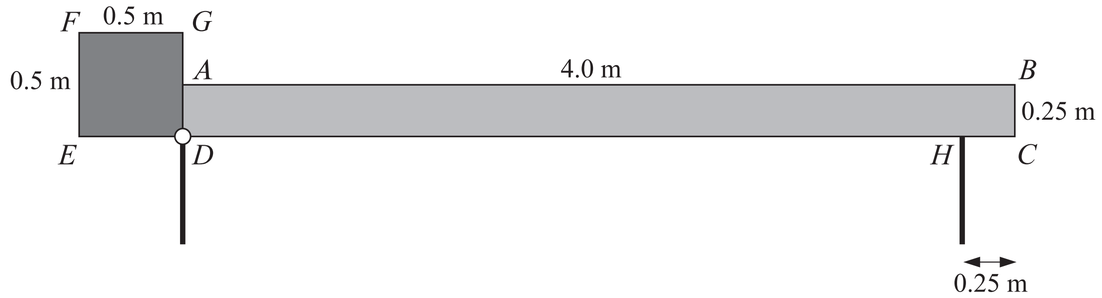
(i) Calculate the work done by the car's engine as the car moves from P to Q, assuming that any resistances to the car's motion may be neglected. [4]

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]

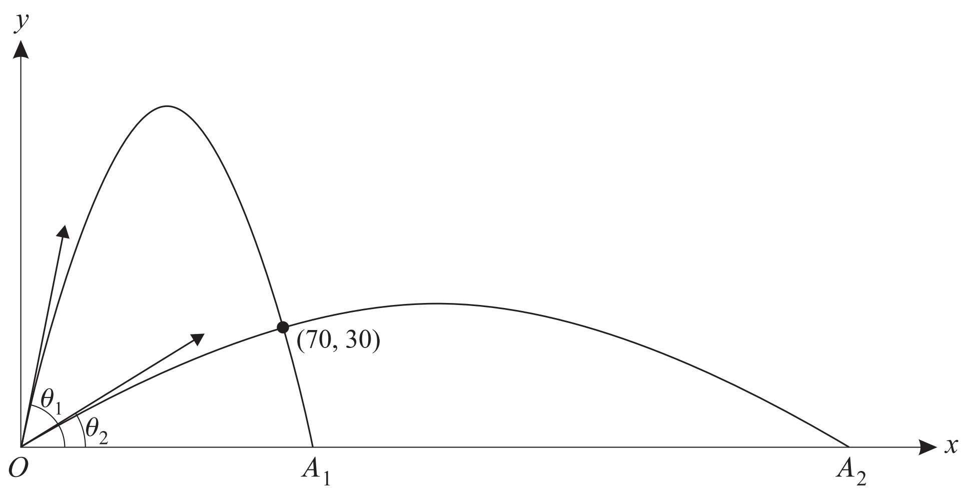
In the open position, the centre of mass of the barrier is vertically above *D*.

(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

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

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