OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education

MATHEMATICS 2639

Mechanics 3

Wednesday **16 JUNE 2004** Afternoon 1 hour 20 minutes

Additional materials:
Answer booklet
Graph paper
List of Formulae (MF8)

TIME 1 hour 20 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.
- Where a numerical value for the acceleration due to gravity is needed, use $9.8\,\mathrm{m\,s^{-2}}$.
- You are permitted to use a graphic 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 60.
- 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 3 printed pages and 1 blank page.

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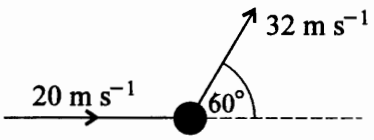
1



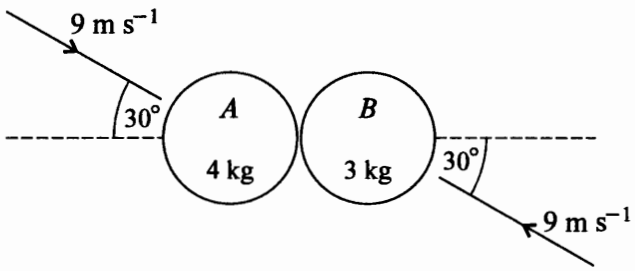
A cricket ball of mass 0.4 kg is moving with speed 20 m s^{-1} when it is struck by a bat. It leaves the bat moving with speed 32 m s^{-1} in a direction making an angle of 60° with its original direction of motion (see diagram). Find the magnitude of the impulse on the ball. [4]

2 A stone of mass m is thrown vertically upwards with initial speed u. When it is at a height x above the point of projection, its speed is v. The only forces acting on the stone are its weight and air resistance of magnitude mkv^2, where k is a constant. The stone is modelled as a particle.

(i) Show that, while the stone is moving upwards, $\left(\frac{v}{g+kv^2}\right)\frac{dv}{dx} = -1$. [2]

(ii) Find the greatest height above the point of projection reached by the stone. [5]

3



Two uniform smooth spheres A and B, of equal radius, have masses 4 kg and 3 kg respectively. They are moving on a horizontal surface when they collide. Immediately before the collision, both spheres have speed 9 m s^{-1}; they are moving in opposite directions, each at 30° to the line of centres (see diagram). After the collision, A moves in a direction perpendicular to the line of centres.

(i) Find the speed and the direction of motion of B immediately after the collision. [6]

(ii) Find the coefficient of restitution between the spheres. [3]

4 A simple pendulum consists of a heavy particle connected to a fixed point by a light inextensible wire of length 12.8 m. The pendulum is oscillating in a vertical plane, and the maximum angle between the wire and the vertical is 0.1 radians. Air resistance may be neglected.

(i) Prove that the motion is approximately simple harmonic, and find the period of oscillation. [5]

(ii) Find the time taken for the pendulum to swing directly from a position where the wire makes an angle of 0.06 radians with the vertical to the position where the wire makes an angle of 0.06 radians on the other side of the vertical. [4]

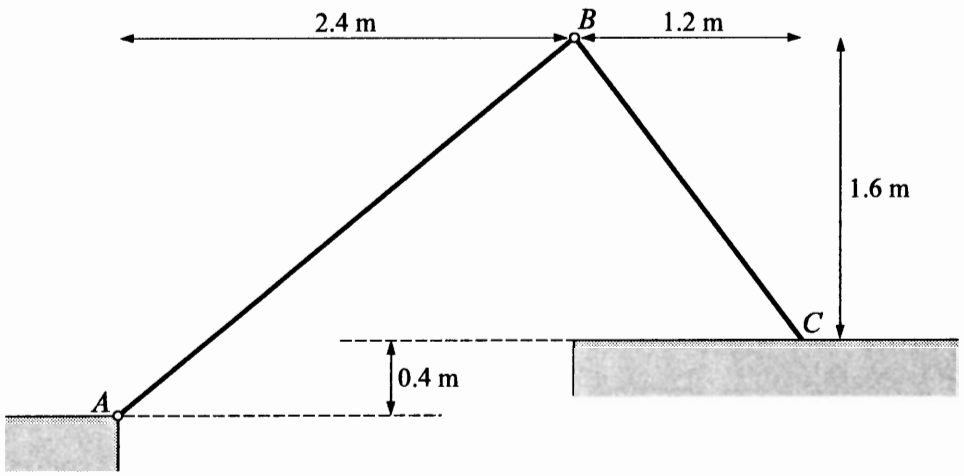
5 A bungee jumper of mass 60 kg is joined to a fixed point O by an elastic rope with natural length 30 m and modulus of elasticity 1260 N. The jumper starts from rest at O and falls vertically.

(i) Show that the maximum speed occurs when the jumper has fallen a distance of 44 m. [3]

(ii) Find the maximum speed of the jumper. [5]

(iii) State two modelling assumptions made when answering this question. [2]

6



Two uniform rods, AB and BC, are freely jointed to each other at B, and A is freely jointed to a fixed point. The rods are in equilibrium in a vertical plane with C resting on a rough horizontal surface. This surface is 0.4 m above the level of A and 1.6 m below the level of B. The horizontal distance between A and B is 2.4 m and the horizontal distance between B and C is 1.2 m (see diagram). The weight of AB is 55 N and the weight of BC is 140 N.

(i) Find the horizontal and vertical components of the force acting on BC at B. [7]

(ii) Given that friction is limiting at C, find the coefficient of friction. [3]

7 A particle P of mass m is connected to a fixed point O by a light inextensible string of length a. While hanging at a distance a vertically below O, the particle is given a horizontal velocity u and begins to move in a vertical circle of radius a. Air resistance may be neglected. When OP makes an angle θ with the downward vertical, the speed of P is v and the tension in the string is T.

(i) Find v^2 in terms of u, a, g and θ, and show that $T = \frac{mu^2}{a} + mg(3\cos\theta - 2)$. [6]

(ii) Given that P oscillates each side of the vertical with the string making a maximum angle of $\frac{1}{3}\pi$ radians with the downward vertical, find u in terms of a and g. [2]

(iii) Given instead that $u = \sqrt{(3ag)}$, find the value of θ at the instant when the string becomes slack. [3]