OCR RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education

MATHEMATICS 4730

Mechanics 3

Monday **22 MAY 2006** Morning 1 hour 30 minutes

Additional materials:
8 page 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.

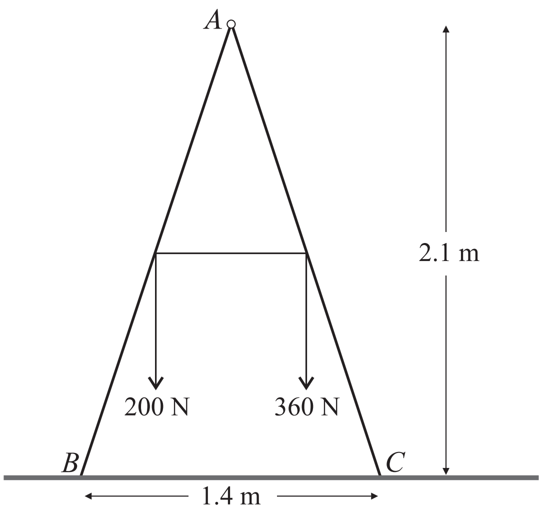
1 A ball of mass 0.4 kg is moving in a straight line, with speed $25\,\mathrm{m\,s^{-1}}$, when it is struck by a bat. The bat exerts an impulse of magnitude 20 N s and the ball is deflected through an angle of 90°. Calculate

(i) the direction of the impulse, [3]

(ii) the speed of the ball immediately after it is struck. [3]

2 A duck of mass 2 kg is travelling with horizontal speed $4\,\mathrm{m\,s^{-1}}$ when it lands on a lake. The duck is brought to rest by the action of resistive forces, acting in the direction opposite to the duck's motion and having total magnitude $(2v + 3v^2)$ N, where $v\,\mathrm{m\,s^{-1}}$ is the speed of the duck. Show that the duck comes to rest after travelling approximately 1.30 m from the point of its initial contact with the surface of the lake. [8]

3



Two uniform rods AB and AC, of equal lengths, and of weights 200 N and 360 N respectively, are freely jointed at A. The mid-points of the rods are joined by a taut light inextensible string. The rods are in equilibrium in a vertical plane with B and C in contact with a smooth horizontal surface. The point A is 2.1 m above the surface and $BC = 1.4$ m (see diagram).

(i) Show that the force exerted on AB at B has magnitude 240 N and find the tension in the string. [6]

(ii) Find the horizontal and vertical components of the force exerted on AB at A and state their directions. [3]

4 A particle is connected to a fixed point by a light inextensible string of length 2.45 m to make a simple pendulum. The particle is released from rest with the string taut and inclined at 0.1 radians to the downward vertical.

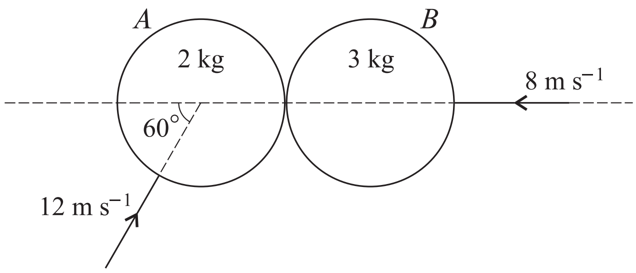
(i) Show that the motion of the particle is approximately simple harmonic with period 3.14 s, correct to 3 significant figures. [5]

Calculate, in either order,

(ii) the angular speed of the pendulum when it has moved 0.04 radians from the **initial** position, [3]

(iii) the time taken by the pendulum to move 0.04 radians from the **initial** position. [3]

5



Two uniform smooth spheres A and B, of equal radius, have masses 2 kg and 3 kg respectively. They are moving on a horizontal surface when they collide. Immediately before the collision A is moving with speed $12\,\mathrm{m\,s^{-1}}$ at $60°$ to the line of centres, and B is moving with speed $8\,\mathrm{m\,s^{-1}}$ along the line of centres (see diagram). The coefficient of restitution between the spheres is 0.5. Find the speed and direction of motion of each sphere after the collision. [12]

6 A bungee jumper of mass 70 kg is joined to a fixed point O by a light elastic rope of natural length 30 m and modulus of elasticity 1470 N. The jumper starts from rest at O and falls vertically. The jumper is modelled as a particle and air resistance is ignored.

(i) Find the distance fallen by the jumper when maximum speed is reached. [4]

(ii) Show that this maximum speed is $26.9\,\mathrm{m\,s^{-1}}$, correct to 3 significant figures. [4]

(iii) Find the extension of the rope when the jumper is at the lowest position. [4]

[Question 7 is printed overleaf.]

[Turn over

7

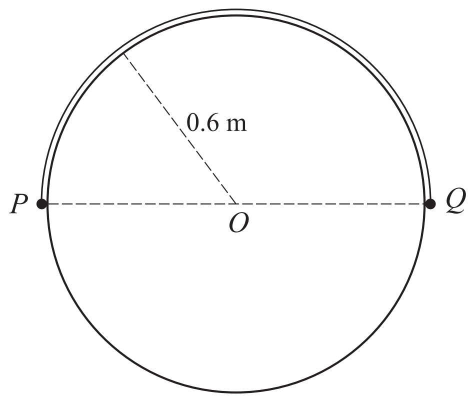


Fig. 1

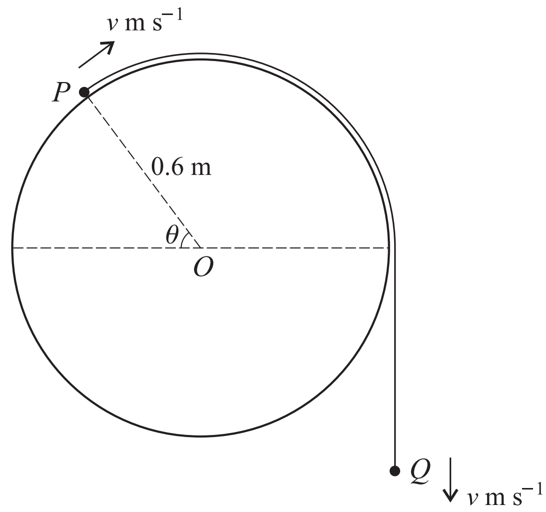


Fig. 2

A smooth horizontal cylinder of radius 0.6 m is fixed with its axis horizontal and passing through a fixed point O. A light inextensible string of length 0.6π m has particles P and Q, of masses 0.3 kg and 0.4 kg respectively, attached at its ends. The string passes over the cylinder and is held at rest with P, O and Q in a straight horizontal line (see Fig. 1). The string is released and Q begins to descend. When the line OP makes an angle θ radians, $0 \leqslant \theta \leqslant \frac{1}{2}\pi$, with the horizontal, the particles have speed v m s^{-1} (see Fig. 2).

(i) By considering the total energy of the system, or otherwise, show that

$$v^2 = 6.72\theta - 5.04 \sin \theta.$$ [5]

(ii) Show that the magnitude of the contact force between P and the cylinder is

$$(5.46 \sin \theta - 3.36\theta) \text{ newtons.}$$

Hence find the value of θ for which the magnitude of the contact force is greatest. [6]

(iii) Find the transverse component of the acceleration of P in terms of θ. [3]