OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE

MATHEMATICS 4730

Mechanics 3

Candidates answer on the answer booklet.

OCR supplied materials:
- 8 page answer booklet (sent with general stationery)
- List of Formulae (MF1)

Other materials required:
- Scientific or graphical calculator

Monday 24 January 2011
Morning

Duration: 1 hour 30 minutes

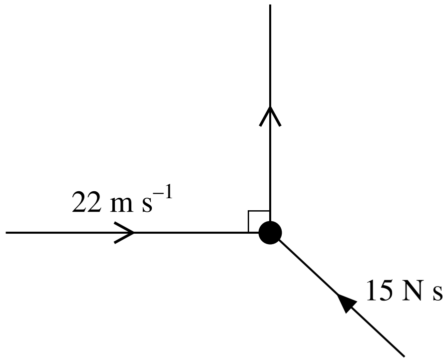
INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the spaces provided on the answer booklet. Please write clearly and in capital letters.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- 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 scientific or 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.
- **You are reminded of the need for clear presentation in your answers.**
- The total number of marks for this paper is **72**.
- This document consists of **4** pages. Any blank pages are indicated.

1



A ball of mass 0.5 kg is moving with speed 22 m s^{-1} in a straight line when it is struck by a bat. The impulse exerted by the bat has magnitude 15 N s and the ball is deflected through an angle of 90° (see diagram). Find

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

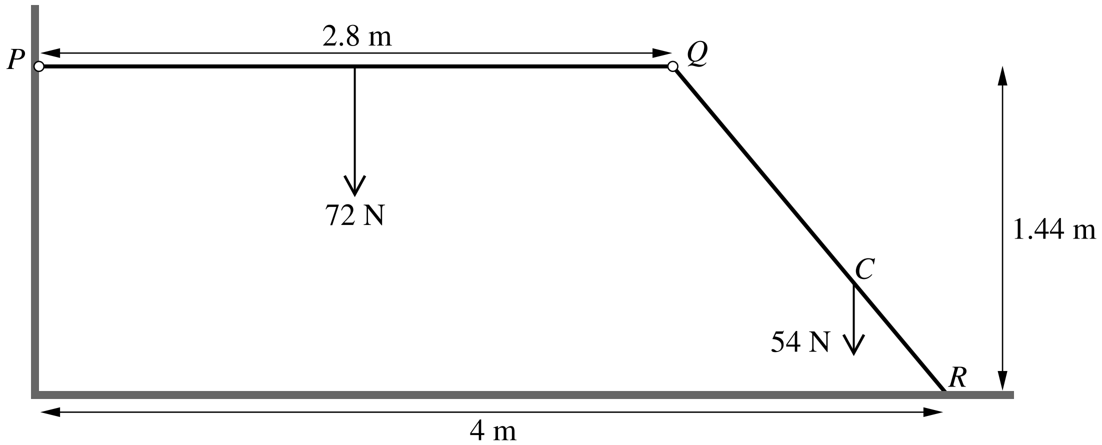
(ii) the speed of the ball immediately after it is struck. **[3]**

2 A particle of mass 0.4 kg is attached to a fixed point O by a light inextensible string of length 0.5 m. The particle is projected horizontally with speed 6 m s^{-1} from the point 0.5 m vertically below O. The particle moves in a complete circle. Find the tension in the string when

(i) the string is horizontal,

(ii) the particle is vertically above O. **[6]**

3



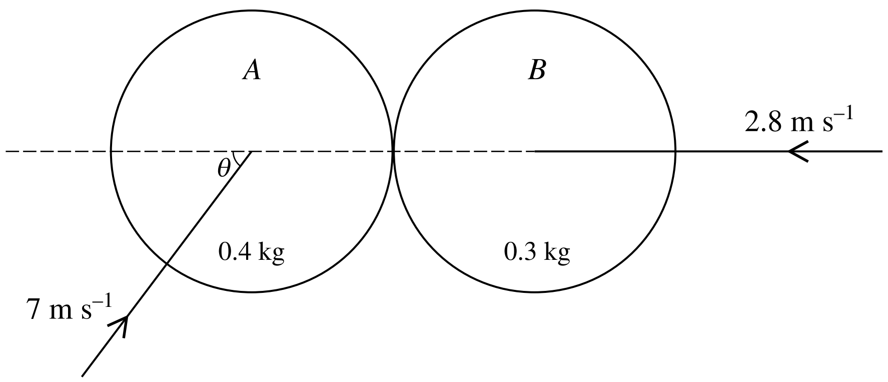
A uniform rod PQ has weight 72 N. A non-uniform rod QR has weight 54 N and its centre of mass is at C, where $QC = 2CR$. The rods are freely jointed to each other at Q. The rod PQ is freely jointed to a fixed point of a vertical wall at P and the rod QR rests on horizontal ground at R. The rod PQ is 2.8 m long and is horizontal. The point R is 1.44 m below the level of PQ and 4 m from the wall (see diagram).

(i) Find the vertical component of the force exerted by the wall on PQ. **[2]**

(ii) Hence show that the normal component of the force exerted by the ground on QR is 90 N. **[2]**

(iii) Given that the friction at R is limiting, find the coefficient of friction between the rod QR and the ground. **[5]**

4



Two uniform smooth spheres A and B of equal radius are moving on a horizontal surface when they collide. A has mass 0.4 kg and B has mass 0.3 kg. Immediately before the collision A is moving with speed 7 m s^{-1} at an acute angle θ to the line of centres, where $\cos\theta = 0.6$, and B is moving with speed 2.8 m s^{-1} along the line of centres (see diagram). The coefficient of restitution between the spheres is 0.7. Find

(i) the speed of B immediately after the collision, **[6]**

(ii) the angle turned through by the direction of motion of A as a result of the collision. **[5]**

5 A particle P of mass 0.05 kg is suspended from a fixed point O by a light elastic string of natural length 0.5 m and modulus of elasticity 2.45 N.

(i) Show that the equilibrium position of P is 0.6 m below O. **[3]**

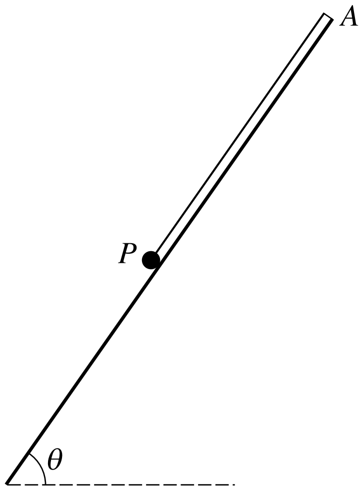
P is held at rest at a point 0.675 m vertically below O and then released. At time t s after P is released, its downward displacement from the equilibrium position is x m.

(ii) Show that $\frac{d^2x}{dt^2} = -98x$. **[3]**

(iii) Find the value of x and the magnitude and direction of the velocity of P when $t = 0.2$. **[7]**

[Questions 6 and 7 are printed overleaf.]

6



A particle P, of mass 3.5 kg, is in equilibrium suspended from the top A of a smooth slope inclined at an angle θ to the horizontal, where $\sin\theta = \frac{40}{49}$, by an elastic rope of natural length 4 m and modulus of elasticity 112 N (see diagram). Another particle Q, of mass 0.5 kg, is released from rest at A and slides freely downwards until it reaches P and becomes attached to it.

(i) Find the value of V^2, where $V\,\text{m s}^{-1}$ is the speed of Q immediately before it becomes attached to P, and show that the speed of the combined particles, immediately after Q becomes attached to P, is $\frac{1}{2}\sqrt{5}\,\text{m s}^{-1}$. **[6]**

The combined particles slide downwards for a distance of X m, before coming instantaneously to rest at B.

(ii) Show that $28X^2 - 8X - 5 = 0$. **[6]**

7 A particle P of mass 0.2 kg is released from rest at a point O and falls vertically. Air resistance of magnitude $\frac{v^2}{2000}$ N acts upwards on P, where $v\,\text{m s}^{-1}$ is the velocity of P when it has fallen a distance of x m.

(i) Show that $\left(\frac{400v}{3920 - v^2}\right)\frac{dv}{dx} = 1$. **[2]**

(ii) Find v^2 in terms of x and hence show that $v^2 < 3920$ for all values of x. **[7]**

(iii) Find the work done against the air resistance while P is falling, from O, to the point where its downward acceleration is $5.8\,\text{m s}^{-2}$. **[6]**

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