OCR
RECOGNISING ACHIEVEMENT

Friday 25 January 2013 – Afternoon

A2 GCE MATHEMATICS

4730/01 Mechanics 3

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:
- Printed Answer Book 4730/01
- List of Formulae (MF1)

Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

These instructions are the same on the Printed Answer Book and the Question Paper.
- The Question Paper will be found in the centre of the Printed Answer Book.
- Write your name, centre number and candidate number in the spaces provided on the Printed Answer Book. Please write clearly and in capital letters.
- **Write your answer to each question in the space provided in the Printed Answer Book**. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Do **not** write in the bar codes.
- You are permitted to use a scientific or graphical calculator in this paper.
- 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 $g = 9.8$.

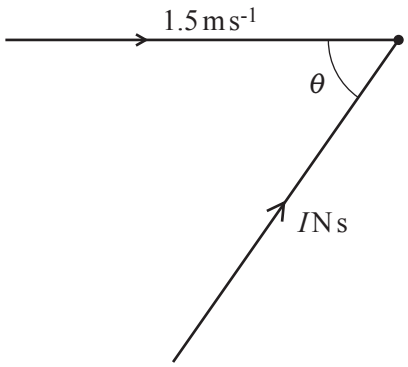
INFORMATION FOR CANDIDATES

This information is the same on the Printed Answer Book and the Question Paper.
- The number of marks is given in brackets **[ ]** at the end of each question or part question on the Question Paper.
- **You are reminded of the need for clear presentation in your answers.**
- The total number of marks for this paper is **72**.
- The Printed Answer Book consists of **12** pages. The Question Paper consists of **4** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER / INVIGILATOR

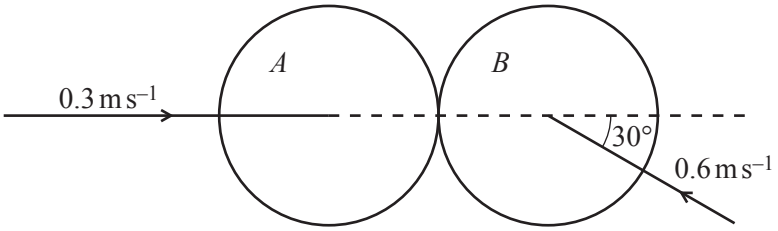
- Do not send this Question Paper for marking; it should be retained in the centre or recycled. Please contact OCR Copyright should you wish to re-use this document.

1



A ball of mass 0.6 kg is moving with speed $1.5\,\text{m s}^{-1}$ in a straight line. It is struck by an impulse I N s acting at an acute angle θ to its direction of motion (see diagram). The impulse causes the direction of motion of the ball to change by an acute angle α, where $\sin\alpha = \frac{8}{17}$. After the impulse acts the ball is moving with a speed of $3.4\,\text{m s}^{-1}$. Find I and θ. **[5]**

2 Two uniform smooth spheres A and B, of equal radius and equal mass, are moving towards each other on a horizontal surface. Immediately before they collide, A has speed $0.3\,\text{m s}^{-1}$ along the line of centres and B has speed $0.6\,\text{m s}^{-1}$ at an angle of 30° to the line of centres (see diagram).



After the collision, the direction of motion of B is at right angles to its original direction of motion. Find

(i) the speed of B after the collision, **[3]**

(ii) the speed and direction of motion of A after the collision, **[3]**

(iii) the coefficient of restitution between A and B. **[3]**

3 At time $t = 0$ s a particle P, of mass 0.3 kg, is 1 m away from a point O on a smooth horizontal plane and is moving away from O with speed $\sqrt{5}\,\text{m s}^{-1}$. The only horizontal force acting on P has magnitude $1.5x$ N, where x is the distance OP, and acts away from O.

(i) Show that the speed of P, $v\,\text{m s}^{-1}$, is given by $v = \sqrt{5}x$. **[4]**

(ii) Find an expression for v in terms of t. **[4]**

4 A smooth cylinder of radius a m is fixed with its axis horizontal and O is the centre of a cross-section. Particle P, of mass 0.4 kg, and particle Q, of mass 0.6 kg, are connected by a light inextensible string of length πa m. The string is held at rest with P and Q at opposite ends of the horizontal diameter of the cross-section through O (see Fig. 1). The string is released and Q begins to descend. When OP has rotated through θ radians, with P remaining in contact with the cylinder, the speed of each particle is v m s^{-1} (see Fig. 2).

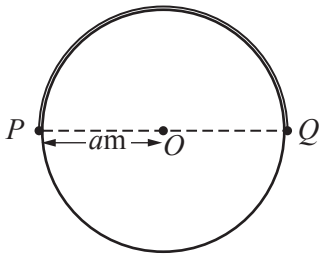


Fig. 1

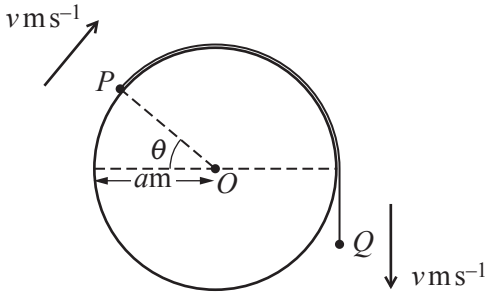


Fig. 2

(i) Show that $v^2 = 3.92a(3\theta - 2\sin\theta)$ and find an expression in terms of θ for the normal force of the cylinder on P at this time. **[9]**

(ii) Given that P leaves the surface of the cylinder when $\theta = \alpha$, show that $\sin\alpha = k\alpha$ where k is a constant to be found. **[2]**

5 A particle P, of mass 2.5 kg, is in equilibrium suspended from a fixed point A by a light elastic string of natural length 3 m and modulus of elasticity 36.75 N. Another particle Q, of mass 1 kg, is released from rest at A and falls freely until it reaches P and becomes attached to it.

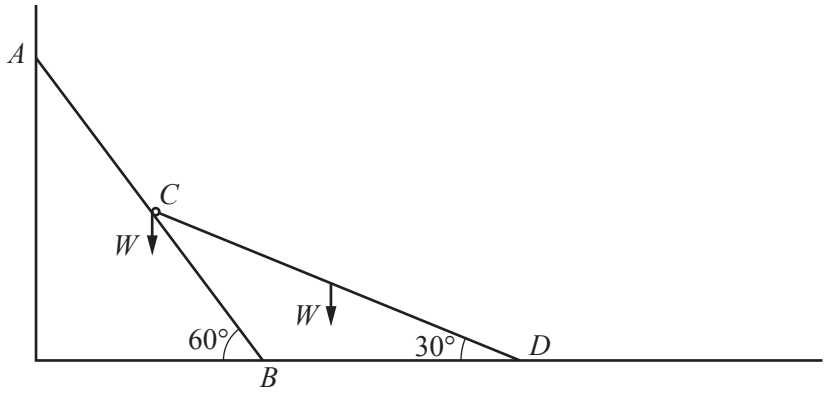
(i) Show that the speed of the combined particles, immediately after Q becomes attached to P, is $2\sqrt{2}$ m s^{-1}. **[6]**

The combined particles fall a further distance X m before coming to instantaneous rest.

(ii) Find a quadratic equation satisfied by X, and show that it simplifies to $35X^2 - 56X - 80 = 0$. **[6]**

[Questions 6 and 7 are printed overleaf]

6 A uniform rod AB, of weight W and length $2l$ is in equilibrium at 60° to the horizontal with A resting against a smooth vertical plane and B resting on a rough section of a horizontal plane. Another uniform rod CD, of length $\sqrt{3}l$ and weight W, is freely jointed to the mid-point of AB at C; its other end D rests on a smooth section of the horizontal plane. CD is inclined at 30° to the horizontal (see diagram).



(i) Show that the force exerted by the horizontal plane on CD is $\frac{1}{2}W$. Find the normal component of the force exerted by the horizontal plane on AB. **[5]**

(ii) Find the magnitude and direction of the force exerted by CD on AB. **[3]**

(iii) Given that AB is in limiting equilibrium, find the coefficient of friction between AB and the horizontal plane. **[5]**

7 A simple pendulum consists of a light inextensible string of length 0.8 m and a particle P of mass m kg. The pendulum is hanging vertically at rest from a fixed point O when P is given a horizontal velocity of $0.3\,\mathrm{m\,s^{-1}}$.

(i) Show that, in the subsequent motion, the maximum angle between the string and the downward vertical is 0.107 radians, correct to 3 significant figures. **[3]**

(ii) Show that the motion may be modelled as simple harmonic motion, and find the period of this motion. **[5]**

(iii) Find the time after the start of the motion when the velocity of the particle is first $-0.2\,\mathrm{m\,s^{-1}}$ and find the angular displacement of OP from the downward vertical at this time. **[6]**