

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 $g \text{ m s}^{-2}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

INFORMATION FOR CANDIDATES

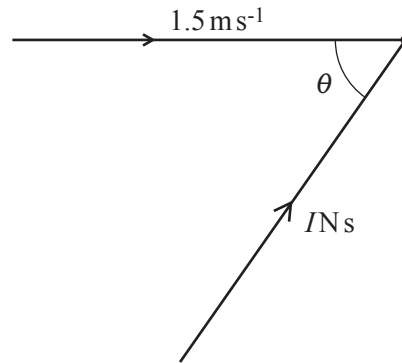
This information is the same on the Printed Answer Book and the Question Paper.

- 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

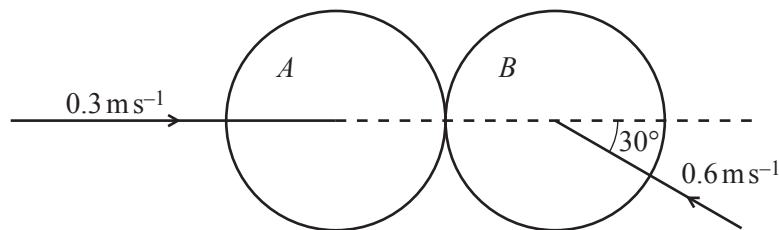
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1



A ball of mass 0.6 kg is moving with speed 1.5 m s^{-1} in a straight line. It is struck by an impulse $I \text{ N s}$ 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 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 m s^{-1} along the line of centres and B has speed 0.6 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 $t = 0 \text{ s}$ 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 $1.5x \text{ N}$, 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).

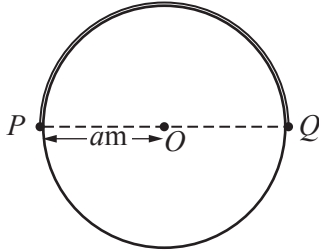


Fig. 1

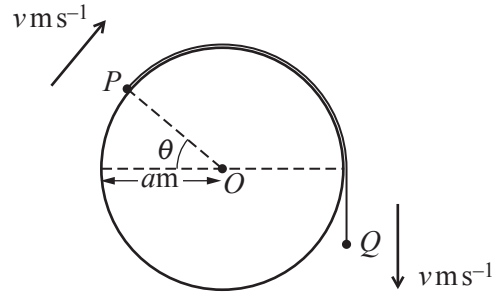


Fig. 2

- (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.

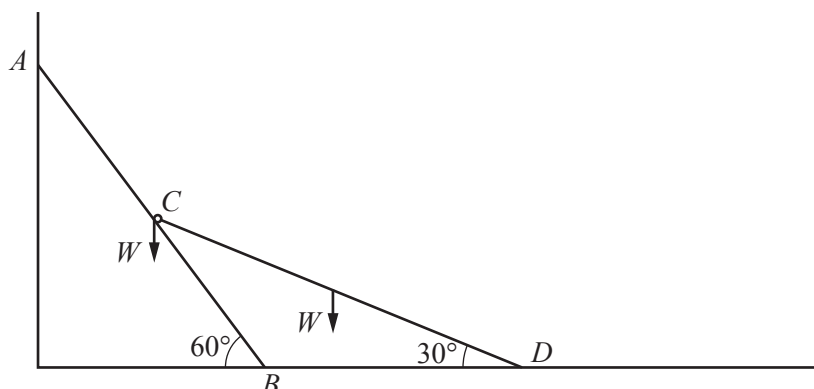
- (i) Show that the speed of the combined particles, immediately after Q becomes attached to P , is $2\sqrt{2}$ m s⁻¹. [6]

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 $m\text{ kg}$. The pendulum is hanging vertically at rest from a fixed point O when P is given a horizontal velocity of 0.3 ms^{-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 ms^{-1} and find the angular displacement of OP from the downward vertical at this time. [6]

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