

Thursday 21 June 2012 – Afternoon

A2 GCE MATHEMATICS

4730 Mechanics 3

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:

- Printed Answer Book 4730
- 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 $g = 9.8$.

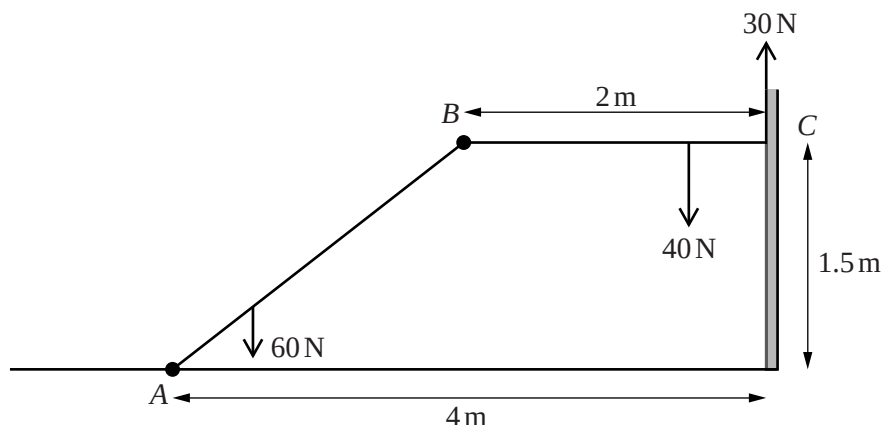
INFORMATION FOR CANDIDATES

- 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 **16** pages. The Question Paper consists of **8** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER/INVIGILATOR

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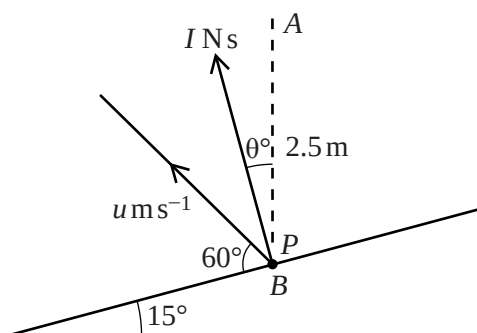
1



Two non-uniform rods AB and BC have weights 60 N and 40 N respectively. The rods are freely jointed to each other at B . The rod AB is freely jointed to a fixed point on horizontal ground at A and the rod BC rests against a vertical wall at C . The rod BC , whose length is 2 m , is horizontal at a height of 1.5 m above the ground. The point A is 4 m from the wall. The frictional force exerted on BC at C has magnitude 30 N (see diagram). The coefficient of friction between the rod BC and the wall is 0.75 .

- (i) Find the distance of the centre of mass of BC from B . [2]
- (ii) Given that the rod BC is on the point of slipping downwards at C , find the magnitude and direction of both the vertical component and the horizontal component of the force exerted on AB at B . [4]
- (iii) Find the distance of the centre of mass of AB from A . [3]

2



B is a point on a smooth plane surface inclined at an angle of 15° to the horizontal. A particle P of mass 0.45 kg is released from rest at the point A which is 2.5 m vertically above B . The particle P rebounds from the surface at an angle of 60° to the line of greatest slope through B , with a speed of $u \text{ ms}^{-1}$. The impulse exerted on P by the surface has magnitude $I \text{ N s}$ and is in a direction making an angle of θ° with the upward vertical through B (see diagram).

(i) Explain why $\theta = 15$. [1]

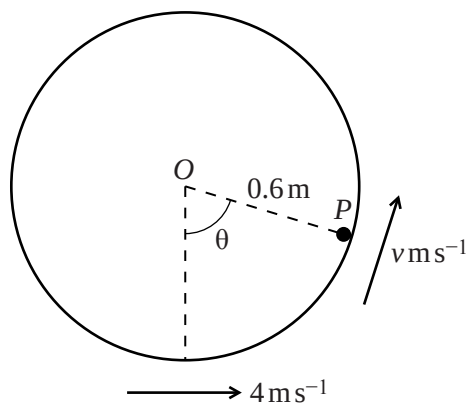
(ii) Find the values of u and I . [7]

3 A particle P of mass $m \text{ kg}$ is released from rest and falls vertically. When P has fallen a distance of $x \text{ m}$ it has a speed of $v \text{ ms}^{-1}$. The only forces acting on P are its weight and air resistance of magnitude $\frac{1}{400}mv^2 \text{ N}$.

(i) Find v^2 in terms of x and show that v^2 must be less than 3920. [8]

(ii) Find the speed of P when it has fallen 100 m . [2]

4



A hollow cylinder is fixed with its axis horizontal. The inner surface of the cylinder is smooth and has radius 0.6 m . A particle P of mass 0.45 kg is projected horizontally with speed 4 m s^{-1} from the lowest point of a vertical cross-section of the cylinder and moves in the plane of the cross-section, which is perpendicular to the axis of the cylinder. While P remains in contact with the surface, its speed is $v\text{ m s}^{-1}$ when OP makes an angle θ with the downward vertical at O , where O is the centre of the cross-section (see diagram). The force exerted on P by the surface is $R\text{ N}$.

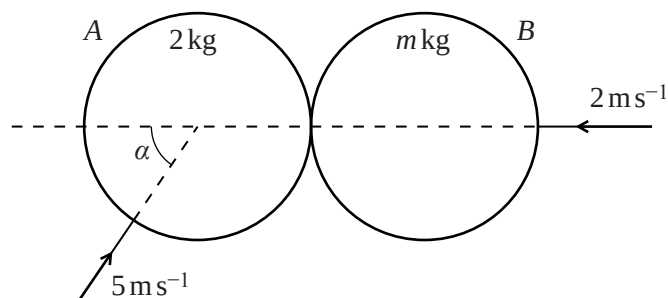
(i) Show that $v^2 = 4.24 + 11.76 \cos \theta$ and find an expression for R in terms of θ . [6]

(ii) Find the speed of P at the instant when it leaves the surface. [4]

- 5 One end of a light elastic string, of natural length 0.78 m and modulus of elasticity $0.8mg\text{ N}$, is attached to a fixed point O on a smooth plane inclined at angle α to the horizontal, where $\sin \alpha = \frac{5}{13}$. A particle P of mass $m\text{ kg}$ is attached to the other end of the string. P is released from rest at O and moves down the plane without reaching the bottom. Find

(i) the maximum speed of P in the subsequent motion, [6]

(ii) the distance of P from O when it is at its lowest point. [4]



Two smooth uniform spheres A and B , of equal radius, have masses 2 kg and $m \text{ kg}$ respectively. They are moving on a horizontal surface when they collide. Immediately before the collision, A has speed 5 m s^{-1} and is moving towards B at an angle of α to the line of centres, where $\cos \alpha = 0.6$. B has speed 2 m s^{-1} and is moving towards A along the line of centres (see diagram). As a result of the collision, A 's loss of kinetic energy is 7.56 J , B 's direction of motion is reversed and B 's speed after the collision is 0.8 m s^{-1} . Find

- (i) the speed of A after the collision, [3]
- (ii) the component of A 's velocity after the collision, parallel to the line of centres, stating with a reason whether its direction is to the left or to the right, [3]
- (iii) the value of m , [3]
- (iv) the coefficient of restitution between A and B . [2]

- 7 S_A and S_B are light elastic strings. S_A has natural length 2 m and modulus of elasticity 120 N; S_B has natural length 3 m and modulus of elasticity 180 N. A particle P of mass 0.8 kg is attached to one end of each of the strings. The other ends of S_A and S_B are attached to fixed points A and B respectively, on a smooth horizontal table. The distance AB is 6 m. P is released from rest at the point of the line segment AB which is 2.9 m from A .

- (i) For the subsequent motion, show that the total elastic potential energy of the strings is the same when $AP = 2.1$ m and when $AP = 2.9$ m. Deduce that neither string becomes slack. [3]
- (ii) Find, in terms of x , an expression for the acceleration of P in the direction of AB when $AP = (2.5 + x)$ m. [3]
- (iii) State, giving a reason, the type of motion of P and find the time taken between successive occasions when P is instantaneously at rest. [3]

For the instant 0.6 seconds after P is released, find

- (iv) the distance travelled by P , [3]
- (v) the speed of P . [2]

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