OCR
RECOGNISING ACHIEVEMENT

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

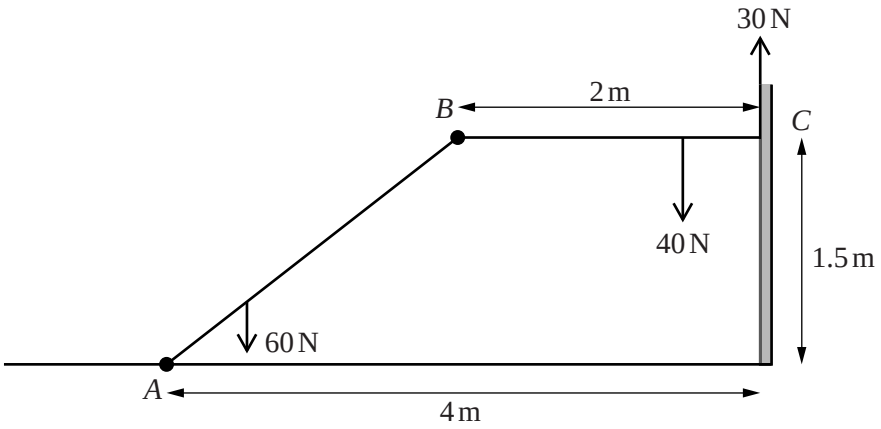
INFORMATION FOR CANDIDATES

- 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

- 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



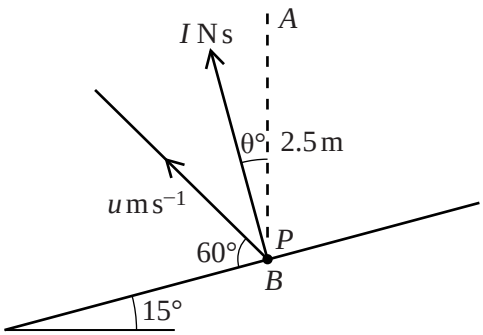
Two non-uniform rods *AB* and *BC* have weights 60 N and 40 N respectively. The rods are freely jointed to each other at *B*. The rod *AB* is freely jointed to a fixed point on horizontal ground at *A* and the rod *BC* rests against a vertical wall at *C*. The rod *BC*, whose length is 2 m, is horizontal 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 $u\,\text{m s}^{-1}$. The impulse exerted on *P* by the surface has magnitude *I* N s and is in a direction making an angle of $\theta°$ with the upward vertical through *B* (see diagram).

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

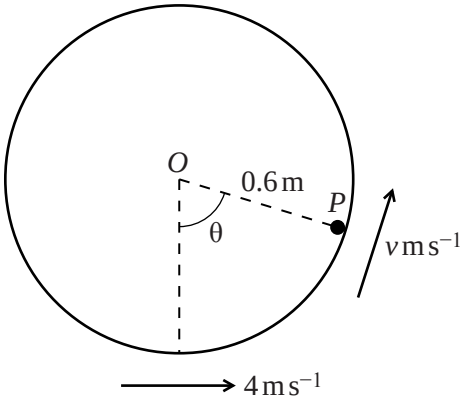
(ii) Find the values of *u* and *I*. **[7]**

3 A particle *P* of mass *m* kg is released from rest and falls vertically. When *P* has fallen a distance of *x* m it has a speed of $v\,\text{m s}^{-1}$. The only forces acting on *P* are its weight and air resistance of magnitude $\frac{1}{400}mv^2$ 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 $4\,\text{m s}^{-1}$ 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 N.

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

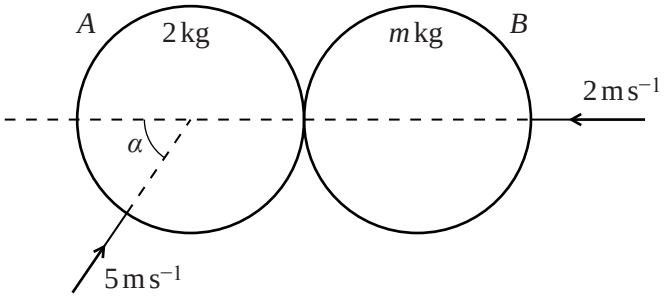
(ii) Find the speed of P at the instant when it leaves the surface. **[4]**

5 One end of a light elastic string, of natural length 0.78 m and modulus of elasticity $0.8mg$ 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 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]**

6



Two smooth uniform spheres A and B, of equal radius, have masses 2 kg and m kg respectively. They are moving on a horizontal surface when they collide. Immediately before the collision, A has speed $5\,\text{m s}^{-1}$ and is moving towards B at an angle of α to the line of centres, where $\cos\alpha = 0.6$. B has speed $2\,\text{m s}^{-1}$ 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 $0.8\,\text{m s}^{-1}$. 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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