OCR

Friday 6 June 2014 – 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 inside 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 particle P of mass 0.3 kg is moving on a smooth horizontal surface with speed $0.8\,\text{m s}^{-1}$ when it is struc by a horizontal impulse. The magnitude of the impulse is 0.6 N s.

(i) (a) Find the greatest possible speed of P after the impulse acts.

(b) Find the least possible speed of P after the impulse acts.

[3]

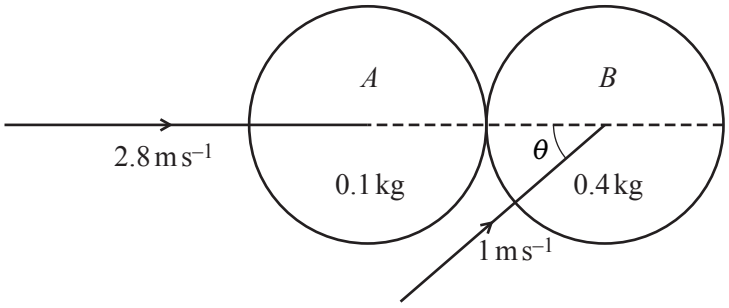
(ii) In fact the speed of P after the impulse acts is $2.5\,\text{m s}^{-1}$. Find the angle the impulse makes with the original direction of travel of P and draw a sketch to make this direction clear. **[4]**

2 One end of a light elastic string, of natural length 0.6 m and modulus of elasticity 30 N, is attached to a fixed point O. A particle P of weight 48 N is attached to the other end of the string. P is released from rest at a point d m vertically below O. Subsequently P just reaches O.

(i) Find d. **[4]**

(ii) Find the magnitude and direction of the acceleration of P when it has travelled 1.3 m from its point of release. **[4]**

3



Two uniform smooth spheres A and B of equal radius are moving on a horizontal surface when they collide. A has mass 0.1 kg and B has mass 0.4 kg. Immediately before the collision A is moving with speed $2.8\,\text{m s}^{-1}$ along the line of centres, and B is moving with speed $1\,\text{m s}^{-1}$ at an angle θ to the line of centres, where $\cos\theta = 0.8$ (see diagram). Immediately after the collision A is stationary. Find

(i) the coefficient of restitution between A and B, **[5]**

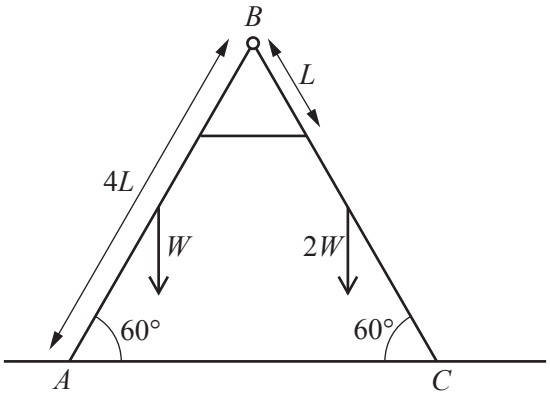
(ii) the angle turned through by the direction of motion of B as a result of the collision. **[4]**

4 A particle P of mass 0.4 kg is projected horizontally with speed $2\,\text{m s}^{-1}$ from a fixed point O on a smooth horizontal surface. At time t s after projection P is x m from O and is moving away from O with speed $v\,\text{m s}^{-1}$. There is a force of magnitude $1.6v^2$ N resisting the motion of P.

(i) Find an expression for $\frac{\text{d}v}{\text{d}x}$ in terms of v, and hence show that $v = 2\text{e}^{-4x}$. **[5]**

(ii) Find the distance travelled by P in the 0.5 seconds after it leaves O. **[5]**

5



Two uniform rods AB and BC, each of length $4L$, are freely jointed at B, and rest in a vertical plane with A and C on a smooth horizontal surface. The weight of AB is W and the weight of BC is $2W$. The rods are joined by a horizontal light inextensible string fixed to each rod at a point distance L from B, so that each rod is inclined at an angle of 60° to the horizontal (see diagram).

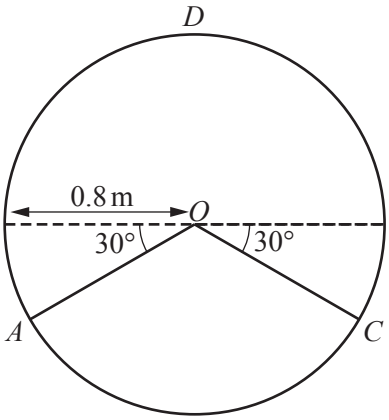
(i) By considering the equilibrium of the whole body, show that the force acting on BC at C is $1.75W$ and find the force acting on AB at A. **[4]**

(ii) Find the tension in the string in terms of W. **[4]**

(iii) Find the horizontal and vertical components of the force acting on AB at B, and state the direction of the component in each case. **[3]**

Question 6 begins on page 4.

6

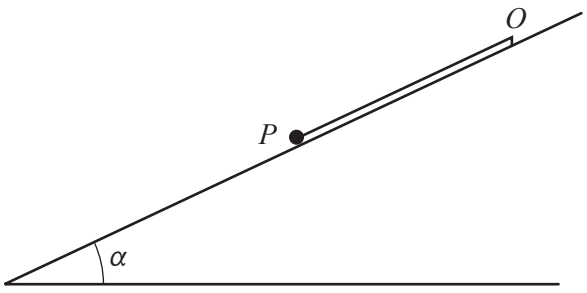


A hollow cylinder is fixed with its axis horizontal. O is the centre of a vertical cross-section of the cylinder and D is the highest point on the cross-section. A and C are points on the circumference of the cross-section such that AO and CO are both inclined at an angle of 30° below the horizontal diameter through O. The inner surface of the cylinder is smooth and has radius 0.8 m (see diagram). A particle P, of mass m kg, and a particle Q, of mass $5m$ kg, are simultaneously released from rest from A and C, respectively, inside the cylinder. P and Q collide; the coefficient of restitution between them is 0.95.

(i) Show that, immediately after the collision, P moves with speed $6.3\,\text{m s}^{-1}$, and find the speed and direction of motion of Q. **[8]**

(ii) Find, in terms of m, an expression for the normal reaction acting on P when it subsequently passes through D. **[6]**

7



One end of a light elastic string, of natural length 0.3 m, is attached to a fixed point O on a smooth plane that is inclined at an angle α to the horizontal, where $\sin\alpha = 0.2$. A particle P of mass m kg is attached to the other end of the string. The string lies along a line of greatest slope of the plane and has modulus of elasticity $2.45m$ N (see diagram).

(i) Show that in the equilibrium position the extension of the string is 0.24 m. **[2]**

P is given a velocity of $0.3\,\text{m s}^{-1}$ down the plane from the equilibrium position.

(ii) Show that P performs simple harmonic motion with period 2.20 s (correct to 3 significant figures), and find the amplitude of the motion. **[6]**

(iii) Find the distance of P from O and the velocity of P at the instant 1.5 seconds after P is set in motion. **[5]**