

**Wednesday 3 June 2015 – Morning**

**A2 GCE MATHEMATICS**

**4730/01** Mechanics 3

**QUESTION PAPER**

Candidates answer on the Printed Answer Book.

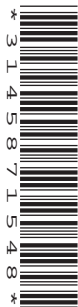
**OCR supplied materials:**

- 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  $g \text{ m s}^{-2}$ . 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

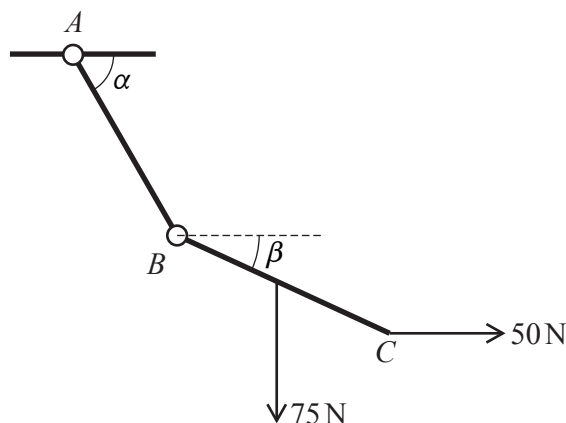
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- 1 A particle  $P$  of mass  $0.2\text{ kg}$  is moving on a smooth horizontal surface with speed  $3\text{ m s}^{-1}$ , when it is struck by an impulse of magnitude  $I\text{ N s}$ . The impulse acts horizontally in a direction perpendicular to the original direction of motion of  $P$ , and causes the direction of motion of  $P$  to change by an angle  $\alpha$ , where  $\tan \alpha = \frac{5}{12}$ .

(i) Show that  $I = 0.25$ . [4]

(ii) Find the speed of  $P$  after the impulse acts. [2]

2



Two uniform rods  $AB$  and  $BC$ , each of length  $2L$ , are freely jointed at  $B$ , and  $AB$  is freely jointed to a fixed point at  $A$ . The rods are held in equilibrium in a vertical plane by a light horizontal string attached at  $C$ . The rods  $AB$  and  $BC$  make angles  $\alpha$  and  $\beta$  to the horizontal respectively. The weight of rod  $BC$  is  $75\text{ N}$ , and the tension in the string is  $50\text{ N}$  (see diagram).

(i) Show that  $\tan \beta = \frac{3}{4}$ . [3]

(ii) Given that  $\tan \alpha = \frac{12}{5}$ , find the weight of  $AB$ . [5]

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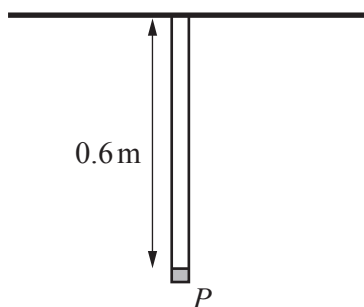
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3



A small object  $P$  is attached to one end of each of two vertical light elastic strings. One string is of natural length  $0.4\text{ m}$  and has modulus of elasticity  $10\text{ N}$ ; the other string is of natural length  $0.5\text{ m}$  and has modulus of elasticity  $12\text{ N}$ . The upper ends of both strings are attached to a fixed horizontal beam and  $P$  hangs in equilibrium  $0.6\text{ m}$  below the beam (see diagram).

- (i) Show that the weight of  $P$  is  $7.4\text{ N}$  and find the total elastic potential energy stored in the two strings when  $P$  is hanging in equilibrium. [6]

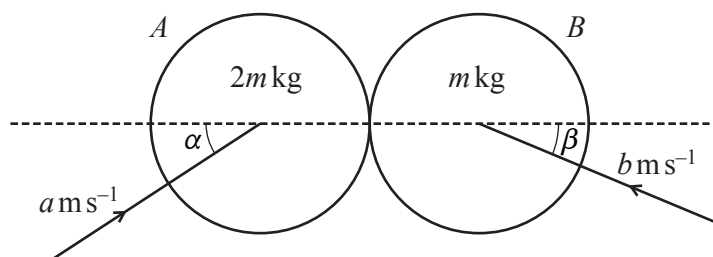
$P$  is then held at a point  $0.7\text{ m}$  below the beam with the strings vertical.  $P$  is released from rest.

- (ii) Show that, throughout the subsequent motion,  $P$  performs simple harmonic motion, and find the period. [7]

- 4 A particle of mass  $0.4\text{ kg}$ , moving on a smooth horizontal surface, passes through a point  $O$  with velocity  $10\text{ ms}^{-1}$ . At time  $t\text{ s}$  after the particle passes through  $O$ , the particle has a displacement  $x\text{ m}$  from  $O$ , has a velocity  $v\text{ ms}^{-1}$  away from  $O$ , and is acted on by a force of magnitude  $\frac{1}{8}v\text{ N}$  acting towards  $O$ . Find

- (i) the time taken for the velocity of the particle to reduce from  $10\text{ ms}^{-1}$  to  $5\text{ ms}^{-1}$ , [5]  
 (ii) the average velocity of the particle over this time. [6]

5



Two uniform smooth spheres  $A$  and  $B$ , of equal radius, have masses  $2m$  kg and  $m$  kg respectively. The spheres are moving on a horizontal surface when they collide. Before the collision,  $A$  is moving with speed  $a$  ms<sup>-1</sup> in a direction making an angle  $\alpha$  with the line of centres and  $B$  is moving towards  $A$  with speed  $b$  ms<sup>-1</sup> in a direction making an angle  $\beta$  with the line of centres (see diagram). After the collision,  $A$  moves with velocity  $2$  ms<sup>-1</sup> in a direction perpendicular to the line of centres and  $B$  moves with velocity  $2$  ms<sup>-1</sup> in a direction making an angle of  $45^\circ$  with the line of centres. The coefficient of restitution between  $A$  and  $B$  is  $\frac{2}{3}$ .

(i) Show that  $a \cos \alpha = \frac{5}{6}\sqrt{2}$  and find  $b \cos \beta$ . [7]

(ii) Find the values of  $a$  and  $\alpha$ . [4]

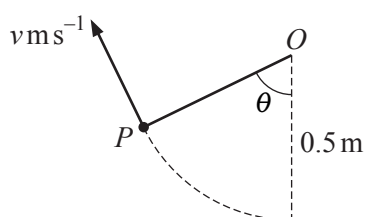
6 A particle  $P$  starts from rest from a point  $A$  and moves in a straight line with simple harmonic motion about a point  $O$ . At time  $t$  seconds after the motion starts the displacement of  $P$  from  $O$  is  $x$  m towards  $A$ . The particle  $P$  is next at rest when  $t = 0.25\pi$  having travelled a distance of  $1.2$  m.

(i) Find the maximum velocity of  $P$ . [3]

(ii) Find the value of  $x$  and the velocity of  $P$  when  $t = 0.7$ . [4]

(iii) Find the other values of  $t$ , for  $0 < t < 1$ , at which  $P$ 's speed is the same as when  $t = 0.7$ . Find also the corresponding values of  $x$ . [4]

7



One end of a light inextensible string of length  $0.5$  m is attached to a fixed point  $O$ . A particle  $P$  of mass  $0.2$  kg is attached to the other end of the string.  $P$  is projected horizontally from the point  $0.5$  m below  $O$  with speed  $u$  ms<sup>-1</sup>. When the string makes an angle of  $\theta$  with the downward vertical the particle has speed  $v$  ms<sup>-1</sup> (see diagram).

(i) Show that, while the string is taut, the tension,  $T$  N, in the string is given by

$$T = 5.88 \cos \theta + 0.4u^2 - 3.92. \quad [5]$$

(ii) Find the least value of  $u$  for which the particle will move in a complete circle. [3]

(iii) If in fact  $u = 3.5$  ms<sup>-1</sup>, find the speed of the particle at the point where the string first becomes slack. [4]

**END OF QUESTION PAPER**