OCR
Oxford Cambridge and RSA

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

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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 $g\,\mathrm{m\,s^{-2}}$. 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.

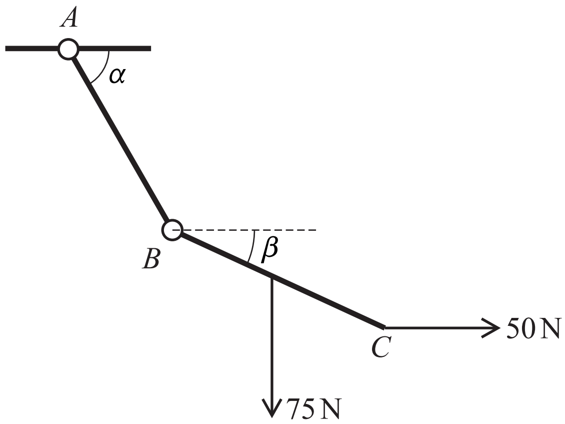
Turn over

1 A particle P of mass $0.2\,\text{kg}$ is moving on a smooth horizontal surface with speed $3\,\text{m}\,\text{s}^{-1}$, when it is struck by an impulse of magnitude $I\,\text{N}\,\text{s}$. 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 α, 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

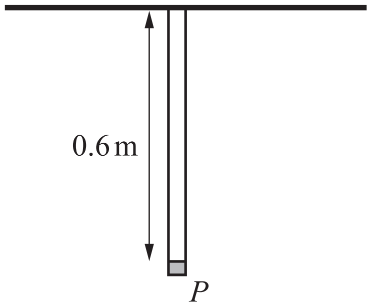


Two uniform rods AB and BC, each of length $2L$, are freely jointed at B, and AB is freely jointed to a fixed point at A. The rods are held in equilibrium in a vertical plane by a light horizontal string attached at C. The rods AB and BC make angles α and β to the horizontal respectively. The weight 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]**

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 m and has modulus of elasticity 10 N; the other string is of natural length 0.5 m and has modulus of elasticity 12 N. The upper ends of both strings are attached to a fixed horizontal beam and P hangs in equilibrium 0.6 m below the beam (see diagram).

(i) Show that the weight of P is 7.4 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 m below the beam with the strings vertical. P is released from rest.

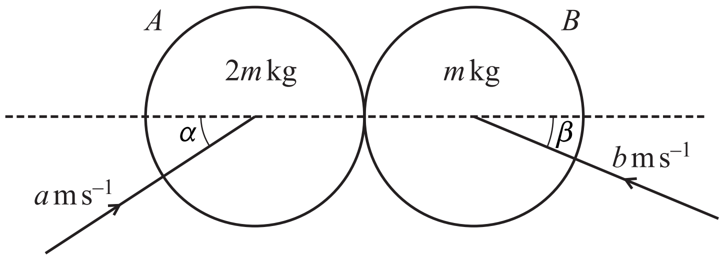
(ii) Show that, throughout the subsequent motion, P performs simple harmonic motion, and find the period. **[7]**

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

(i) the time taken for the velocity of the particle to reduce from $10\,\mathrm{m\,s^{-1}}$ to $5\,\mathrm{m\,s^{-1}}$, **[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 $a\,\mathrm{m\,s^{-1}}$ in a direction making an angle α with the line of centres and B is moving towards A with speed $b\,\mathrm{m\,s^{-1}}$ in a direction making an angle β with the line of centres (see diagram). After the collision, A moves with velocity $2\,\mathrm{m\,s^{-1}}$ in a direction perpendicular to the line of centres and B moves with velocity $2\,\mathrm{m\,s^{-1}}$ in a direction making an angle of 45° 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 α. **[4]**

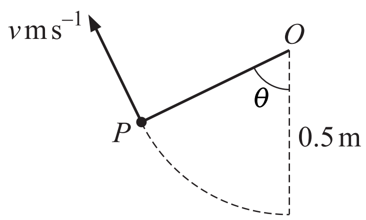
6 A particle P starts from rest from a point A and moves in a straight line with simple harmonic motion about a point O. At time t seconds after the motion starts the displacement of P from O is x m towards A. The particle P is next at rest when $t = 0.25\pi$ having travelled a distance of 1.2 m.

(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 $u\,\mathrm{m\,s^{-1}}$. When the string makes an angle of θ with the downward vertical the particle has speed $v\,\mathrm{m\,s^{-1}}$ (see diagram).

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

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

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

(iii) If in fact $u = 3.5\,\mathrm{m\,s^{-1}}$, find the speed of the particle at the point where the string first becomes slack. **[4]**

END OF QUESTION PAPER