OXFORD CAMBRIDGE AND RSA EXAMINATIONS

A2 GCE
4730/01
MATHEMATICS
Mechanics 3
QUESTION PAPER

WEDNESDAY 3 JUNE 2015:
Morning
DURATION: 1 hour 30 minutes
plus your additional time allowance
MODIFIED ENLARGED 24pt

Candidates answer on the Printed Answer Book or any suitable paper provided by the centre.
The Printed Answer Book may be enlarged by the centre.

OCR SUPPLIED MATERIALS:
Printed Answer Book 4730/01
List of Formulae (MF1)

OTHER MATERIALS REQUIRED:
Scientific or graphical calculator

READ INSTRUCTIONS OVERLEAF

DC (LK/AR) 5302851198 108771/1

INSTRUCTIONS TO CANDIDATES

Write your name, centre number and candidate number in the spaces provided on the Printed Answer Book or on the paper provided by the centre. Please write clearly and in capital letters.

IF YOU USE THE PRINTED ANSWER BOOK WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED. 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.

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.

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.

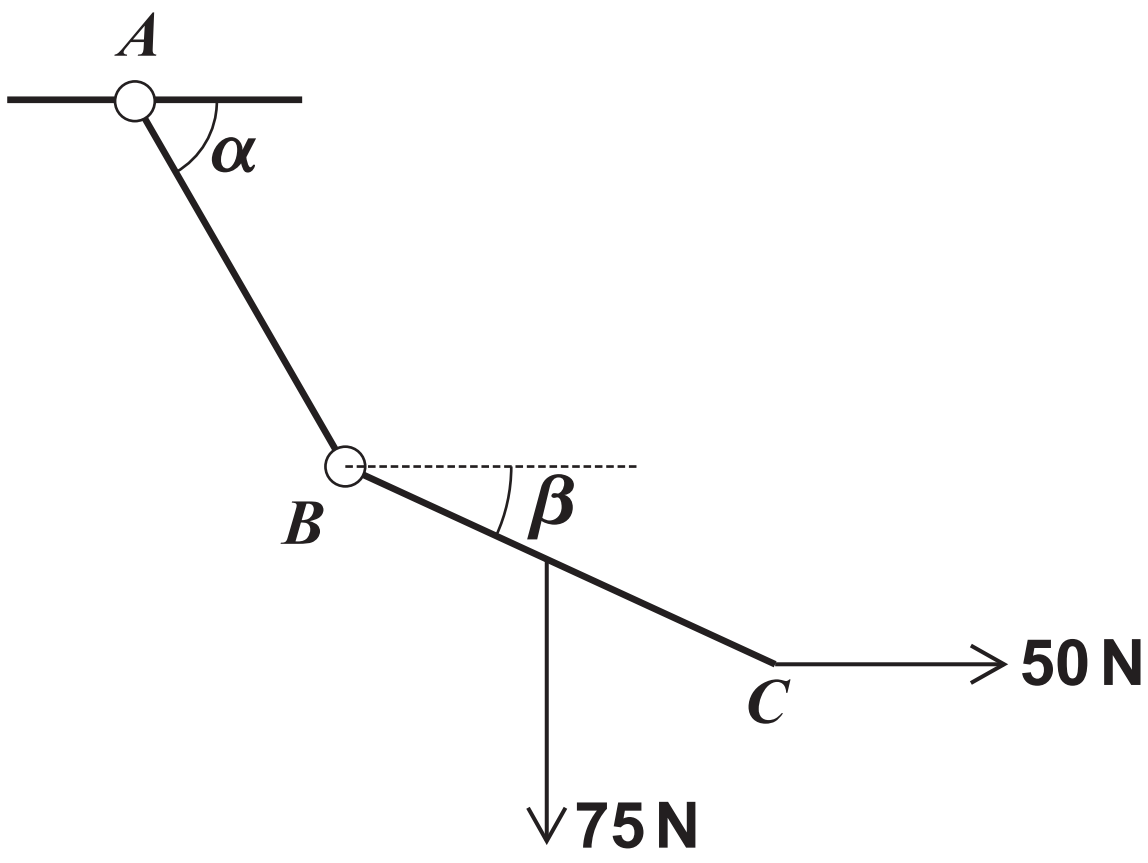
Answer ALL the questions.

1 A particle P of mass 0.2 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 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 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]

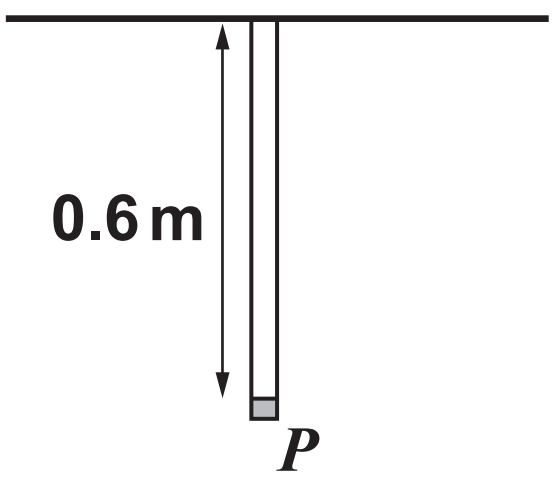
2 Two uniform rods AB and BC, each of length $2L$, are freely jointed at B, and AB is freely jointed to a fixed point at A. The rods are held in equilibrium in a vertical plane by a light horizontal string attached at C. The rods AB and BC make angles α and β to the horizontal respectively. The weight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



(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 below).



(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.

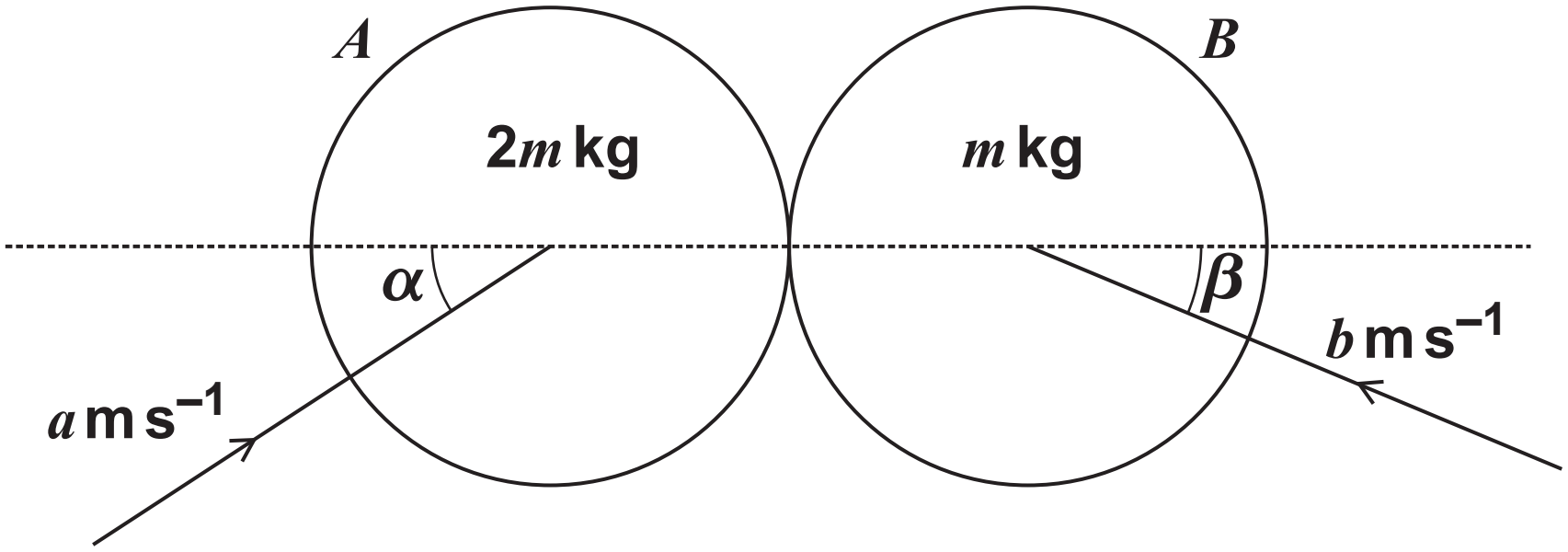
(ii) Show that, throughout the subsequent motion, P performs simple harmonic motion, and find the period. [7]

4 A particle of mass 0.4 kg, moving on a smooth horizontal surface, passes through a point O with velocity 10 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 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 m s^{-1} to 5 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 $a\,\text{m s}^{-1}$ in a direction making an angle α with the line of centres and B is moving towards A with speed $b\,\text{m s}^{-1}$ in a direction making an angle β with the line of centres (see diagram below). After the collision, A moves with velocity $2\,\text{m s}^{-1}$ in a direction perpendicular to the line of centres and B moves with velocity $2\,\text{m s}^{-1}$ 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]

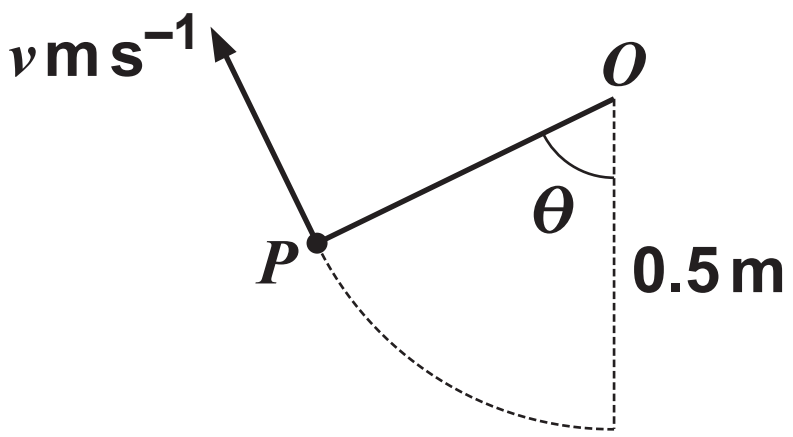
6 A particle P starts from rest from a point A and moves in a straight line with simple harmonic motion about a point O. At time t seconds after the motion starts the displacement of P from O is x m towards A. The particle P is next at rest when $t = 0.25\pi$ having travelled a distance of 1.2 m.

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



(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 $u = 3.5\,\text{m s}^{-1}$, find the speed of the particle at the point where the string first becomes slack. [4]

END OF QUESTION PAPER