OCR
RECOGNISING ACHIEVEMENT

Tuesday 18 June 2013 – 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

* 4 7 3 3 4 2 0 6 1 3 *

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

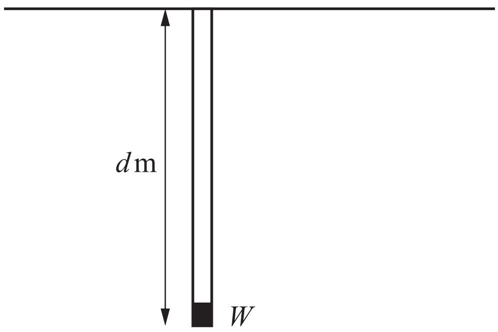
INFORMATION FOR CANDIDATES

- 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 small object W of weight 100 N is attached to one end of each of two parallel light elastic strings. One string is of natural length 0.4 m and has modulus of elasticity 20 N; the other string is of natural length 0.6 m and has modulus of elasticity 30 N. The upper ends of both strings are attached to a horizontal ceiling and W hangs in equilibrium at a distance d m below the ceiling (see diagram). Find d. **[5]**

2 A particle of mass 0.3 kg is projected horizontally under gravity with velocity 3.5 m s^{-1} from a point 0.4 m above a smooth horizontal plane. The particle first hits the plane at point A; it bounces and hits the plane a second time at point B. The distance AB is 1 m. Calculate

(i) the vertical component of the velocity of the particle when it arrives at A, and the time taken for the particle to travel from A to B, **[3]**

(ii) the coefficient of restitution between the particle and the plane, **[3]**

(iii) the impulse exerted by the plane on the particle at A. **[2]**

3 A particle P of mass 0.2 kg moves on a smooth horizontal plane. Initially it is projected with velocity 0.8 m s^{-1} from a fixed point O towards another fixed point A. At time t s after projection, P is x m from O and is moving with velocity v m s^{-1}, with the direction OA being positive. A force of $(1.5t - 1)$ N acts on P in the direction parallel to OA.

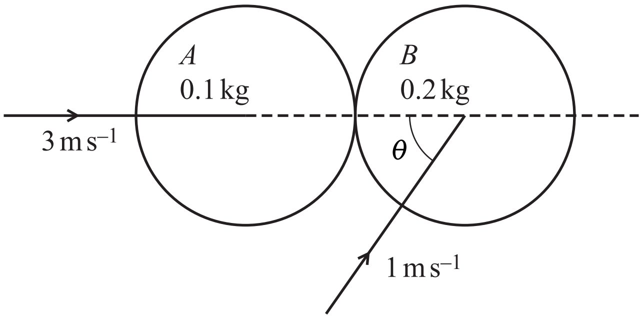
(i) Find an expression for v in terms of t. **[3]**

(ii) Find the time when the velocity of P is next 0.8 m s^{-1}. **[2]**

(iii) Find the times when P subsequently passes through O. **[4]**

(iv) Find the distance P travels in the third second of its motion. **[2]**

4 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 0.2 kg. Immediately before the collision A is moving with speed $3\,\mathrm{m\,s^{-1}}$ along the line of centres, and B is moving away from A with speed $1\,\mathrm{m\,s^{-1}}$ at an acute angle θ to the line of centres, where $\cos\theta = 0.6$ (see diagram).

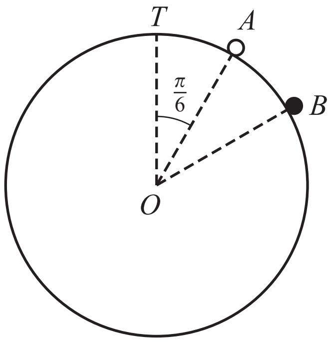


The coefficient of restitution between the spheres is 0.8. Find

(i) the velocity of A immediately after the collision, **[6]**

(ii) the angle turned through by the direction of motion of B as a result of the collision. **[5]**

5



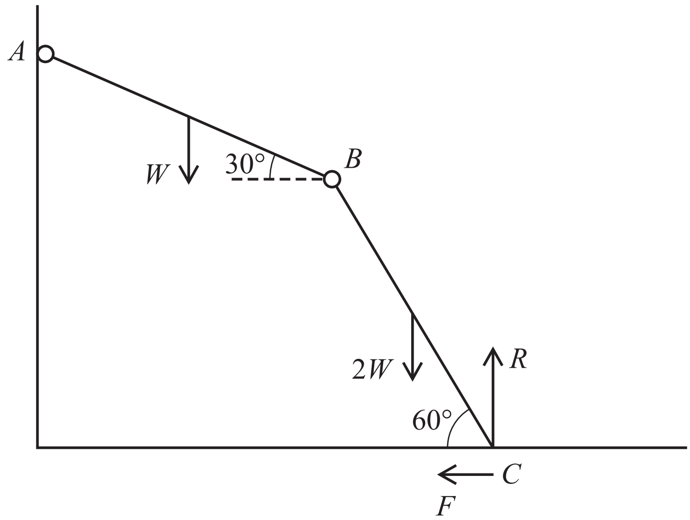
A fixed smooth sphere of radius 0.6 m has centre O and highest point T. A particle of mass m kg is released from rest at a point A on the sphere, such that angle TOA is $\frac{\pi}{6}$ radians. The particle leaves the surface of the sphere at B (see diagram).

(i) Show that $\cos TOB = \frac{\sqrt{3}}{3}$. **[6]**

(ii) Find the speed of the particle at B. **[2]**

(iii) Find the transverse acceleration of the particle at B. **[2]**

6 Two uniform rods AB and BC, each of length $2l$, are freely jointed at B. The weight of AB is W and the weight of BC is $2W$. The rods are in a vertical plane with A freely pivoted at a fixed point and C resting in equilibrium on a rough horizontal plane. The normal and frictional components of the force acting on BC at C are R and F respectively. The rod AB makes an angle 30° to the horizontal and the rod BC makes an angle 60° to the horizontal (see diagram).



(i) By considering the equilibrium of rod BC, show that $W + \sqrt{3}F = R$. **[2]**

(ii) By taking moments about A for the equilibrium of the whole system, find another equation involving W, F and R. **[4]**

(iii) Given that the friction at C is limiting, calculate the value of the coefficient of friction at C. **[5]**

7 A particle P of mass m kg is attached to one end of a light elastic string of natural length 0.8 m and modulus of elasticity $39.2m$ N. The other end of the string is attached to a fixed point O. The particle is released from rest at O.

(i) Show that, while the string is in tension, the particle performs simple harmonic motion about a point 1 m below O. **[3]**

(ii) Show that when P is at its lowest point the extension of the string is 0.8 m. **[3]**

(iii) Find the time after its release that P first reaches its lowest point. **[6]**

(iv) Find the velocity of P 0.8 s after it is released from O. **[4]**