

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

A2 GCE

4730/01

MATHEMATICS

Mechanics 3

QUESTION PAPER

TUESDAY 18 JUNE 2013: Morning

**DURATION: 1 hour 30 minutes
plus your additional time allowance**

MODIFIED ENLARGED

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

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.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Answer ALL the questions.
- 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 $g = 9.8$.

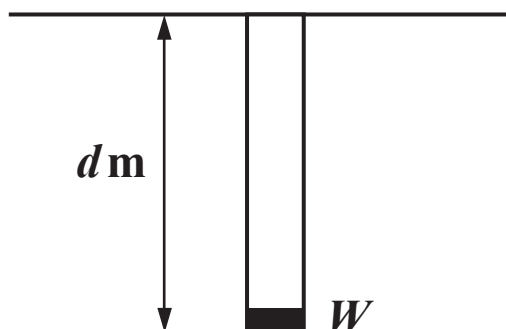
INFORMATION FOR CANDIDATES

- 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.

INSTRUCTION TO EXAMS OFFICER/INVIGILATOR

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1 Look at the following diagram.



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 $d\text{ m}$ below the ceiling (see diagram above). Find d . [5]

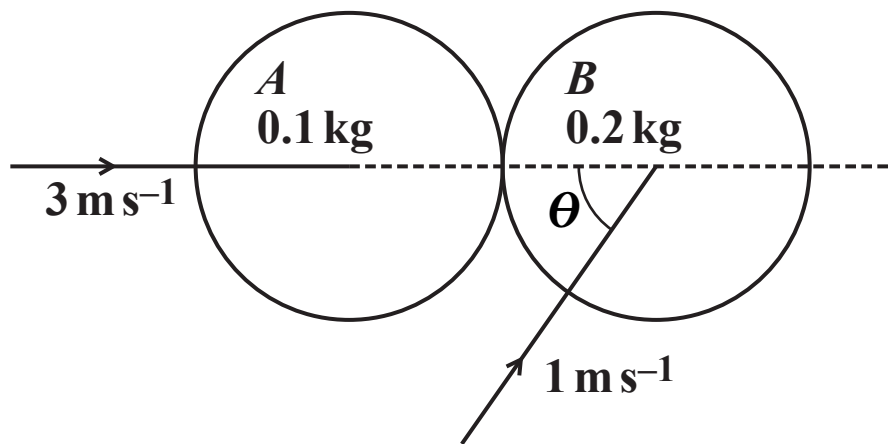
2 A particle of mass 0.3 kg is projected horizontally under gravity with velocity 3.5 m s^{-1} from a point 0.4 m above a smooth horizontal plane. The particle first hits the plane at point A ; it bounces and hits the plane a second time at point B . The distance AB is 1 m . Calculate

- (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 $t\text{ s}$ after projection, P is $x\text{ m}$ from O and is moving with velocity $v\text{ m s}^{-1}$, with the direction OA being positive. A force of $(1.5t - 1)\text{ N}$ 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]

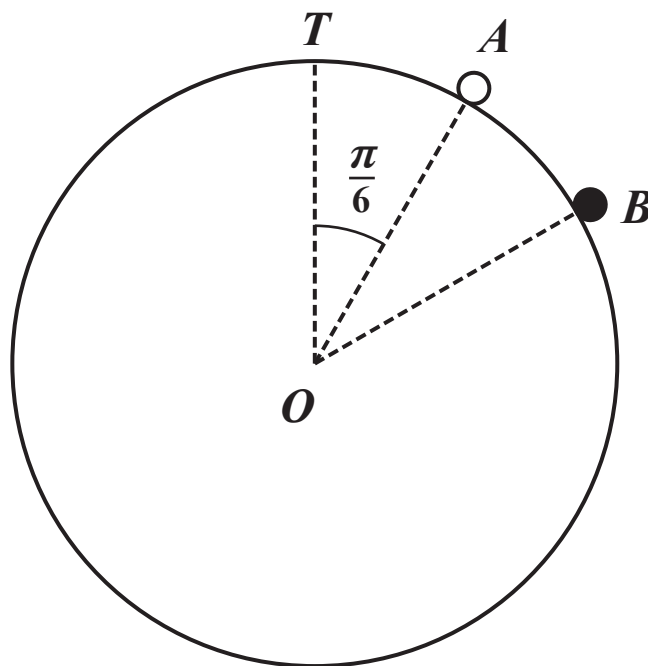
- 4 Two uniform smooth spheres A and B of equal radius are moving on a horizontal surface when they collide. A has mass 0.1 kg and B has mass 0.2 kg . Immediately before the collision A is moving with speed 3 m s^{-1} along the line of centres, and B is moving away from A with speed 1 m s^{-1} at an acute angle θ to the line of centres, where $\cos \theta = 0.6$ (see diagram below).



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]

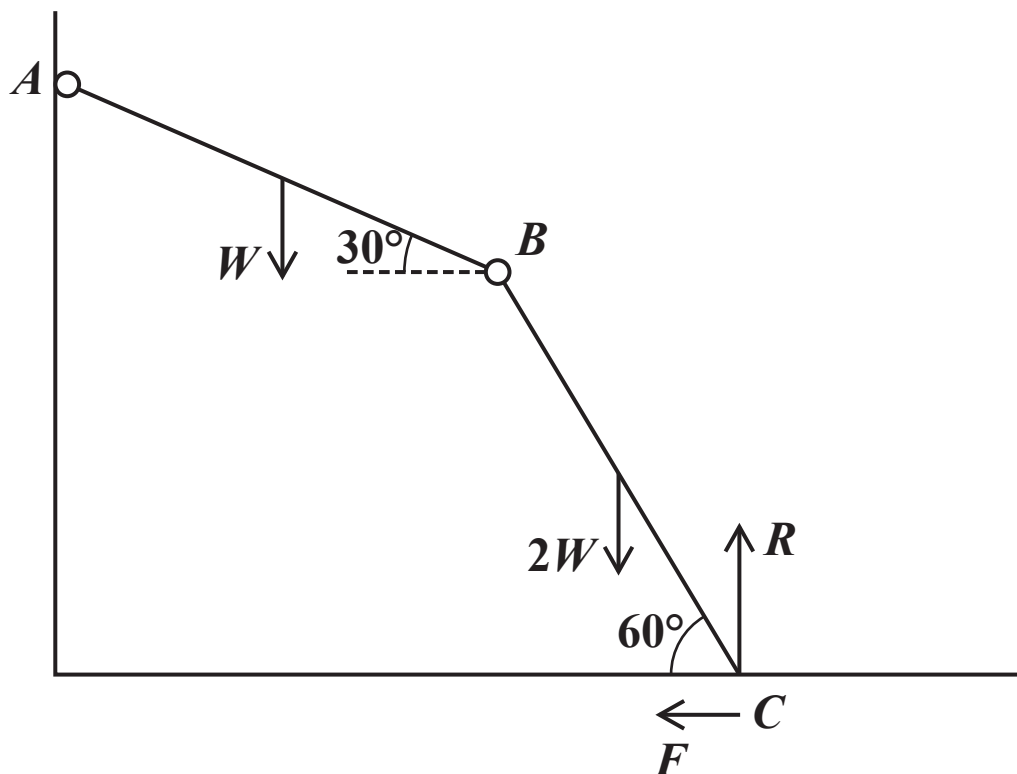
5 Look at the following diagram.



A fixed smooth sphere of radius 0.6 m has centre O and highest point T . A particle of mass $m\text{ kg}$ 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 above).

- (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 below).



- (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]

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