

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
A2 GCE
4730/01
MATHEMATICS
Mechanics 3
QUESTION PAPER

FRIDAY 25 JANUARY 2013: Afternoon
DURATION: 1 hour 30 minutes
plus your additional time allowance
MODIFIED ENLARGED 18pt

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

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.**
- **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

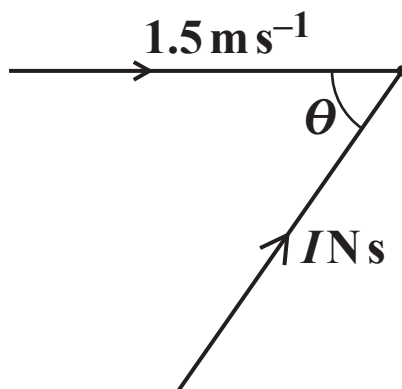
This information is the same on the Printed Answer Book and the Question Paper.

- **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 Question Paper consists of 12 pages. The Printed Answer Book consists of 12 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.**

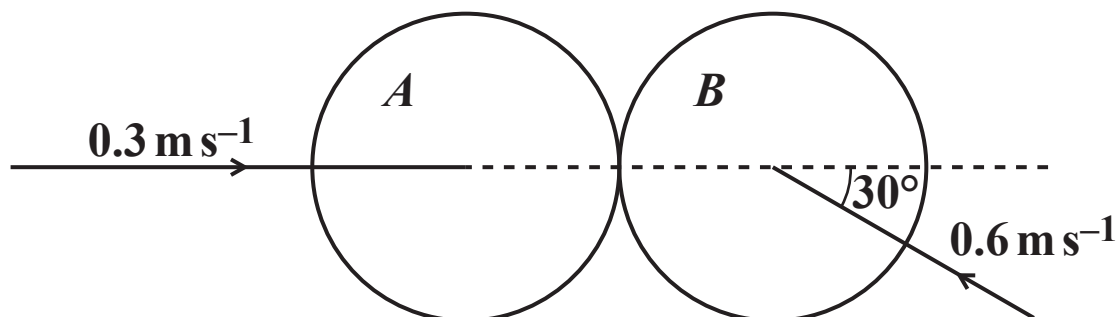
1 Look at the following diagram.



A ball of mass 0.6 kg is moving with speed 1.5 m s^{-1} in a straight line. It is struck by an impulse $I \text{ N s}$ acting at an acute angle θ to its direction of motion (see diagram above). The impulse causes the direction of motion of the ball to change by an acute angle α , where $\sin \alpha = \frac{8}{17}$. After the impulse acts the ball is moving with a speed of 3.4 m s^{-1} . Find I and θ .

[5]

- 2 Two uniform smooth spheres A and B , of equal radius and equal mass, are moving towards each other on a horizontal surface. Immediately before they collide, A has speed 0.3 m s^{-1} along the line of centres and B has speed 0.6 m s^{-1} at an angle of 30° to the line of centres (see diagram below).



After the collision, the direction of motion of B is at right angles to its original direction of motion. Find

- (i) the speed of B after the collision, [3]
- (ii) the speed and direction of motion of A after the collision, [3]
- (iii) the coefficient of restitution between A and B . [3]

- 3** At time $t = 0$ s a particle P , of mass 0.3 kg, is 1 m away from a point O on a smooth horizontal plane and is moving away from O with speed $\sqrt{5}$ m s⁻¹. The only horizontal force acting on P has magnitude $1.5x$ N, where x is the distance OP , and acts away from O .

(i) Show that the speed of P , v m s⁻¹, is given by $v = \sqrt{5}x$. [4]

(ii) Find an expression for v in terms of t . [4]

- 4 A smooth cylinder of radius a m is fixed with its axis horizontal and O is the centre of a cross-section. Particle P , of mass 0.4 kg, and particle Q , of mass 0.6 kg, are connected by a light inextensible string of length πa m. The string is held at rest with P and Q at opposite ends of the horizontal diameter of the cross-section through O (see Fig. 1 below). The string is released and Q begins to descend. When OP has rotated through θ radians, with P remaining in contact with the cylinder, the speed of each particle is v m s⁻¹ (see Fig. 2 below).

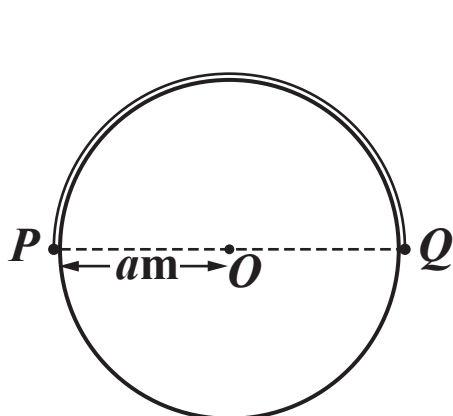


Fig. 1

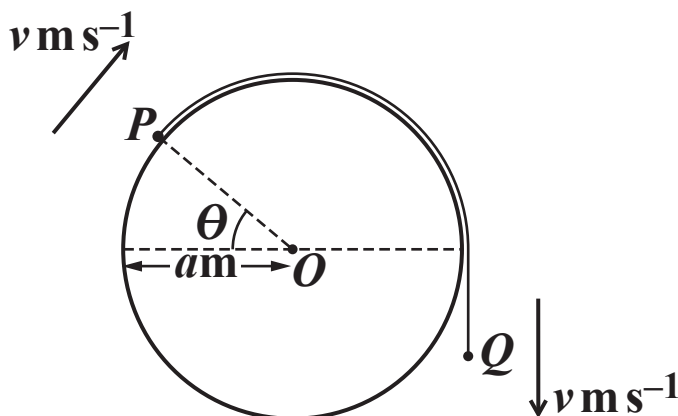


Fig. 2

- (i) Show that $v^2 = 3.92a(3\theta - 2 \sin \theta)$ and find an expression in terms of θ for the normal force of the cylinder on P at this time. [9]
- (ii) Given that P leaves the surface of the cylinder when $\theta = \alpha$, show that $\sin \alpha = k\alpha$ where k is a constant to be found. [2]

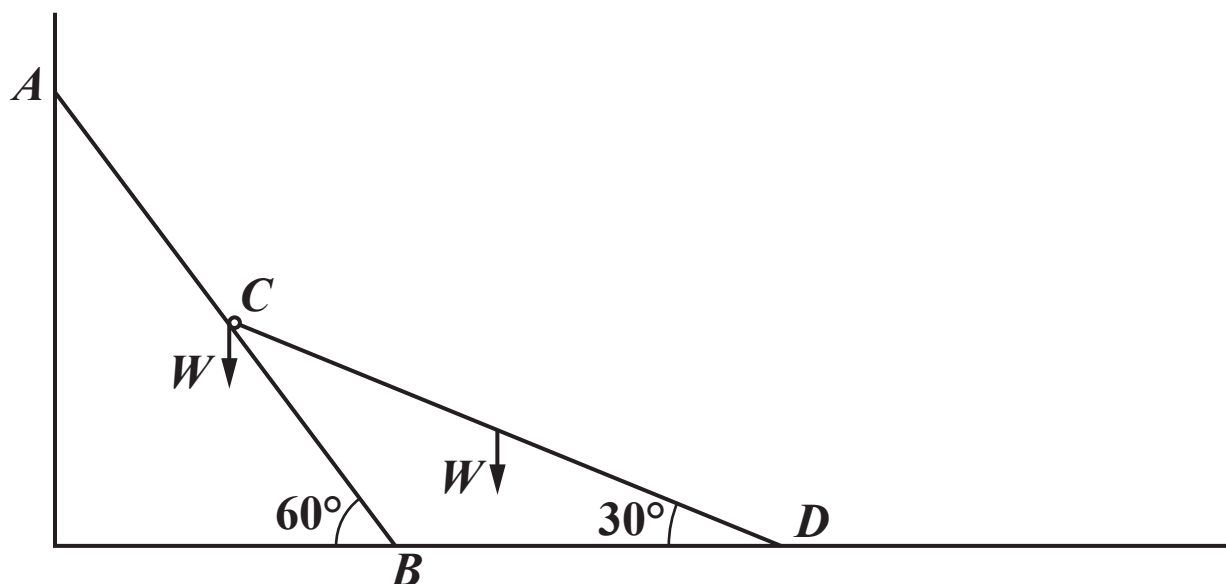
- 5** A particle P , of mass 2.5 kg , is in equilibrium suspended from a fixed point A by a light elastic string of natural length 3 m and modulus of elasticity 36.75 N . Another particle Q , of mass 1 kg , is released from rest at A and falls freely until it reaches P and becomes attached to it.

- (i) Show that the speed of the combined particles, immediately after Q becomes attached to P , is $2\sqrt{2}\text{ m s}^{-1}$. [6]

The combined particles fall a further distance $X\text{ m}$ before coming to instantaneous rest.

- (ii) Find a quadratic equation satisfied by X , and show that it simplifies to $35X^2 - 56X - 80 = 0$. [6]

- 6 A uniform rod AB , of weight W and length $2l$ is in equilibrium at 60° to the horizontal with A resting against a smooth vertical plane and B resting on a rough section of a horizontal plane. Another uniform rod CD , of length $\sqrt{3}l$ and weight W , is freely jointed to the mid-point of AB at C ; its other end D rests on a smooth section of the horizontal plane. CD is inclined at 30° to the horizontal (see diagram below).



- (i) Show that the force exerted by the horizontal plane on CD is $\frac{1}{2}W$. Find the normal component of the force exerted by the horizontal plane on AB . [5]
- (ii) Find the magnitude and direction of the force exerted by CD on AB . [3]
- (iii) Given that AB is in limiting equilibrium, find the coefficient of friction between AB and the horizontal plane. [5]

- 7** A simple pendulum consists of a light inextensible string of length 0.8 m and a particle P of mass $m\text{ kg}$. The pendulum is hanging vertically at rest from a fixed point O when P is given a horizontal velocity of 0.3 m s^{-1} .
- (i) Show that, in the subsequent motion, the maximum angle between the string and the downward vertical is 0.107 radians, correct to 3 significant figures. [3]
- (ii) Show that the motion may be modelled as simple harmonic motion, and find the period of this motion. [5]
- (iii) Find the time after the start of the motion when the velocity of the particle is first -0.2 m s^{-1} and find the angular displacement of OP from the downward vertical at this time. [6]

BLANK PAGE

Copyright Information

OCR is committed to seeking permission to reproduce all third-party content that it uses in its assessment materials. OCR has attempted to identify and contact all copyright holders whose work is used in this paper. To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced in the OCR Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download from our public website (www.ocr.org.uk) after the live examination series.

If OCR has unwittingly failed to correctly acknowledge or clear any third-party content in this assessment material, OCR will be happy to correct its mistake at the earliest possible opportunity.

For queries or further information please contact the Copyright Team, First Floor, 9 Hills Road, Cambridge CB2 1GE.

OCR is part of the Cambridge Assessment Group; Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.

