

**OXFORD CAMBRIDGE AND RSA EXAMINATIONS**

**A2 GCE**

**4729**

**MATHEMATICS**

**Mechanics 2**

**QUESTION PAPER**

**FRIDAY 22 JUNE 2012: Afternoon**

**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 4729**

**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 Printed Answer Book consists of 16 pages. Any blank pages are indicated.

## **INSTRUCTION TO EXAMS OFFICER/INVIGILATOR**

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**1 A particle, of mass 0.8 kg, moves along a smooth horizontal surface. It hits a vertical wall, which is at right angles to the direction of motion of the particle, and rebounds. The speed of the particle as it hits the wall is  $4 \text{ m s}^{-1}$  and the coefficient of restitution between the particle and the wall is 0.3. Find**

**(i) the impulse that the wall exerts on the particle, [3]**

**(ii) the kinetic energy lost in the impact. [2]**

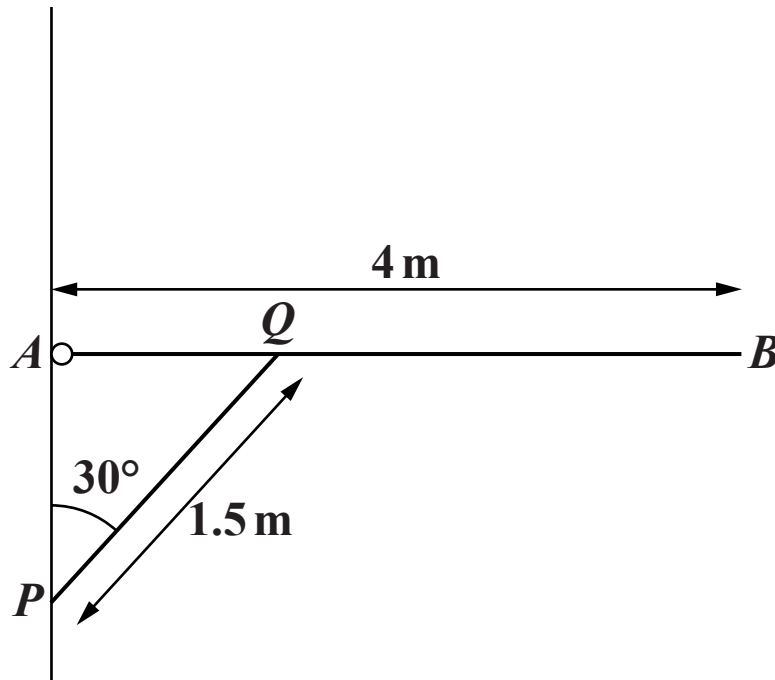
**2 A car of mass 1600 kg moves along a straight horizontal road. The resistance to the motion of the car has constant magnitude 800 N and the car's engine is working at a constant rate of 20 kW.**

**(i) Find the acceleration of the car at an instant when the car's speed is  $20 \text{ m s}^{-1}$ . [4]**

**The car now moves up a hill inclined at  $4^\circ$  to the horizontal. The car's engine continues to work at 20 kW and the magnitude of the resistance to motion remains at 800 N.**

**(ii) Find the greatest steady speed at which the car can move up the hill. [4]**

**3 Look at the following diagram.**



**A uniform beam  $AB$  of mass  $15\text{ kg}$  and length  $4\text{ m}$  is freely hinged to a vertical wall at  $A$ . The beam is held in equilibrium in a horizontal position by a light rod  $PQ$  of length  $1.5\text{ m}$ .  $P$  is fixed to the wall vertically below  $A$  and  $PQ$  makes an angle of  $30^\circ$  with the vertical (see diagram). The force exerted on the beam at  $Q$  by the rod is in the direction  $PQ$ . Find**

- (i) the magnitude of the force exerted on the beam at  $Q$ , [3]**
- (ii) the magnitude and direction of the force exerted on the beam at  $A$ . [6]**

- 4 A boy throws a small ball at a vertical wall. The ball is thrown horizontally, from a point  $O$ , at a speed of  $14.4 \text{ m s}^{-1}$  and it hits the wall at a point which is  $0.2 \text{ m}$  below the level of  $O$ .**

**(i) Find the horizontal distance from  $O$  to the wall. [4]**

**The boy now moves so that he is  $6 \text{ m}$  from the wall. He throws the ball at an angle of  $15^\circ$  above the horizontal. The ball again hits the wall at a point which is  $0.2 \text{ m}$  below the level from which it was thrown.**

**(ii) Find the speed at which the ball was thrown. [6]**

- 5 A particle  $P$ , of mass  $2 \text{ kg}$ , is attached to fixed points  $A$  and  $B$  by light inextensible strings, each of length  $2 \text{ m}$ .  $A$  and  $B$  are  $3.2 \text{ m}$  apart with  $A$  vertically above  $B$ . The particle  $P$  moves in a horizontal circle with centre at the mid-point of  $AB$ .**

**(i) Find the tension in each string when the angular speed of  $P$  is  $4 \text{ rad s}^{-1}$ . [7]**

**(ii) Find the least possible speed of  $P$ . [6]**

- 6** Three particles  $A$ ,  $B$  and  $C$  are in a straight line on a smooth horizontal surface. The particles have masses  $0.2\text{ kg}$ ,  $0.4\text{ kg}$  and  $0.6\text{ kg}$  respectively.  $B$  is at rest.  $A$  is projected towards  $B$  with a speed of  $1.8\text{ m s}^{-1}$  and collides with  $B$ . The coefficient of restitution between  $A$  and  $B$  is  $\frac{1}{3}$ .

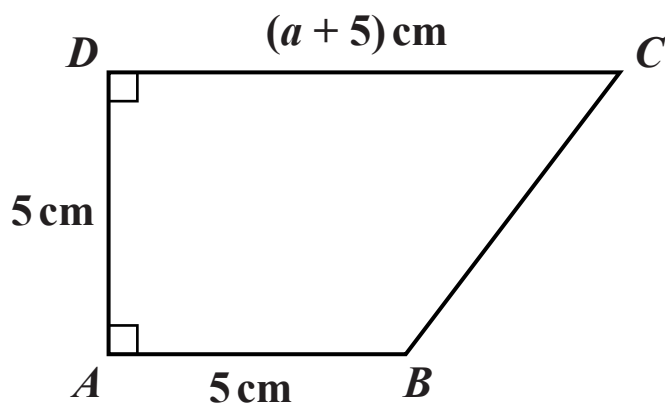
- (i) Show that the speed of  $B$  after the collision is  $0.8\text{ m s}^{-1}$  and find the speed of  $A$  after the collision. [6]

$C$  is moving with speed  $0.2\text{ m s}^{-1}$  in the same direction as  $B$ . Particle  $B$  subsequently collides with  $C$ . The coefficient of restitution between  $B$  and  $C$  is  $e$ .

- (ii) Find the set of values for  $e$  such that  $B$  does not collide again with  $A$ . [7]

[Question 7 is printed overleaf.]

**7 Look at the following diagram.**



The diagram shows the cross-section through the centre of mass of a uniform solid prism. The cross-section is a trapezium  $ABCD$  with  $AB$  and  $CD$  perpendicular to  $AD$ . The lengths of  $AB$  and  $AD$  are each 5 cm and the length of  $CD$  is  $(a + 5)$  cm.

- (i) Show the distance of the centre of mass of the prism from  $AD$  is

$$\frac{a^2 + 15a + 75}{3(a + 10)} \text{ cm. [5]}$$

The prism is placed with the face containing  $AB$  in contact with a horizontal surface.

- (ii) Find the greatest value of  $a$  for which the prism does not topple. [3]

The prism is now placed on an inclined plane which makes an angle  $\theta^\circ$  with the horizontal.  $AB$  lies along a line of greatest slope with  $B$  higher than  $A$ .

- (iii) Using the value for  $a$  found in part (ii), and assuming the prism does not slip down the plane, find the greatest value of  $\theta$  for which the prism does not topple. [6]