

**OXFORD CAMBRIDGE AND RSA EXAMINATIONS**

**A2 GCE**

**4729/01**

**MATHEMATICS**

**Mechanics 2**

**QUESTION PAPER**

**FRIDAY 21 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 4729/01  
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**

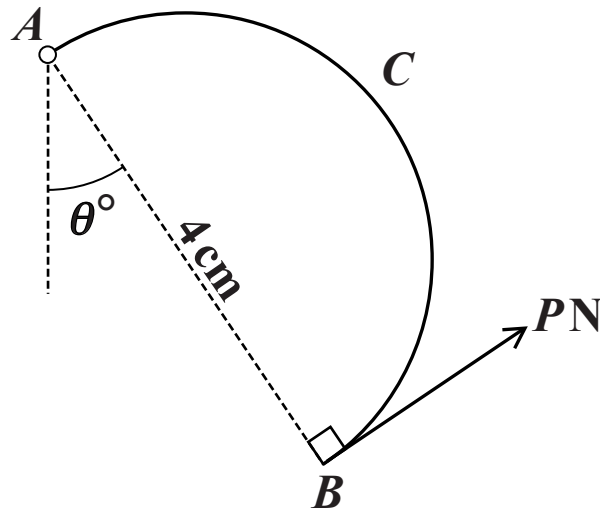
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- 1** *A* and *B* are two points on a line of greatest slope of a smooth inclined plane, with *B* a vertical distance of 8 m below the level of *A*. A particle of mass 0.75 kg is projected down the plane from *A* with a speed of  $2 \text{ m s}^{-1}$ . Find
- (i) the loss in potential energy of the particle as it moves from *A* to *B*, [2]
  - (ii) the speed of the particle when it reaches *B*. [4]
- 2** The power developed by the engine of a car as it travels at a constant speed of  $32 \text{ m s}^{-1}$  on a horizontal road is 20 kW.
- (i) Calculate the resistance to the motion of the car. [3]
- The car, of mass 1500 kg, now travels down a straight road inclined at  $2^\circ$  to the horizontal. The resistance to the motion of the car is unchanged.
- (ii) Find the power produced by the engine of the car when the car has speed  $32 \text{ m s}^{-1}$  and is accelerating at  $0.1 \text{ m s}^{-2}$ . [4]



**3 Look at the following diagram.**



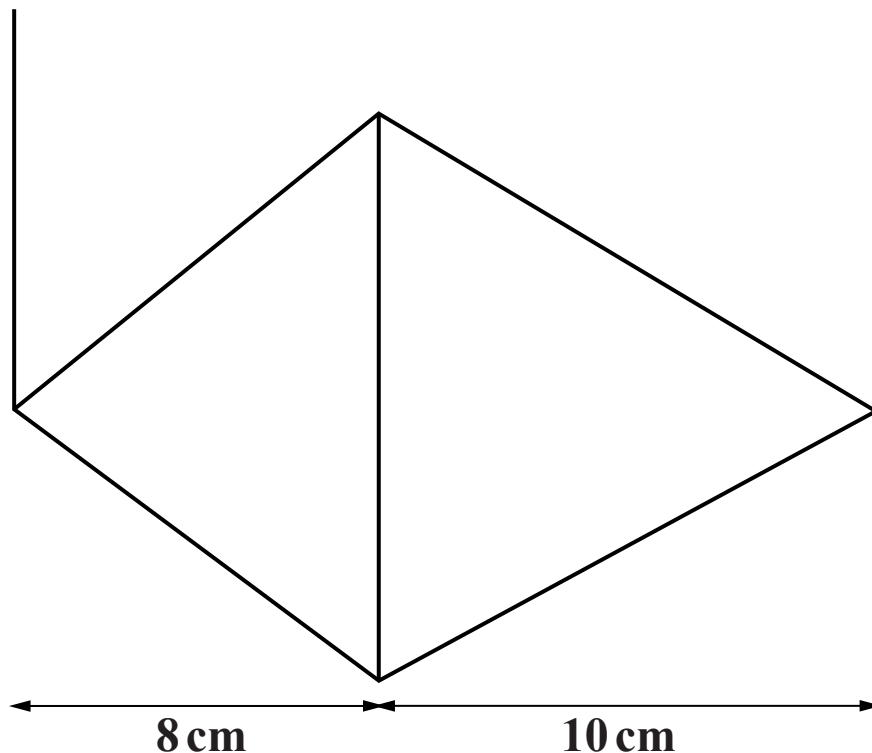
**A uniform semicircular arc  $ACB$  is freely pivoted at  $A$ . The arc has mass  $0.3\text{ kg}$  and is held in equilibrium by a force of magnitude  $P\text{ N}$  applied at  $B$ . The line of action of this force lies in the same plane as the arc, and is perpendicular to  $AB$ . The diameter  $AB$  has length  $4\text{ cm}$  and makes an angle of  $\theta^\circ$  with the downward vertical (see diagram above).**

- (i) Given that  $\theta = 0$ , find the magnitude of the force acting on the arc at  $A$ . [6]**
- (ii) Given instead that  $\theta = 30$ , find the value of  $P$ . [4]**



- 4 A solid uniform cone has height 8 cm, base radius 5 cm and mass 4 kg. A uniform conical shell has height 10 cm, base radius 5 cm and mass 0.4 kg. The two shapes are joined together so that the circumferences of their circular bases coincide.

(i) Find the distance of the centre of mass of the shape from the common circular base. [4]



The object is suspended with a string attached to the vertex of the cone and another string attached to the vertex of the conical shell. The object is in equilibrium with the strings vertical and the axis of symmetry of the object horizontal. A side view of this is shown on the diagram above.

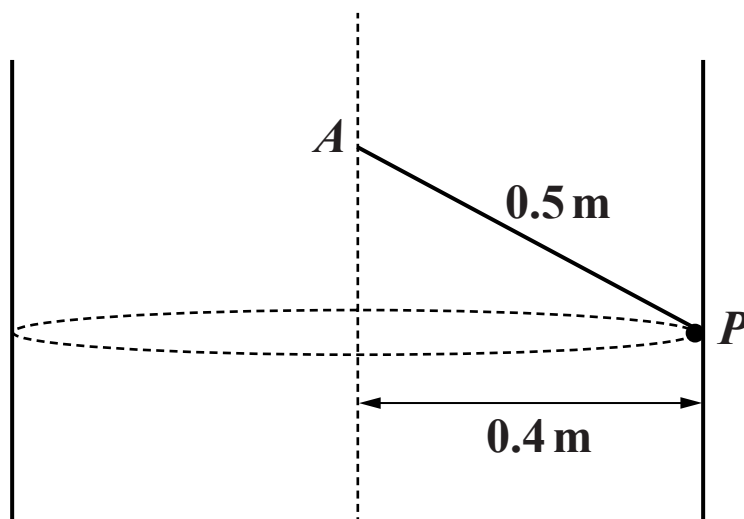
(ii) Find the tension in each string. [4]



- 5 A vertical hollow cylinder of radius 0.4 m is rotating about its axis. A particle  $P$  is in contact with the rough inner surface of the cylinder. The cylinder and  $P$  rotate with the same constant angular speed. The coefficient of friction between  $P$  and the cylinder is  $\mu$ .

- (i) Given that the angular speed of the cylinder is  $7 \text{ rad s}^{-1}$  and  $P$  is on the point of moving downwards, find the value of  $\mu$ . [5]

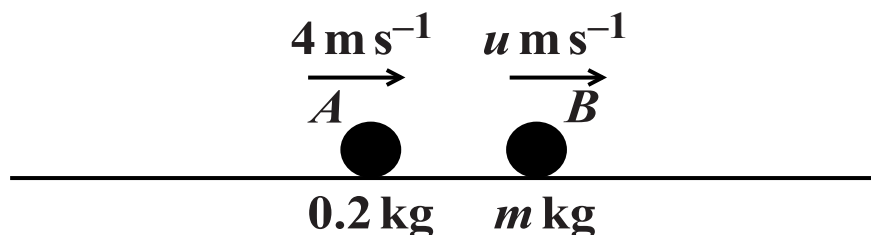
The particle is now attached to one end of a light inextensible string of length 0.5 m. The other end is fixed to a point  $A$  on the axis of the cylinder (see diagram below).



- (ii) Find the angular speed for which the contact force between  $P$  and the cylinder becomes zero. [5]



**6 Look at the following diagram.**

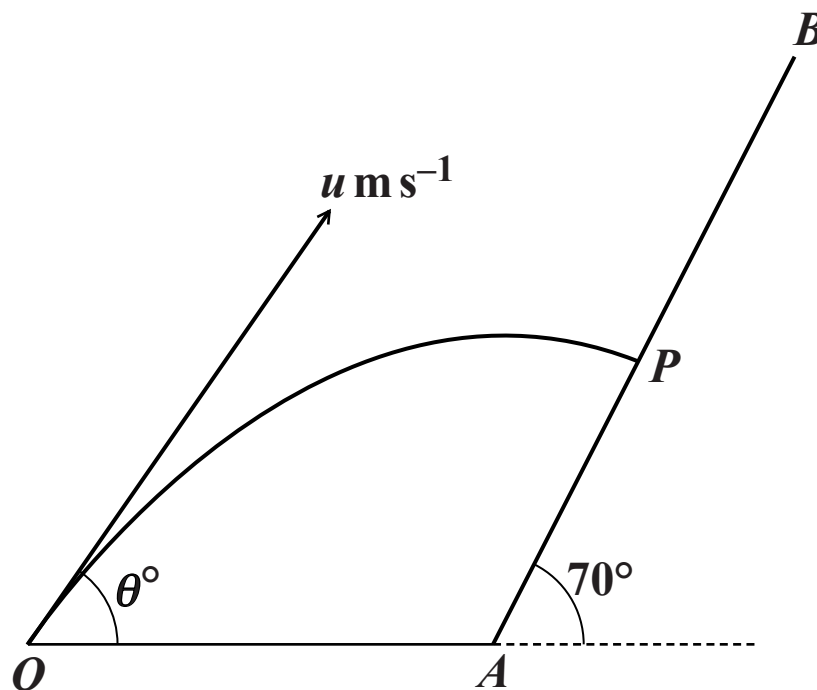


The masses of two particles  $A$  and  $B$  are  $0.2 \text{ kg}$  and  $m \text{ kg}$  respectively. The particles are moving with constant speeds  $4 \text{ m s}^{-1}$  and  $u \text{ m s}^{-1}$  in the same horizontal line and in the same direction (see diagram above). The two particles collide and the coefficient of restitution between the particles is  $e$ . After the collision,  $A$  and  $B$  continue in the same direction with speeds  $4(1 - e + e^2) \text{ m s}^{-1}$  and  $4 \text{ m s}^{-1}$  respectively.

- (i) Find  $u$  and  $m$  in terms of  $e$ . [6]
- (ii) Find the value of  $e$  for which the speed of  $A$  after the collision is least and find, in this case, the total loss in kinetic energy due to the collision. [5]
- (iii) Find the possible values of  $e$  for which the magnitude of the impulse that  $B$  exerts on  $A$  is  $0.192 \text{ N s}$ . [4]



**7 Look at the following diagram.**



The diagram above shows a surface consisting of a horizontal part  $OA$  and a plane  $AB$  inclined at an angle of  $70^\circ$  to the horizontal. A particle is projected from the point  $O$  with speed  $u \text{ m s}^{-1}$  at an angle of  $\theta^\circ$  above the horizontal  $OA$ . The particle hits the plane  $AB$  at the point  $P$ , with speed  $14 \text{ m s}^{-1}$  and at right angles to the plane,  $1.4 \text{ s}$  after projection.

- (i) Show that the value of  $u$  is  $15.9$ , correct to 3 significant figures, and find the value of  $\theta$ . [7]
- (ii) Find the height of  $P$  above the level of  $A$ . [3]

The particle rebounds with speed  $v \text{ m s}^{-1}$ . The particle next lands at  $A$ .

- (iii) Find the value of  $v$ . [5]
- (iv) Find the coefficient of restitution between the particle and the plane at  $P$ . [1]



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