

# OCR

Oxford Cambridge and RSA

## Wednesday 13 May 2015 – Morning

### A2 GCE MATHEMATICS

4729/01 Mechanics 2

#### QUESTION PAPER

Candidates answer on the Printed Answer Book.

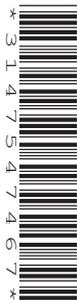
**OCR supplied materials:**

- Printed Answer Book 4729/01
- List of Formulae (MF1)

**Other materials required:**

- Scientific or graphical calculator

**Duration:** 1 hour 30 minutes



#### INSTRUCTIONS TO CANDIDATES

These instructions are the same on the Printed Answer Book and the Question Paper.

- The Question Paper will be found inside 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  $g \text{ ms}^{-2}$ . 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.

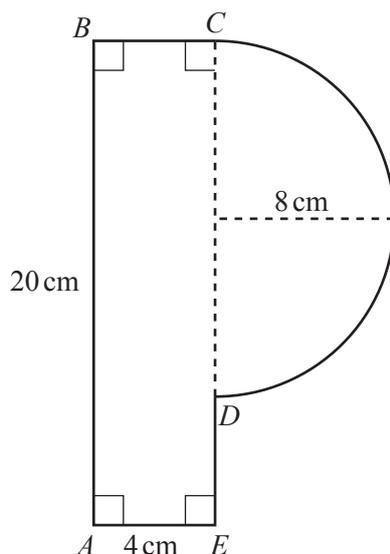
- The number of marks is given in brackets [ ] at the end of each question or part question on the Question Paper.
- **You are reminded of the need for clear presentation in your answers.**
- The total number of marks for this paper is **72**.
- The Printed Answer Book consists of **16** pages. The Question Paper consists of **4** pages. Any blank pages are indicated.

#### INSTRUCTION TO EXAMS OFFICER/INVIGILATOR

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- 1 A cyclist travels along a straight horizontal road. The total mass of the cyclist and her bicycle is 80 kg and the resistance to motion is a constant 60 N.
- (i) The cyclist travels at a constant speed working at a constant rate of 480 W. Find the speed at which she travels. [3]
- (ii) The cyclist now instantaneously increases her power to 600 W. After travelling at this power for 14.2 s her speed reaches  $9.4 \text{ m s}^{-1}$ . Find the distance travelled at this power. [4]
- 2 A particle of mass 0.3 kg is attached to one end of a light inextensible string. The other end of the string is attached to a fixed point  $A$ . The particle moves in a horizontal circle of radius 0.343 m, with centre vertically below  $A$ , at a constant angular speed of  $6 \text{ rad s}^{-1}$ . Find the tension in the string and the angle at which the string is inclined to the vertical. [6]
- 3 A car of mass 1500 kg travels along a straight horizontal road with its engine working at a constant rate of  $P \text{ W}$ . There is a constant resistance to motion of  $R \text{ N}$ . Points  $A$  and  $B$  are on the road. At point  $A$  the car's speed is  $16 \text{ m s}^{-1}$  and its acceleration is  $0.3875 \text{ m s}^{-2}$ . At point  $B$  the car's speed is  $25 \text{ m s}^{-1}$  and its acceleration is  $0.2 \text{ m s}^{-2}$ . Find the values of  $P$  and  $R$ . [6]

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A uniform solid prism has cross-section  $ABCDE$  in the shape of a rectangle measuring 20 cm by 4 cm joined to a semicircle of radius 8 cm as shown in the diagram. The centre of mass of the solid lies in this cross-section.

- (i) Find the distance of the centre of mass of the solid from  $AB$ . [5]

The solid is placed with  $AE$  on rough horizontal ground (so the object does not slide) and is in equilibrium with a horizontal force of magnitude 4 N applied along  $CB$ .

- (ii) Find the greatest and least possible values for the weight of the solid. [5]

- 5 A small sphere of mass  $0.2 \text{ kg}$  is projected vertically downwards with a speed of  $5 \text{ m s}^{-1}$  from a height of  $1.6 \text{ m}$  above horizontal ground. It hits the ground and rebounds vertically upwards coming to instantaneous rest at a height of  $h \text{ m}$  above the ground. The coefficient of restitution between the sphere and the ground is  $0.7$ .

(i) Find  $h$ . [4]

(ii) Find the magnitude and direction of the impulse exerted on the sphere by the ground. [3]

(iii) Find the loss of energy of the sphere between the instant of projection and the instant it comes to instantaneous rest at height  $h \text{ m}$ . [3]

- 6 A particle is projected with speed  $v \text{ m s}^{-1}$  from a point  $O$  on horizontal ground. The angle of projection is  $\theta^\circ$  above the horizontal. At time  $t$  seconds after the instant of projection the horizontal displacement of the particle from  $O$  is  $x \text{ m}$  and the upward vertical displacement from  $O$  is  $y \text{ m}$ .

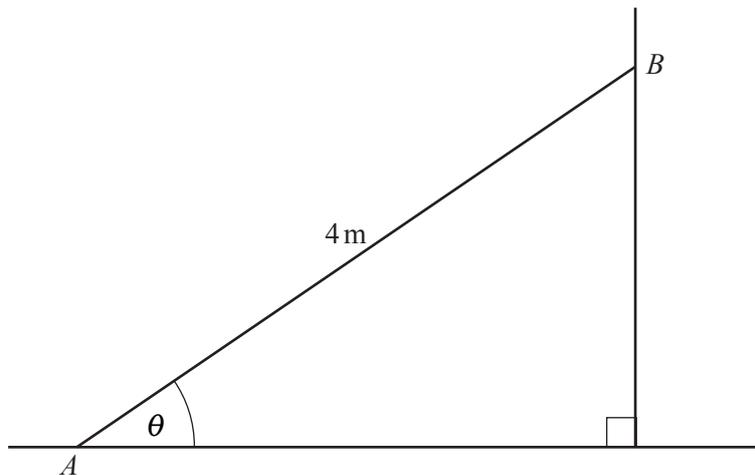
(i) Show that

$$y = x \tan \theta - \frac{4.9x^2}{v^2 \cos^2 \theta}. \quad [4]$$

A stone is thrown from the top of a vertical cliff  $100 \text{ m}$  high. The initial speed of the stone is  $16 \text{ m s}^{-1}$  and the angle of projection is  $\theta^\circ$  to the horizontal. The stone hits the sea  $40 \text{ m}$  from the foot of the cliff.

(ii) Find the two possible values of  $\theta$ . [6]

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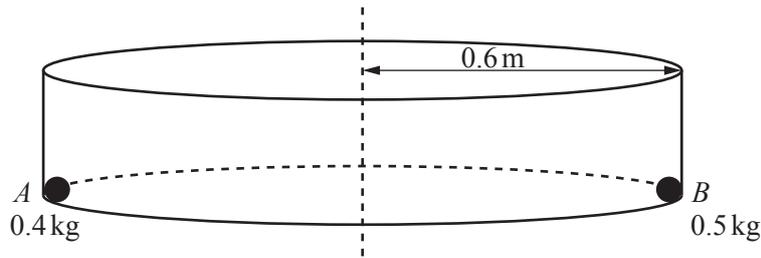


A uniform ladder  $AB$  of weight  $W \text{ N}$  and length  $4 \text{ m}$  rests with its end  $A$  on rough horizontal ground and its end  $B$  against a smooth vertical wall. The ladder is inclined at an angle  $\theta$  to the horizontal where  $\tan \theta = \frac{1}{2}$  (see diagram). A small object  $S$  of weight  $2W \text{ N}$  is placed on the ladder at a point  $C$ , which is  $1 \text{ m}$  from  $A$ . The coefficient of friction between the ladder and the ground is  $\mu$  and the system is in limiting equilibrium.

(i) Show that  $\mu = \frac{2}{3}$ . [6]

A small object of weight  $aW \text{ N}$  is placed on the ladder at its mid-point and the object  $S$  of weight  $2W \text{ N}$  is placed on the ladder at its lowest point  $A$ .

(ii) Given that the system is in equilibrium, find the set of possible values of  $a$ . [5]



Two small spheres,  $A$  and  $B$ , are free to move on the inside of a smooth hollow cylinder, in such a way that they remain in contact with both the curved surface of the cylinder and its horizontal base. The mass of  $A$  is  $0.4\text{ kg}$ , the mass of  $B$  is  $0.5\text{ kg}$  and the radius of the cylinder is  $0.6\text{ m}$  (see diagram). The coefficient of restitution between  $A$  and  $B$  is  $0.35$ . Initially,  $A$  and  $B$  are at opposite ends of a diameter of the base of the cylinder with  $A$  travelling at a constant speed of  $v\text{ m s}^{-1}$  and  $B$  stationary. The magnitude of the force exerted on  $A$  by the curved surface of the cylinder is  $6\text{ N}$ .

(i) Show that  $v = 3$ . [2]

(ii) Calculate the speeds of the particles after  $A$ 's first impact with  $B$ . [6]

Sphere  $B$  is removed from the cylinder and sphere  $A$  is now set in motion with constant angular speed  $\omega\text{ rad s}^{-1}$ . The magnitude of the total force exerted on  $A$  by the cylinder is  $4.9\text{ N}$ .

(iii) Find  $\omega$ . [4]

**END OF QUESTION PAPER**

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