

**Monday 14 January 2013 – 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 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.
- 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 **12** pages. The Question Paper consists of **8** 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 A block is being pushed in a straight line along horizontal ground by a force of 18 N inclined at  $15^\circ$  below the horizontal. The block moves a distance of 6 m in 5 s with constant speed. Find

(i) the work done by the force, [3]

(ii) the power with which the force is working. [2]

2 A car of mass 1500 kg travels along a straight horizontal road. The resistance to the motion of the car is  $kv^{\frac{1}{2}}$  N, where  $v \text{ m s}^{-1}$  is the speed of the car and  $k$  is a constant. At the instant when the engine produces a power of 15 000 W, the car has speed  $15 \text{ m s}^{-1}$  and is accelerating at  $0.4 \text{ m s}^{-2}$ .

(i) Find the value of  $k$ . [4]

It is given that the greatest steady speed of the car on this road is  $30 \text{ m s}^{-1}$ .

(ii) Find the greatest power that the engine can produce. [3]

3 A particle  $A$  is released from rest from the top of a smooth plane, which makes an angle of  $30^\circ$  with the horizontal. The particle  $A$  collides 2 s later with a particle  $B$ , which is moving up a line of greatest slope of the plane. The coefficient of restitution between the particles is 0.4 and the speed of  $B$  immediately before the collision is  $2 \text{ m s}^{-1}$ .  $B$  has velocity  $1 \text{ m s}^{-1}$  down the plane immediately after the collision. Find

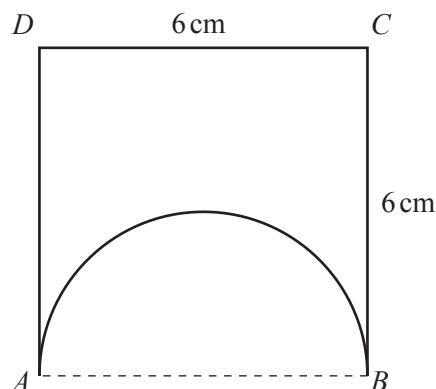
(i) the speed of  $A$  immediately after the collision, [4]

(ii) the distance  $A$  moves up the plane after the collision. [2]

The masses of  $A$  and  $B$  are 0.5 kg and  $m$  kg, respectively.

(iii) Find the value of  $m$ . [3]

4



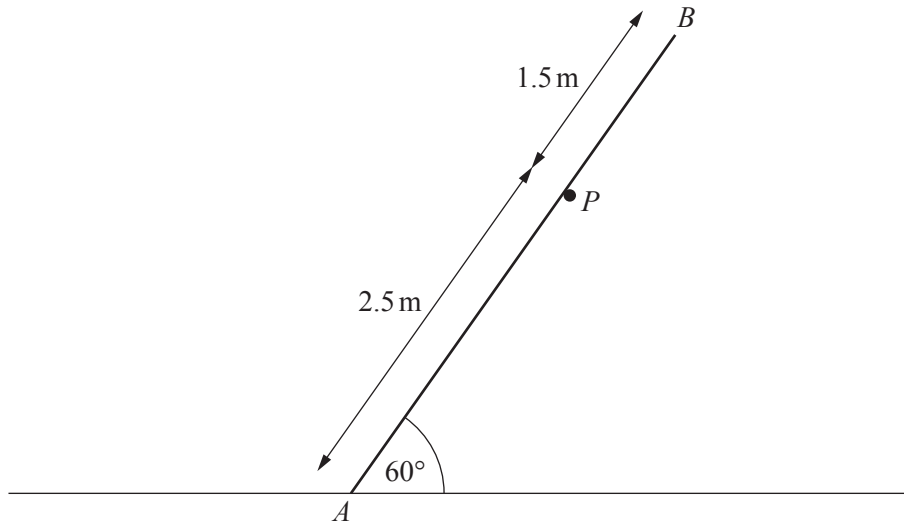
A uniform square lamina  $ABCD$  of side 6 cm has a semicircular piece, with  $AB$  as diameter, removed (see diagram).

(i) Find the distance of the centre of mass of the remaining shape from  $CD$ . [6]

The remaining shape is suspended from a fixed point by a string attached at  $C$  and hangs in equilibrium.

(ii) Find the angle between  $CD$  and the vertical. [2]

5



A uniform rod  $AB$ , of mass 3 kg and length 4 m, is in limiting equilibrium with  $A$  on rough horizontal ground. The rod is at an angle of  $60^\circ$  to the horizontal and is supported by a small smooth peg  $P$ , such that the distance  $AP$  is 2.5 m (see diagram). Find

(i) the force acting on the rod at  $P$ , [3]

(ii) the coefficient of friction between the ground and the rod. [5]

6 A particle of mass 0.5 kg is held at rest at a point  $P$ , which is at the bottom of an inclined plane. The particle is given an impulse of 1.8 N s directed up a line of greatest slope of the plane.

(i) Find the speed at which the particle starts to move. [2]

The particle subsequently moves up the plane to a point  $Q$ , which is 0.3 m above the level of  $P$ .

(ii) Given that the plane is smooth, find the speed of the particle at  $Q$ . [4]

It is given instead that the plane is rough. The particle is now projected up the plane from  $P$  with initial speed  $3 \text{ m s}^{-1}$ , and comes to rest at a point  $R$  which is 0.2 m above the level of  $P$ .

(iii) Given that the plane is inclined at  $30^\circ$  to the horizontal, find the magnitude of the frictional force on the particle. [4]

- 7 A particle is projected with speed  $u \text{ m s}^{-1}$  at an angle of  $\theta$  above the horizontal from a point  $O$ . At time  $t$  s after projection, the horizontal and vertically upwards displacements of the particle from  $O$  are  $x$  m and  $y$  m respectively.

(i) Express  $x$  and  $y$  in terms of  $t$  and  $\theta$  and hence obtain the equation of trajectory

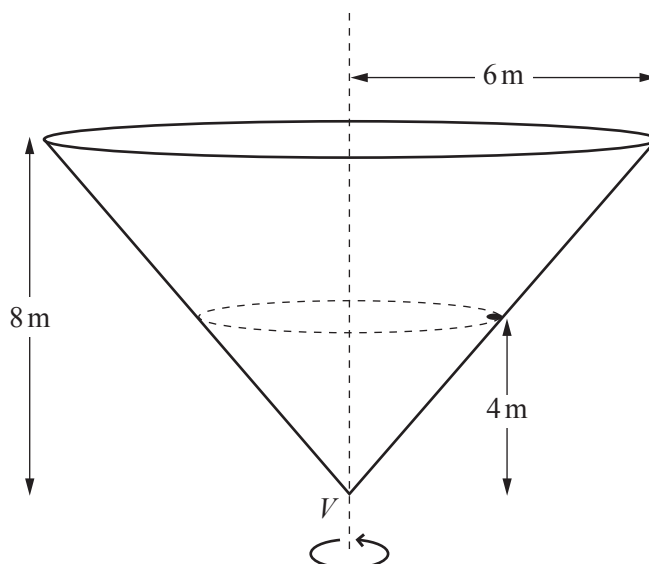
$$y = x \tan \theta - \frac{gx^2 \sec^2 \theta}{2u^2}. \quad [4]$$

In a shot put competition, a shot is thrown from a height of 2.1 m above horizontal ground. It has initial velocity of  $14 \text{ m s}^{-1}$  at an angle of  $\theta$  above the horizontal. The shot travels a horizontal distance of 22 m before hitting the ground.

(ii) Show that  $12.1 \tan^2 \theta - 22 \tan \theta + 10 = 0$ , and find the value of  $\theta$ . [5]

(iii) Find the time of flight of the shot. [2]

8



A conical shell has radius 6 m and height 8 m. The shell, with its vertex  $V$  downwards, is rotating about its vertical axis. A particle, of mass 0.4 kg, is in contact with the rough inner surface of the shell. The particle is 4 m above the level of  $V$  (see diagram). The particle and shell rotate with the same constant angular speed. The coefficient of friction between the particle and the shell is  $\mu$ .

(i) The frictional force on the particle is  $F\text{N}$ , and the normal force of the shell on the particle is  $R\text{N}$ . It is given that the speed of the particle is  $4.5 \text{ m s}^{-1}$ , which is the smallest possible speed for the particle not to slip.

(a) By resolving vertically, show that  $4F + 3R = 19.6$ . [2]

(b) By finding another equation connecting  $F$  and  $R$ , find the values of  $F$  and  $R$  and show that  $\mu = 0.336$ , correct to 3 significant figures. [6]

(ii) Find the largest possible angular speed of the shell for which the particle does not slip. [6]

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