OCR
Oxford Cambridge and RSA

Wednesday 18 May 2016 – 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 $g\,\text{m}\,\text{s}^{-2}$. 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 **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.

Answer **all** the questions.

1 A car of mass 1400 kg is travelling on a straight horizontal road against a constant resistance to motion of 600 N. At a certain instant the car is accelerating at $0.3\,\mathrm{m\,s^{-2}}$ and the engine of the car is working at a rate of 23 kW.

(i) Find the speed of the car at this instant. **[3]**

Subsequently the car moves up a hill inclined at 10° to the horizontal at a steady speed of $12\,\mathrm{m\,s^{-1}}$. The resistance to motion is still a constant 600 N.

(ii) Calculate the power of the car's engine as it moves up the hill. **[3]**

2 A and B are two points on a line of greatest slope of a plane inclined at 55° to the horizontal. A is below the level of B and $AB = 4$ m. A particle P of mass 2.5 kg is projected up the plane from A towards B and the speed of P at B is $6.7\,\mathrm{m\,s^{-1}}$. The coefficient of friction between the plane and P is 0.15. Find

(i) the work done against the frictional force as P moves from A to B, **[3]**

(ii) the initial speed of P at A. **[4]**

3

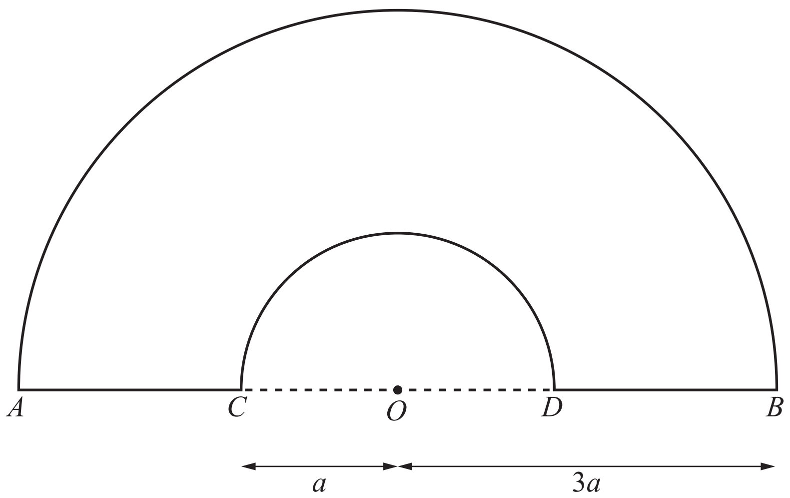


Fig. 1

A uniform lamina $ABDC$ is bounded by two semicircular arcs AB and CD, each with centre O and of radii $3a$ and a respectively, and two straight edges, AC and DB, which lie on the line AOB (see Fig. 1).

(i) Show that the distance of the centre of mass of the lamina from O is $\dfrac{13a}{3\pi}$. **[5]**

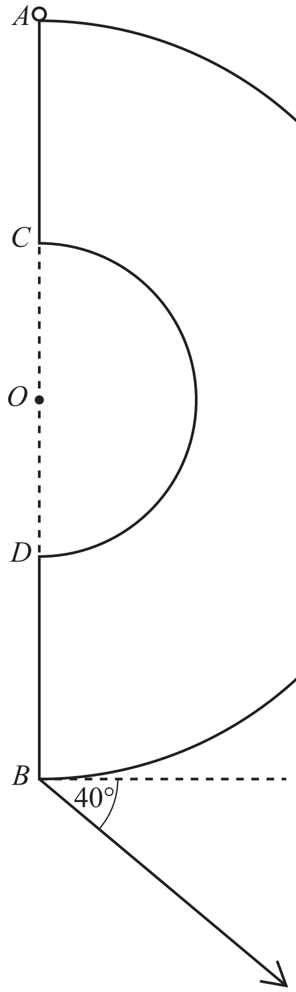


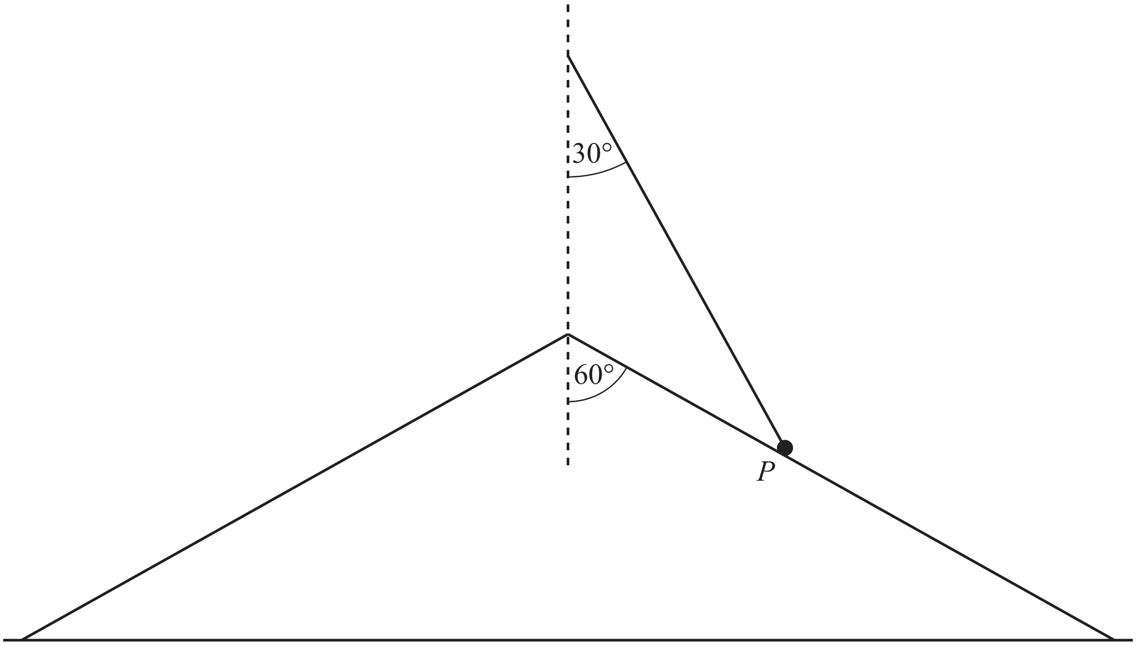
Fig. 2

The lamina has mass 3 kg and is freely pivoted to a fixed point at A. The lamina is held in equilibrium with AB vertical by means of a light string attached to B. The string lies in the same plane as the lamina and is at an angle of 40° below the horizontal (see Fig. 2).

(ii) Calculate the tension in the string. **[3]**

(iii) Find the direction of the force acting on the lamina at A. **[4]**

4



A smooth solid cone of semi-vertical angle 60° is fixed to the ground with its axis vertical. A particle P of mass m is attached to one end of a light inextensible string of length a. The other end of the string is attached to a fixed point vertically above the vertex of the cone. P rotates in a horizontal circle on the surface of the cone with constant angular velocity ω. The string is inclined to the downward vertical at an angle of 30° (see diagram).

(i) Show that the magnitude of the contact force between the cone and the particle is $\frac{1}{6}m\left(2\sqrt{3}g - 3a\omega^2\right)$. **[6]**

(ii) Given that $a = 0.5$ m and $m = 3.5$ kg, find, in either order, the greatest speed for which the particle remains in contact with the cone and the corresponding tension in the string. **[3]**

5 A uniform ladder AB, of weight W and length $2a$, rests with the end A in contact with rough horizontal ground and the end B resting against a smooth vertical wall. The ladder is inclined at an angle θ to the horizontal, where $\sin\theta = \frac{12}{13}$. A man of weight $6W$ is standing on the ladder at a distance x from A and the system is in equilibrium.

(i) Show that the magnitude of the frictional force exerted by the ground on the ladder is $\frac{5W}{24}\left(1 + \frac{6x}{a}\right)$. **[5]**

The coefficient of friction between the ladder and the ground is $\frac{1}{3}$.

(ii) Find, in terms of a, the greatest value of x for which the system is in equilibrium. **[3]**

The bottom of the ladder A is moved closer to the wall so that the ladder is now inclined at an angle α to the horizontal. The man of weight $6W$ can now stand at the top of the ladder B without the ladder slipping.

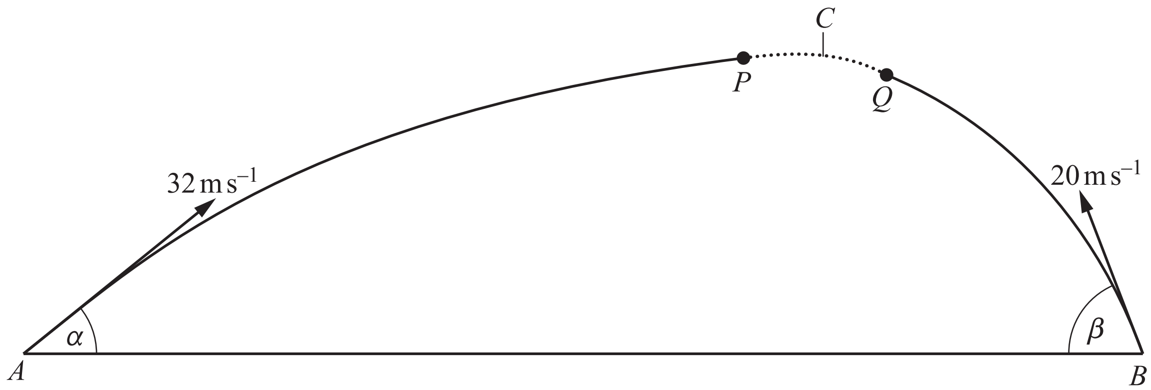
(iii) Find the least possible value of $\tan\alpha$. **[3]**

6 The masses of two particles A and B are 4 kg and 3 kg respectively. The particles are moving towards each other along a straight line on a smooth horizontal surface. A has speed $8\,\mathrm{m\,s^{-1}}$ and B has speed $10\,\mathrm{m\,s^{-1}}$ before they collide. The kinetic energy lost due to the collision is 121.5 J.

(i) Find the speed and direction of motion of each particle after the collision. **[8]**

(ii) Find the coefficient of restitution between A and B. **[2]**

7



A particle P is projected with speed $32\,\mathrm{m\,s^{-1}}$ at an angle of elevation α, where $\sin\alpha = \frac{3}{5}$, from a point A on horizontal ground. At the same instant a particle Q is projected with speed $20\,\mathrm{m\,s^{-1}}$ at an angle of elevation β, where $\sin\beta = \frac{24}{25}$, from a point B on the same horizontal ground. The particles move freely under gravity in the same vertical plane and collide with each other at the point C at the instant when they are travelling horizontally (see diagram).

(i) Calculate the height of C above the ground and the distance AB. **[4]**

Immediately after the collision P falls vertically. P hits the ground and rebounds vertically upwards, coming to instantaneous rest at a height 5 m above the ground.

(ii) Given that the mass of P is 3 kg, find the magnitude and direction of the impulse exerted on P by the ground. **[4]**

The coefficient of restitution between the two particles is $\frac{1}{2}$.

(iii) Find the distance of Q from C at the instant when Q is travelling in a direction of 25° below the horizontal. **[9]**

END OF QUESTION PAPER

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