OCR
Oxford Cambridge and RSA

Wednesday 16 May 2018 – 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 barcodes.
- 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 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 **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.

DC (NF/SW) 153305/1

Answer **all** the questions.

1 A car of mass 1300 kg is travelling uphill along a straight road inclined at 6° to the horizontal. The resistance to the motion of the car is constant and equal to 350 N. The car's engine is working at a rate of 24.5 kW. Find the acceleration of the car at an instant when its speed is $12\,\text{m}\,\text{s}^{-1}$. **[3]**

2 A particle P is projected with speed $35\,\text{m}\,\text{s}^{-1}$ at an angle of 41° above the horizontal. Calculate

(i) the maximum height of P above the level of the point of projection, **[2]**

(ii) the speed and direction of motion of P at time 3 s after projection. **[5]**

3 A small ball of mass 3 kg is held at a height of 20 m above a horizontal floor. The ball is projected vertically downwards with a speed of $4\,\text{m}\,\text{s}^{-1}$. The only forces acting on the ball are its weight and a resistance to motion of magnitude 3.525 N.

(i) Use an energy method to find the speed of the ball immediately before its impact with the floor. **[5]**

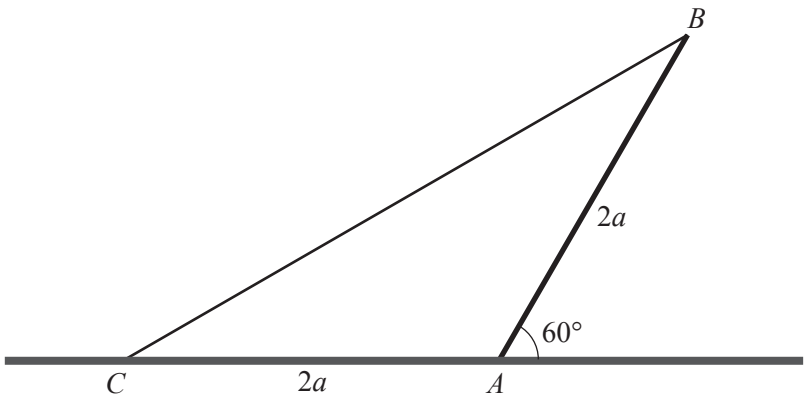
The coefficient of restitution between the ball and the floor is 0.6 and after the ball hits the floor it rebounds vertically upwards.

(ii) Find the magnitude and direction of the impulse exerted on the ball by the floor. **[3]**

While travelling upwards the resistance to the motion of the ball remains at 3.525 N and the ball first comes to instantaneous rest at a height h m above the floor.

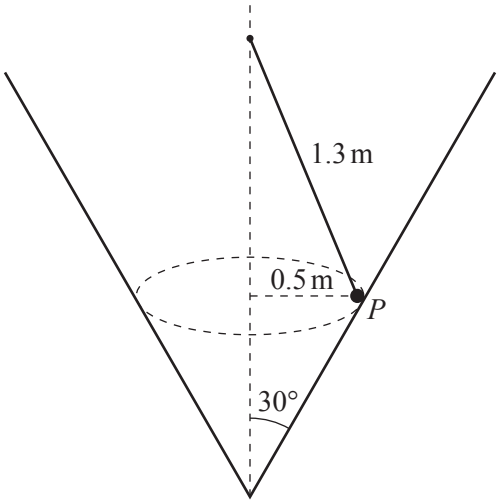
(iii) Find h. **[3]**

4



A uniform rod AB, of length $2a$ and weight W, rests in equilibrium with the end A in contact with rough horizontal ground. The end B is connected to a point C on the ground by a light inextensible string so that A, B and C lie in a vertical plane. The rod is inclined at an angle of 60° to the horizontal and $AC = 2a$ (see diagram). The system is in limiting equilibrium. Find the tension in the string in terms of W, and calculate the value of the coefficient of friction between the rod and the ground. **[8]**

5



A conical shell, of semi-vertical angle 30°, is fixed with its axis vertical and its vertex downwards. A particle P, of mass 0.2 kg, is in contact with the smooth inner surface of the shell. One end of a light inextensible string of length 1.3 m is attached to P and the other end is attached to a fixed point on the axis of the shell. P moves in a horizontal circle of radius 0.5 m (see diagram).

(i) Given that the angular speed of P is 5.2 rad s^{-1}, find the tension in the string. **[6]**

(ii) Find the least possible speed of P for which P remains in contact with the shell. **[3]**

6 Two small spheres A and B, of masses $2m$ and $4m$ respectively, are free to move in a straight line on a smooth horizontal table. Initially B is stationary and A is moving with velocity u directly towards B. Sphere A collides directly with B and the coefficient of restitution for the collision between A and B is e.

(i) Show that the velocity of B after the collision is $\frac{1}{3}u(1+e)$ and find a similar expression for the velocity of A after the collision. **[5]**

It is given that 24% of the kinetic energy of the system is lost in the collision.

(ii) Find the value of e. **[3]**

A third small sphere C of mass $5m$ is free to move in the same straight line as A and B. After the collision between A and B, sphere B subsequently collides with C. The coefficient of restitution between B and C is 0.9, and before this collision C is stationary.

(iii) Show that there are no further collisions. **[5]**

7

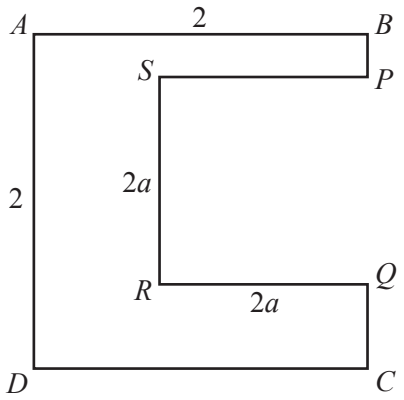


Fig. 1

Fig. 1 shows the cross-section through the centre of mass of a uniform solid prism. The cross-section is a square $ABCD$ of side 2 with a square $PQRS$ of side $2a$ removed. It is given that the centre of mass of the prism lies on the line through R and S.

(i) Show that $2a = \sqrt{k} - 1$, stating the value of the constant k. **[8]**

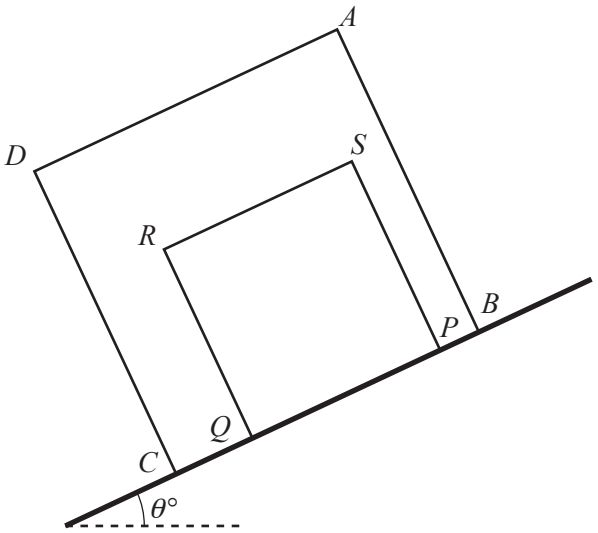
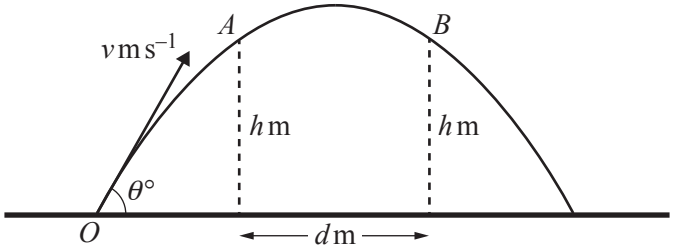


Fig. 2

The prism is now placed on an inclined plane which makes an angle $\theta°$ with the horizontal. BC lies along a line of greatest slope with B higher than C (see Fig. 2). The plane is slowly tilted until the prism topples, without slipping, when $\theta = 30$.

(ii) Find the distance of the centre of mass of the prism from CD. **[3]**

8



A particle is projected with speed v m s^{-1} from a point O on horizontal ground. The angle of projection is $\theta°$ above the horizontal. The particle passes, in succession, through two points A and B at a height h m above the ground and at a distance d m apart (see diagram).

(i) By considering the horizontal and vertical components of the velocity of the particle at A and B, show that

$$4v^4 \sin^2\theta \cos^2\theta - 8ghv^2 \cos^2\theta - g^2d^2 = 0.$$ **[7]**

(ii) Given that $\theta = 60$, $h = 30$ and $d = 22.5$, find the value of v. **[3]**

END OF QUESTION PAPER

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