

OXFORD

INTERNATIONAL AQA EXAMINATIONS

Topic Test: OxfordAQA A level Mathematics

Mechanics

Name: _____

Class: _____

Date: _____

Time: **88 minutes**

Marks: **73 marks**

Comments:

1

A particle moves so that at time t seconds its velocity $\mathbf{v}$ m s⁻¹ is given by

$$\mathbf{v} = (4t^3 - 12t + 3)\mathbf{i} + 5\mathbf{j} + 8t\mathbf{k}$$

- (a) When $t = 0$, the position vector of the particle is $(-5\mathbf{i} + 6\mathbf{k})$ metres.

Find the position vector of the particle at time t .

(4)

- (b) Find the acceleration of the particle at time t .

(2)

- (c) Find the magnitude of the acceleration of the particle at time t . Do not simplify your answer.

(2)

- (d) Hence find the time at which the magnitude of the acceleration is a minimum.

(2)

- (e) The particle is moving under the action of a single variable force $\mathbf{F}$ newtons. The mass of the particle is 7 kg.

Find the minimum magnitude of $\mathbf{F}$.

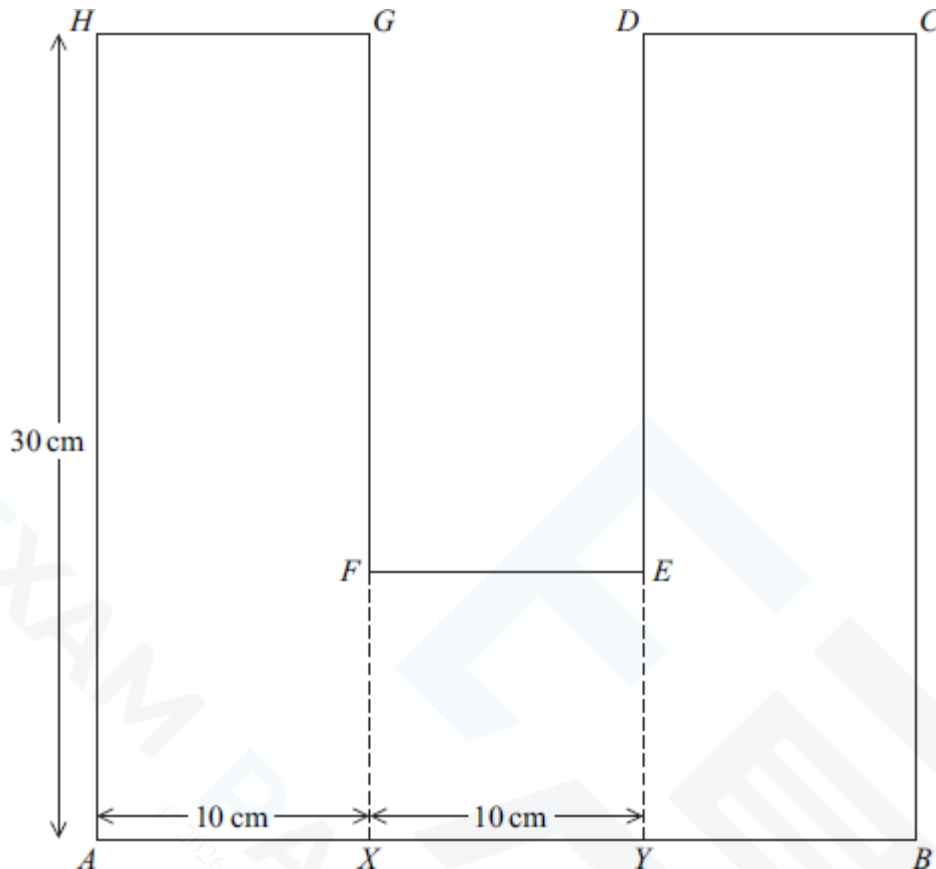
(2)

(Total 12 marks)

2

The diagram shows a uniform lamina which is in the shape of two identical rectangles $AXGH$ and $YBCD$ and a square $XYEF$, arranged as shown.

The length of AX is 10 cm, the length of XY is 10 cm and the length of AH is 30 cm.



- (a) Explain why the centre of mass of the lamina is 15 cm from AH .

(1)

- (b) Find the distance of the centre of mass of the lamina from AB .

(3)

- (c) The lamina is freely suspended from the point H .

Find, to the nearest degree, the angle between HG and the horizontal when the lamina is in equilibrium.

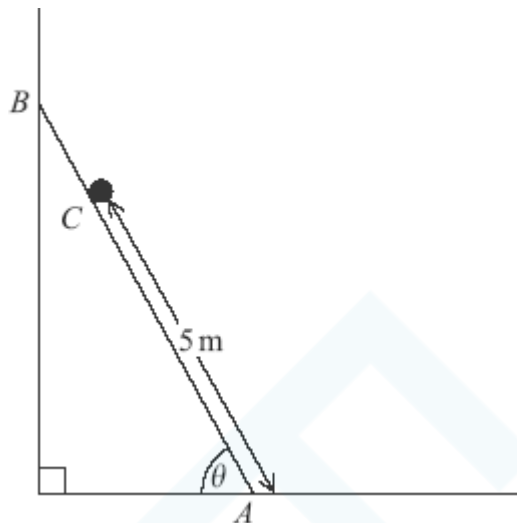
(4)

(Total 8 marks)

3

A uniform ladder, of length 6 metres and mass 22 kg, rests with its foot, A , on a rough horizontal floor and its top, B , leaning against a smooth vertical wall. The vertical plane containing the ladder is perpendicular to the wall, and the angle between the ladder and the floor is θ .

A man, of mass 90 kg, is standing at point C on the ladder so that the distance AC is 5 metres. With the man in this position, the ladder is on the point of slipping. The coefficient of friction between the ladder and the horizontal floor is 0.6. The man may be modelled as a particle at C .



- (a) Show that the magnitude of the frictional force between the ladder and the horizontal floor is 659 N, correct to three significant figures.

(4)

- (b) Find the angle θ .

(5)

(Total 9 marks)

4

A particle moves in a horizontal plane under the action of a single force, $\mathbf{F}$ newtons.

The unit vectors $\mathbf{i}$ and $\mathbf{j}$ are directed east and north respectively. At time t seconds, the velocity of the particle, $\mathbf{v} \text{ m s}^{-1}$, is given by

$$\mathbf{v} = 4e^{-2t} \mathbf{i} + (6t - 3t^2) \mathbf{j}$$

- (a) Find an expression for the acceleration of the particle at time t .

(3)

- (b) The mass of the particle is 5 kg.

- (i) Find an expression for the force $\mathbf{F}$ acting on the particle at time t .

(2)

- (ii) Find the magnitude of $\mathbf{F}$ when $t = 0$.

(2)

- (c) Find the value of t when $\mathbf{F}$ acts due west.

(2)

- (d) When $t = 0$, the particle is at the point with position vector $(6\mathbf{i} + 5\mathbf{j})$ m.

Find the position vector, $\mathbf{r}$ metres, of the particle at time t .

(5)

(Total 14 marks)

- 5** A football is kicked from ground level with an initial velocity of 30 m s^{-1} at an angle of 35° above the horizontal.

- (a) Find the maximum height of the ball above ground level.

(4)

- (b) Show that when the speed of the ball is 28 m s^{-1} , the magnitude of the vertical component of its velocity is 13.4 m s^{-1} , correct to three significant figures.

(4)

- (c) Find the angle between the velocity of the ball and the horizontal when the speed of the ball is 28 m s^{-1} .

(2)

(Total 10 marks)

- 6** When a car, of mass 1200 kg , travels at a speed of $v \text{ m s}^{-1}$, it experiences a resistance force of magnitude $30v$ newtons.

The car has a maximum constant speed of 48 m s^{-1} on a straight horizontal road.

- (a) Show that the maximum power of the car is $69\,120$ watts.

(2)

- (b) The car is travelling along a straight horizontal road.

Find the maximum possible acceleration of the car when it is travelling at a speed of 40 m s^{-1} .

(4)

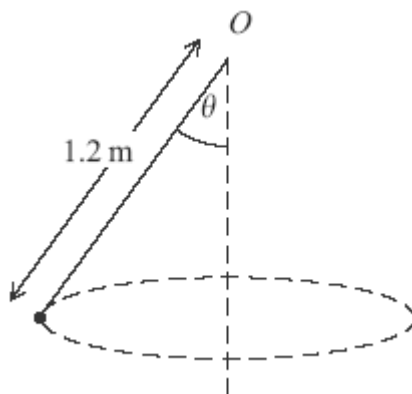
- (c) The car starts to descend a hill on a straight road which is inclined at an angle of 3° to the horizontal. Find the maximum possible constant speed of the car as it travels on this road down the hill.

(7)

(Total 13 marks)

7

A particle, of mass 4 kg, is attached to one end of a light inextensible string of length 1.2 metres. The other end of the string is attached to a fixed point O . The particle moves in a horizontal circle at a constant speed. The angle between the string and the vertical is θ .



- (a) Find the radius of the horizontal circle in terms of θ .

(1)

- (b) The angular speed of the particle is 5 radians per second. Find θ .

(6)

(Total 7 marks)