

1. [In this question \mathbf{i} and \mathbf{j} are perpendicular unit vectors in a horizontal plane.]

A particle P moves in such a way that its velocity \mathbf{v} m s⁻¹ at time t seconds is given by

$$\mathbf{v} = (3t^2 - 1)\mathbf{i} + (4t - t^2)\mathbf{j}$$

- (a) Find the magnitude of the acceleration of P when $t = 1$ **(5)**

Given that, when $t = 0$, the position vector of P is \mathbf{i} metres,

- (b) find the position vector of P when $t = 3$ **(5)**



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2. A particle P of mass $3m$ is moving with speed $2u$ in a straight line on a smooth horizontal plane. The particle P collides directly with a particle Q of mass $4m$ moving on the plane with speed u in the opposite direction to P . The coefficient of restitution between P and Q is e .

(a) Find the speed of Q immediately after the collision. (6)

Given that the direction of motion of P is reversed by the collision,

(b) find the range of possible values of e . (5)



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Question 3 continued

Lined area for writing the answer to Question 3.

Q3

(Total 8 marks)



4.

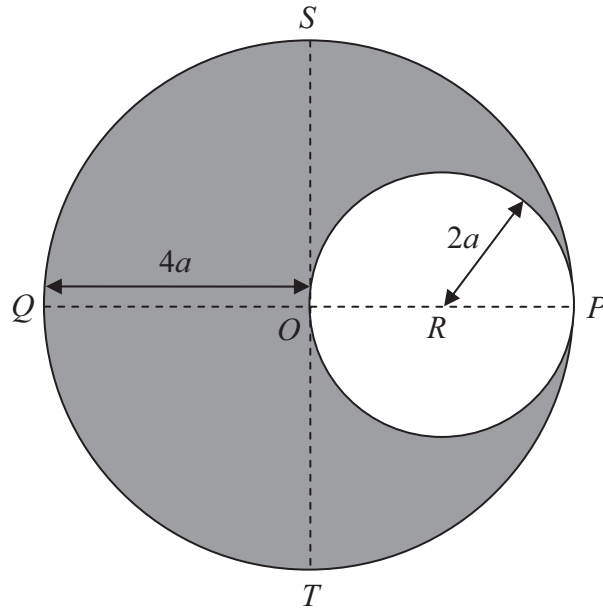


Figure 2

A uniform circular disc has centre O and radius $4a$. The lines PQ and ST are perpendicular diameters of the disc. A circular hole of radius $2a$ is made in the disc, with the centre of the hole at the point R on OP where $OR = 2a$, to form the lamina L , shown shaded in Figure 2.

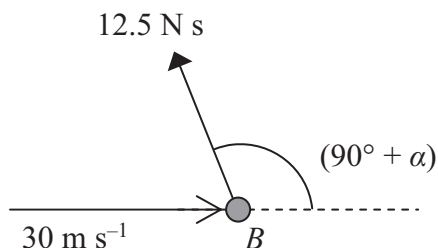
- (a) Show that the distance of the centre of mass of L from P is $\frac{14a}{3}$. (4)

The mass of L is m and a particle of mass km is now fixed to L at the point P . The system is now suspended from the point S and hangs freely in equilibrium. The diameter ST makes an angle α with the downward vertical through S , where $\tan \alpha = \frac{5}{6}$.

- (b) Find the value of k . (5)



5.

**Figure 3**

A small ball B of mass 0.25 kg is moving in a straight line with speed 30 m s^{-1} on a smooth horizontal plane when it is given an impulse. The impulse has magnitude 12.5 N s and is applied in a horizontal direction making an angle of $(90^\circ + \alpha)$, where $\tan \alpha = \frac{3}{4}$, with the initial direction of motion of the ball, as shown in Figure 3.

- (i) Find the speed of B immediately after the impulse is applied.
- (ii) Find the direction of motion of B immediately after the impulse is applied.
- (6)**

Question 5 continued

A series of horizontal lines for writing the answer to Question 5.



6. A car of mass 1200 kg pulls a trailer of mass 400 kg up a straight road which is inclined to the horizontal at an angle α , where $\sin \alpha = \frac{1}{14}$. The trailer is attached to the car by a light inextensible towbar which is parallel to the road. The car's engine works at a constant rate of 60 kW. The non-gravitational resistances to motion are constant and of magnitude 1000 N on the car and 200 N on the trailer.

At a given instant, the car is moving at 10 m s^{-1} . Find

- (a) the acceleration of the car at this instant, (5)

- (b) the tension in the towbar at this instant. (4)

The towbar breaks when the car is moving at 12 m s^{-1} .

- (c) Find, using the work-energy principle, the further distance that the trailer travels before coming instantaneously to rest. (5)



Question 6 continued

A series of horizontal lines for writing.



7.

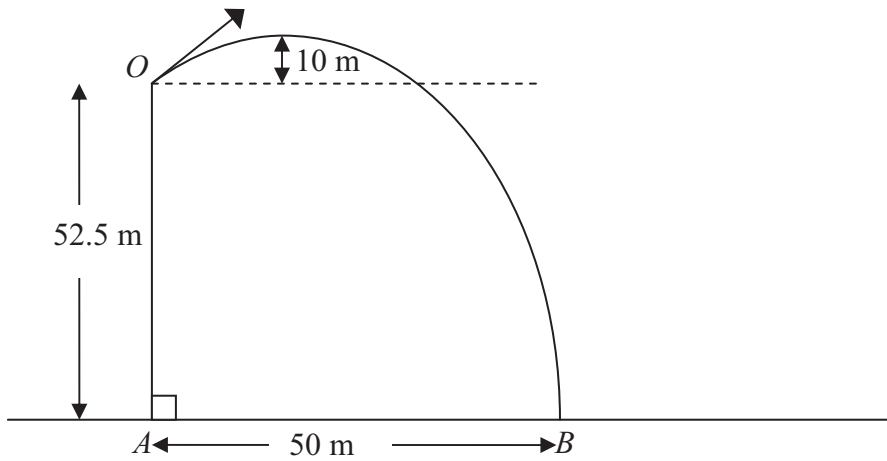


Figure 4

A small stone is projected from a point O at the top of a vertical cliff OA . The point O is 52.5 m above the sea. The stone rises to a maximum height of 10 m above the level of O before hitting the sea at the point B , where $AB = 50$ m, as shown in Figure 4. The stone is modelled as a particle moving freely under gravity.

- (a) Show that the vertical component of the velocity of projection of the stone is 14 m s^{-1} . (3)
- (b) Find the speed of projection. (9)
- (c) Find the time after projection when the stone is moving parallel to OB . (5)



