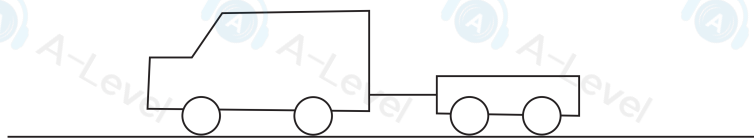


The model of the design for a pendant consists of a uniform triangular lamina, ABC , and two uniform rods AD and DC , as shown in Figure 3. The rods are in the same plane as the lamina. The lamina ABC has mass $8M$, sides $AB = 6a$ and $BC = 9a$, and angle $ABC = 90^\circ$. The rod AD has mass $2M$ and length $9a$. The rod DC has mass kM and length $6a$.

- The model is suspended from A and hangs freely in equilibrium with AC vertical.

- (b) Find the value of k . (7)

2.

**Figure 2**

A van of mass 900 kg is moving along a straight horizontal road.
The van is towing a trailer of mass 300 kg.
The trailer is attached to the van by a rigid towbar which is parallel to the direction of motion of the van and the trailer, as shown in Figure 2.

The resistance to the motion of the van is modelled as a constant force of magnitude 500 N.

The resistance to the motion of the trailer is modelled as a constant force of magnitude 200 N.

The towbar is modelled as a light rod.

The engine of the van is working at a constant rate of 18 kW.

At the instant when the speed of the van is 12 ms^{-1} , the tension in the towbar has magnitude T newtons.

- (a) Find the value of T (7)

Later, the van is towing the trailer up a straight road inclined at an angle α to the horizontal, where $\sin \alpha = \frac{1}{15}$

The towbar is still parallel to the direction of motion of the van and the trailer.

The resistance to the motion of the van from non-gravitational forces is modelled as a constant force of magnitude 500 N.

The resistance to the motion of the trailer from non-gravitational forces is modelled as a constant force of magnitude 200 N.

The towbar is again modelled as a light rod.

When the van is travelling with a constant speed of $v \text{ ms}^{-1}$, the engine of the van is working at a constant rate of 18 kW.

- (b) Find the value of v (4)



1. At time t seconds, $t > 0$, a particle P is at the point with position vector $\mathbf{r}$ m, where

$$\mathbf{r} = (t^4 + 8t^2)\mathbf{i} + (6t^2 - 2t^{\frac{3}{2}})\mathbf{j}$$

- (a) Find the velocity of P when P is moving in a direction parallel to the vector $\mathbf{j}$

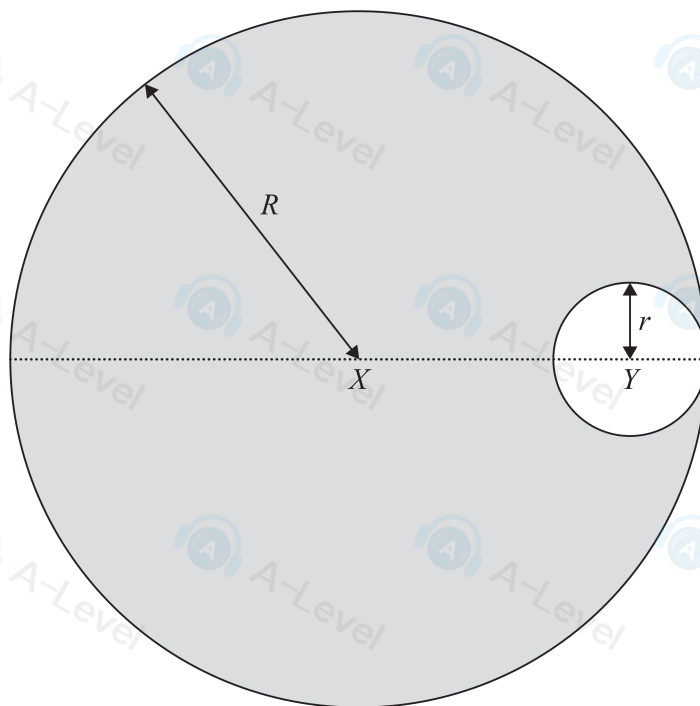
(4)

- (b) Find the acceleration of P when $t = 4$

(3)



3.

**Figure 1**

A uniform circular disc C has centre X and radius R .

A disc with centre Y and radius r , where $0 < r < R$ and $XY = R - r$, is removed from C to form the template shown shaded in Figure 1.

The centre of mass of the template is a distance kr from X .

(a) Show that $r = \frac{k}{1-k}R$ (4)

(b) Hence find the range of possible values of k . (2)

The point P is on the outer edge of the template and PX is perpendicular to XY .

The template is freely suspended from P and hangs in equilibrium.

Given that $k = \frac{4}{9}$

(c) find the angle that XY makes with the vertical. (3)

The mass of the template is M .

(d) Find, in terms of M , the mass of the lightest particle that could be attached to the template so that it would hang in equilibrium from P with XY horizontal. (3)



- (a) Find the value of R .

Later the cyclist cycles down the same road on the same bicycle. He is again working at a constant rate of 280 W and the resistance to motion is now modelled as a constant force of magnitude 60 N .

- (b) Find the acceleration of the cyclist at the instant when his speed is 3.5 m s^{-1} .

(4)



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- $$\mathbf{v} = (6t^2 + 6t)\mathbf{i} + (3t^2 + 24)\mathbf{j}$$

Find

- (a) the value of T , (3)
- (b) the acceleration of P as it passes through the point A , (3)
- (c) the distance OA . (5)



- (5)

(5)

4.

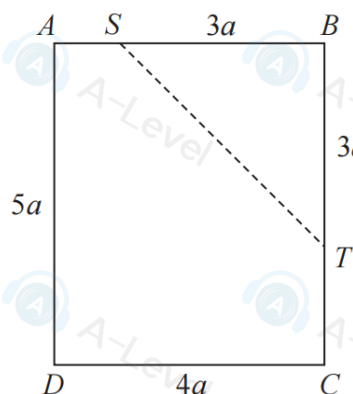


Figure 2

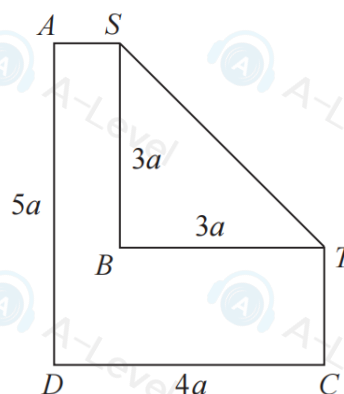


Figure 3

The uniform rectangular lamina $ABCD$, shown in Figure 2, has $DC = 4a$ and $AD = 5a$.

The points S on AB and T on BC are such that $SB = BT = 3a$.

The lamina is folded along ST to form the folded lamina L , shown in Figure 3.

The distance of the centre of mass of L from AD is d .

- (a) Show that $d = \frac{71}{40}a$ (5)

The weight of L is $4W$. A particle of weight W is attached to L at C .

The folded lamina L is freely suspended from S .

A force of magnitude F , acting parallel to DC , is applied to L at D so that AD is vertical.

- (b) Find F in terms of W (4)



2. A van has mass 750 kg. The van is moving up a straight road at constant speed $U \text{ m s}^{-1}$

The road is inclined to the horizontal at an angle θ , where $\sin \theta = \frac{1}{15}$

The resistance to the motion of the van from non-gravitational forces is modelled as a single force of magnitude $30U$ newtons. The engine of the van is working at a constant rate of 16 kW.

Find the value of U .

(5)

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- (c) Find, in terms of d and u , the time interval between the collision at A and the collision at B .

- (6)

(5)