
CHAPTER 3 – DYNAMICS (NUMERICALS)

Q1.

Calculate the torque acting on a spanner of length 20 cm to loosen a nut by applying a force of 50 N. If the same nut is to be loosened by a force of 100 N, what should be the length of the spanner?

Part (a): Torque calculation

Given Data:

Length of spanner

$$L_s = 20 \text{ cm} = 0.20 \text{ m}$$

Applied force

$$F = 50 \text{ N}$$

To Find:

Torque acting on the nut = ?

Explanation:

The turning effect of force is called torque.

We know that,

$$\tau = F \times r$$

where r is the perpendicular distance from the axis of rotation.

Solution:

$$\tau = 50 \times 0.20 \quad \tau = 10 \text{ N m}$$

Answer:

$$\boxed{10 \text{ N m}}$$

Part (b): Required length of spanner**Given Data:**

Torque required

$$\tau = 10 \text{ N m}$$

Applied force

$$F = 100 \text{ N}$$

To Find:

Length of spanner = ?

Explanation:

Using the same torque formula.

Solution:

$$r = \frac{\tau}{F} r = \frac{10}{100} r = 0.10 \text{ m} = 10 \text{ cm}$$

Answer:

10 cm

Q2.

A long uniform steel bar of length 1.0 m is balanced by a pivot at its middle. Two masses m_1 and m_2 are suspended at distances 0.2 m and 0.3 m respectively from the pivot. Ignoring the mass of the bar, find m_2 if $m_1 = 0.6 \text{ kg}$.

Given Data:

Mass on left side

$$m_1 = 0.6 \text{ kg}$$

Distance from pivot

$$d_1 = 0.2 \text{ m}$$

Distance from pivot (right side)

$$d_2 = 0.3 \text{ m}$$

To Find:Mass $m_2 = ?$

Explanation:

For a body in equilibrium, clockwise moment equals anticlockwise moment.

We know that,

$$m_1gd_1 = m_2gd_2$$

Solution:

$$0.6 \times 0.2 = m_2 \times 0.3 \quad m_2 = \frac{0.12}{0.3} m_2 = 0.4 \text{ kg}$$

Answer:

$$\boxed{0.4 \text{ kg}}$$

Q3.

Two masses of 250 g and 100 g are hanging at positions 65 cm and 80 cm respectively on a uniform meter rod pivoted at the 50 cm mark. Where should a third mass of 400 g be placed to balance the rod?

Given Data:

Pivot position

$$x_p = 50 \text{ cm}$$

Masses and positions:

$$m_1 = 250 \text{ g}, \quad d_1 = 65 - 50 = 15 \text{ cm}$$

$$m_2 = 100 \text{ g}, \quad d_2 = 80 - 50 = 30 \text{ cm}$$

Third mass

$$m_3 = 400 \text{ g}$$

To Find:

Position of third mass = ?

Explanation:

For balance, total clockwise moment = total anticlockwise moment.

Solution:

Clockwise moment:

$$(250 \times 15) + (100 \times 30) = 3750 + 3000 = 6750$$

Let distance of 400 g mass from pivot = x

$$400 \times x = 6750 \quad x = 16.9 \text{ cm}$$

Position from left end:

$$50 - 16.9 = 33.1 \text{ cm}$$

Answer:

$$\boxed{33.1 \text{ cm}}$$

Q4.

A car of mass 1200 kg enters a roundabout of diameter 60 m at a speed of 25 km/h. Calculate the centripetal force acting on the car.

Given Data:

Mass of car

$$m = 1200 \text{ kg}$$

Diameter

$$D = 60 \text{ m} \Rightarrow r = 30 \text{ m}$$

Speed

$$v = 25 \text{ km/h} = 6.94 \text{ m/s}$$

To Find:

Centripetal force = ?

Explanation:

For circular motion, centripetal force is given by:

$$F_c = \frac{mv^2}{r}$$

Solution:

$$F_c = \frac{1200 \times (6.94)^2}{30} = 693.3 \text{ N}$$

Answer:

693.3 N

Q5.

A geostationary satellite revolves around the Earth in an orbit of radius 42,000 km. Find the orbital speed of the satellite.

Given Data:

Orbital radius

$$r = 42,000 \text{ km} = 4.2 \times 10^7 \text{ m}$$

Orbital period

$$T = 24 \text{ hours} = 86400 \text{ s}$$

To Find:

Orbital speed = ?

Explanation:

Orbital speed is given by:

$$v = \frac{2\pi r}{T}$$

Solution:

$$v = \frac{2 \times 3.14 \times 4.2 \times 10^7}{86400} \quad v = 3052 \text{ m/s} \quad v = 3.052 \text{ km/s}$$

Answer:

3.052 km/s
