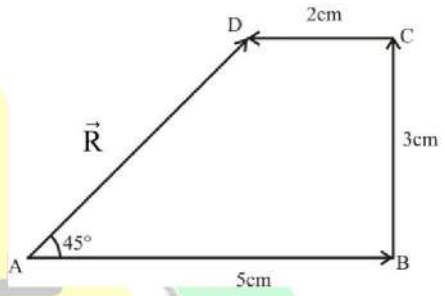
UNIT 4
TURNING EFFECT OF FORCE

PROBLEMS

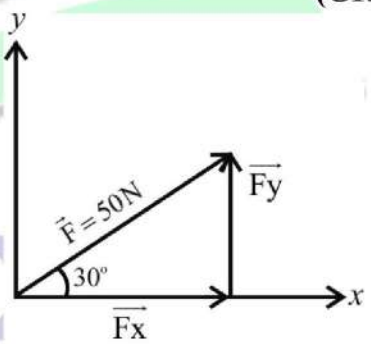
4.1 Find the resultant of the following forces.
(i) 10 N along x – axis
(ii) 6 N along y – axis
(iii)4 N along negative x – axis



Solution

Scale 2N = 1cm
10N = 5cm
6N = 3cm
4N = 2cm

4.2 Find the rectangular components of a force of 50 N making an angle of 30^0 with x – axis. (GRW 2015)



Given Data

Force = F = 50 N
Angle = $\theta = 30^0$

Required

Horizontal component of force = F_x = ?
Vertical component of force = F_y = ?

Solution

As we know that

$F_x = F \cos\theta$

By putting the values, we have

$F_x = 50 \times \cos 30^0$
$F_x = 50 \times 0.866$
$F_x = 43.3$ N

Also we know that

$F_y = F \sin\theta$
$F_y = 50 \times \sin 30^0$
$F_y = 50 \times 0.5$
$F_y = 25$ N

Result

Horizontal component of force = F_x = 43.3 N
Vertical component of force = F_y = 25 N

4.3 Find the magnitude and direction of a force. If its x – component is 12 N and y – component is 5 N. (GRW 2013)

Given Data

X – component of the force = F_x = 12N

Y – component of the force = F_y = 5N

Required

Magnitude of the resultant force = F =?

Direction of the resultant force = θ =?

Solution

According to Pythagoras theorem

$$F = \sqrt{F_x^2 + F_y^2}$$

By putting the values, we have

$$F = \sqrt{(12)^2 + (5)^2}$$
$$F = \sqrt{144 + 25}$$
$$F = \sqrt{169}$$
$$F = 13N$$

We also know that

$$\theta = \tan^{-1} \frac{F_y}{F_x}$$

By putting the values, we have

$$\theta = \tan^{-1} \frac{5}{12}$$
$$\theta = \tan^{-1} 0.4166$$
$$\theta = 22.6^o \text{ with x-axis}$$

Result

Magnitude of the resultant force = F = 13 N

Direction of the resultant force = θ = 22.6° with x-axis

4.4 A force of 100 N is applied perpendicularly on a spanner at a distance of 10 cm from a nut. Find torque produced by the force. (GRW 2013, 2014, 2015)

Given Data

Force acting on spanner = F = 100 N

Distant from nut = L = 10 cm = 0.1 m

Required

Torque produced by the force = τ = ?

Solution

As we know that

$$\tau = F \times L$$

By putting the values, we have

$$\tau = 100 \times 0.1$$
$$\tau = 10 \text{ Nm}$$

Result

Torque produced by the force = τ = 10 Nm

4.5 A force is acting on a body making an angle of 30^0 with the horizontal. The horizontal component of force is 20 N. Find the force. (LHR 2015)

Given Data

Horizontal component of the force = F_x = 20 N

Angle formed with the horizontal = θ = 30^0

Required

Force applied = F = ?

Solution

As we know that

$$F_x = F\cos\theta$$

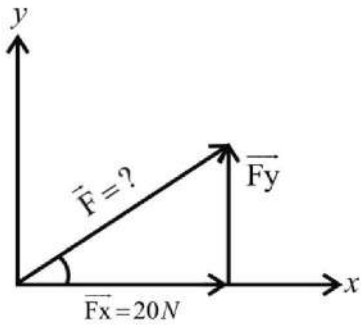
So $$F = \frac{F_x}{\cos\theta}$$

By putting the values, we have

$$F = \frac{20}{\cos 30^0}$$

$$F = \frac{20}{0.866}$$

$$F = 23.09\ N = 23.1\ N$$



Result

Force applied = F = 23.1 N

4.6 The steering of a car has a radius 16 cm. Find the torque produced by a couple of 50 N. (LHR 2013, 2014, 2015)

Given Data

Force of the couple = F = 50 N
Radius of the steering = r = 16cm
Couple arm = d = AB = 32 cm = 0.32 m

Required

Torque produced by the couple = τ = ?

Solution

As we know that

$$\tau = F \times AB$$

By putting the values, we have

$$\tau = 50 \times 0.32$$

$$\tau = 16\ Nm$$

Result

Torque produced by the couple = τ = 16 Nm

4.7 A picture frame is hanging by two vertical strings. The tensions in the strings are 3.8 N and 4.4 N. Find the weight of the picture frame.

Given Data

Tension in the first string = T_1 = 3.8 N
Tension in the second string = T_2 = 4.4 N

Required

Weight of the picture frame = w = ?

Solution

From first condition of equilibrium, we have

$$\sum F_y = 0$$

OR Sum of downward forces = Sum of upward forces

$$w = T_1 + T_2$$

By putting the values, we have

$$w = 3.8\ N + 4.4\ N$$

$$w = 8.2\ N$$

Result

Weight of the picture frame = w = 8.2 N

4.8 Two blocks of 5 kg and 3 kg are suspended by the two strings are shown. Find the tension in each string.

Given Data

Mass of upper block = m_1 = 5 kg
Mass of below block = m_2 = 3 kg
Weight of the upper block = $w_1 = m_1 g = 5 \times 10 = 50$ N
Weight of the below block = $w_2 = m_2 g = 3 \times 10 = 30$ N

Required

Tension in upper string = T_1 = ?
Tension in lower string = T_2 = ?

Solution

From second condition of equilibrium, we have

$$\sum F_y = 0$$

OR Tension in the lower string = weight of the lower block

$$T_2 = w_2$$
$$T_2 = 30 \text{ N}$$

Tension in upper string = weight of lower block + weight of upper block

$$T_1 = w_1 + w_2$$
$$T_1 = 50 \text{ N} + 30 \text{ N}$$
$$T_1 = 80 \text{ N}$$

Result

Tension in upper string = T_1 = 80 N
Tension in lower string = T_2 = 30 N

4.9 A nut has been tightened by a force of 200 N using 10 cm long spanner. What length of spanned is required to loosen the same nut with 150 N force?

(LHR 2013, GRW 2014)

Given Data

Initial force = F_1 = 200 N
Initial moment arm = L_1 = 10 cm = 0.1 m
Second force = F_2 = 150 N

Required

Second moment arm = L_2 = ?

Solution

According to second condition of equilibrium, we have

$$\sum \tau = 0$$

OR Clockwise torque = Anticlockwise torque

$$F_2 \times L_2 = F_1 \times L_1$$
$$150 \times L_2 = 200 \times 0.1$$
$$L_2 = \frac{200 \times 0.1}{150}$$
$$L_2 = 0.133 \text{ m}$$
$$L_2 = 13.3 \text{ cm}$$

Result

Second moment arm = L_2 = 13.3 cm

4.10 A block of 10 kg is suspended at a distance of 20 cm from the centre of uniform bar 1m long. What force is required to balance it at its centre of gravity by applying the force at the other end of the bar?

Given Data

Mass of block = m = 10kg
Weight of the block = w = F_1= mg = 10 x 10 = 100 N
First moment arm = L_1 = 20 cm = 0.2 m
Second moment arm = L_2 = 50 cm = 0.5 m

Required

Second force = F_2 = ?

Solution

According to second condition of equilibrium, we have

$$\sum \tau = 0$$

OR Clockwise torque = Anticlockwise torque

$$F_2 \times L_2 = F_1 \times L_1$$
$$F_2 \times 0.5 = 100 \times 0.2$$

$$F_2 = \frac{100 \times 0.1}{0.50}$$

$$F_2 = 40 \text{ N}$$

Result

Second force = F_2 = 40 N