CH # 6 EQUILIBRIUM

Some important formulae:

i) $\tau = F \times d$

ii) $T = \dfrac{2m_1 m_2 g}{m_1 + m_2}$

6.1: A force of 25N acts on a body. If moment arm is 2m, find the value of torque.

GIVEN:
Force = F = 25N
Moment arm = d = 2m

REQUIRED:
Value of torque = τ = ?

SOLUTION:

Torque = Force x moment arm

$\tau = F \times d$

$\tau = 25 \times 2$

τ = 50Nm

6.2: A force is applied perpendicular on a door, 4 meter wide which requires a torque of 120N-m to open it. What will be the minimum force required.

GIVEN:
Value of torque = τ = 120Nm
Moment arm = d = 4m

REQUIRED:
Force = F = ?

SOLUTION:
Torque = Force x moment arm

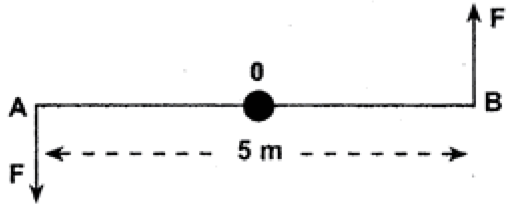
$\tau = F \times d$

$120 = F \times 4$

$F = \dfrac{120}{4}$

F = 30N

6.3: What is the moment of couple of 10N acting at the extremist of a rod 5m long, as shown in figure. How can this couple be balanced.

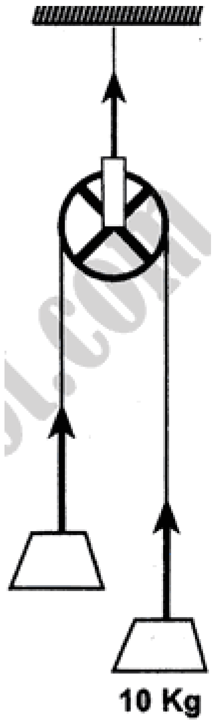


GIVEN:
Force = F = 10N
Arm of couple = AB = 5m

REQUIRED:
Moment of couple = ?

SOLUTION:
Moment of couple = F x AB
Moment of couple = 10 x 5
Moment of couple = 50Nm counter clockwise

6.4: Two 10Kg masses are suspended at the two ends of a rope which passes over light and frictionless pulley. The pulley is attached to the chain which goes to the ceiling, as shown in figure. What is the tension in a (a) Rope (b) Chain?



GIVEN:
Masses = $m_1 = m_2$ = 10Kg

REQUIRED:
Tension in the rope = ?
Tension in the chain = ?

SOLUTION:

$$\text{(a) Tension in the rope } = \text{T} = \frac{2m_1 m_2 g}{(m_1 + m_2)}$$

$$\text{T} = \frac{2 \times 10 \times 10 \times 9.8}{(10 + 10)}$$

$$\text{T} = \frac{1960}{20}$$

T = 98 N

(b) Tension in chain = Weight of the bodies
Tension in chain = W = mg

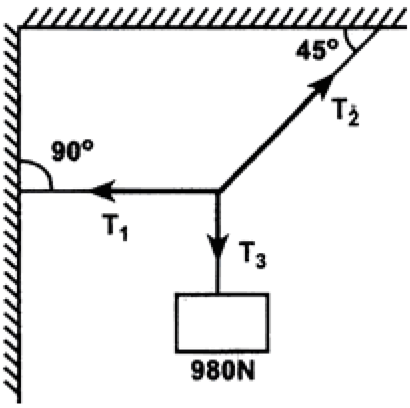
Tension in chain = $(m_1 + m_2)$ g

Tension in chain = (10 + 10) 9.8

Tension in chain = 20 x 9.8

Tension in chain = 196N

6.5: Find the tension in each cord in Figure. If the weight suspended body is 980N.



GIVEN:

Weight of block = W = 980N

Angle of chord from ceiling = θ = 45^0

REQUIRED:

Tension in first chord = T_1 = ?

Tension in second chord = T_2 = ?

Tension in third chord = T_3 = ?

SOLUTION:

Tension in 2nd chord,

$T_{2x} = T_2COS45^0$

$T_{2Y} = T_2Sin45^0$

According to first condition of equilibrium,

ΣFx = 0

$T_2COS45^0 – T_1 = 0$

$0.707T_2 – T_1 = 0$

$T_1 = 0.707T_2$ - - - - - - (1)

ΣFY = 0

$T_2Sin45^0 – W = 0$

$0.707T_2 – 980 = 0$

$0.707T_2 = 980$

$$T_2 = \frac{0.707}{980}$$

T_2 = 1386N

Put it in equation,

T_1 = 0.707(1386)

T_1 = 980N

Consider force along Y-axis,

ΣFy = 0

$T_3 – W = 0$

$T_3 – 980= 0$

T_3 = 980N

6.6: A painter weighing 150N is standing on a uniform plank 10m long at a distance 2m from one end of the plank. The weight of the plank is 50N and it is supported by two ropes at the ends, as shown in

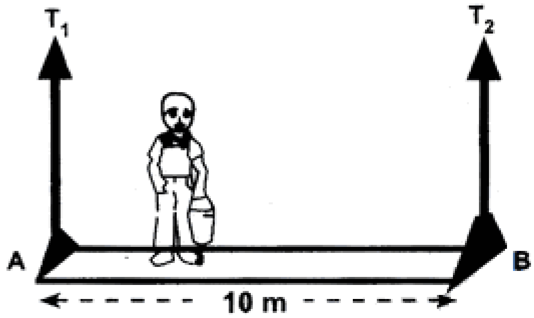


figure. Find the tension in the ropes.

GIVEN:

Weight of painter = W = 150N

Length of plank = l = 10m

Distance between painter and point A = 2m

Weight of plank = W = 50N

REQUIRED:

Tension in ropes T_1 and T_2 = ?

SOLUTION:

The plank is in equilibrium take the force of gravity at the center of the plank. No force acting along axis.

ΣFx = 0 and ΣFy = 0

$T_1 + T_2 – 50 – 150 = 0$

$T_1 + T_2 – 200 = 0$

$T_1 + T_2 = 200$ - - - - - - - - (1)

Στ = 0

T_1 x 5 + 150 x 3 + T_2 – 5 = 0

$5T_1 + 450 – 5T_2 = 0$

$5T_1 – 5T_2 = – 450$ - - - - - - - - (2)

Multiplying equation (1) by ‘5’ we have,

$5T_1 + 5T_2 = 1000$ - - - - - - - - (3)

Now by adding equation (ii) and (iii),

$5T_1 – 5T_2 = – 450$

$5T_1 + 5T_2 = 1000$

$10T_1$ = 550

$$T_1 = \frac{550}{10}$$

T_1 = 55N

Put the value of T_1 in equation (1),

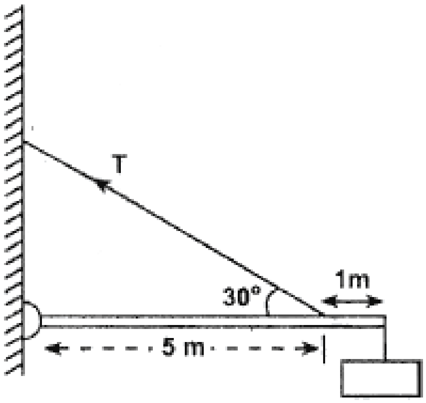
$T_1 + T_2 = 200$

$55 + T_2 = 200$

$T_2 = 200 – 55$

T_2 = 145N

6.7: Find the tension in the cables and the components of the forces exerted on the beam by the wall in figure. The weight of the beam is 300N.



GIVEN:

Weight of beam = W_1 = 300N

Weight at the end of beam = W_2 = 300N

Distance between wall and point A = OA = 5m

Distance between point A and B = AB = 1m

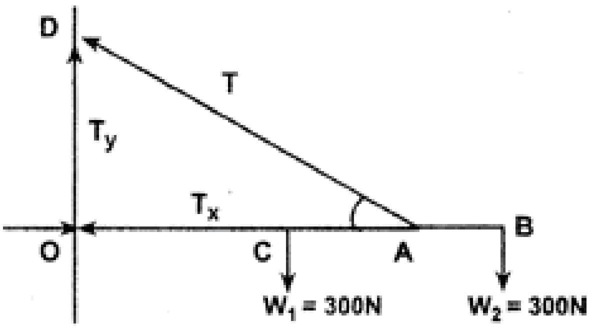
Length of the beam = OB = OA + AB = 5 + 1 = 6m

Weight of the beam act at the center = OC

$$= \frac{OB}{2} = \frac{6}{2} = 3m$$

REQUIRED:

Tension in the cable = T = ?



Horizontal component of the force exerted on the beam by the wall = H = ?

Vertical component of the force exerted on the beam by the wall = V = ?

SOLUTION:

By applying first condition of equilibrium,

ΣFx = 0

H – Tx = 0

H = Tx - - - - - - - - - - (1)

Similarly,

ΣFy = 0

$Ty + V – W_1 – W_2 = 0$

Ty + V – 300 – 300 = 0

Ty + V – 600 = 0

Ty + V = 600

V = 600 – Ty - - - - - - - - - - (2)

Applying the second condition of equilibrium,

Στ = 0

$W_1 \times \overrightarrow{OC} + W_2 \times \overrightarrow{OB} – Ty \times \overrightarrow{OA} = 0$

300 x 3 + 300 x 6 – Ty x 5 = 0

900 + 1800 – 5Ty = 0

2700 – 5Ty = 0

5Ty = 2700

$$Ty = \frac{2700}{5}$$

Ty = 540N - - - - - - - - (3)

Put the value Ty in equation (2),

V = 600 – 540

V = 60N

Consider ΔOBD,

Tx = TCOSθ - - - - - - (4)

Ty = TSinθ - - - - - - -(5)

Take the value of Ty from equation (3) and put in equation (5),

540 = TSin(30)

540 = T (1/2)

T = 540 x 2

T = 1080N

Put it in equation (4)

Tx = (1080)Cos(30)

Tx = 1080 x 0.866

Tx = 935.28N

Put it in equation (1),

H = 935.28N

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