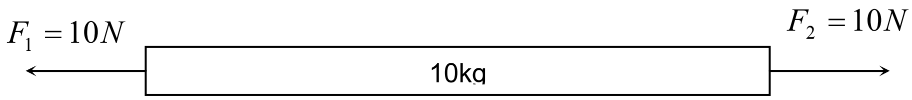
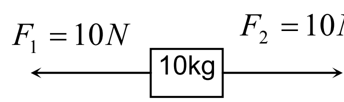
So far we have discussed two types of equilibria, **static** and **dynamic**. In both of these circumstances, the net forces sum to zero.

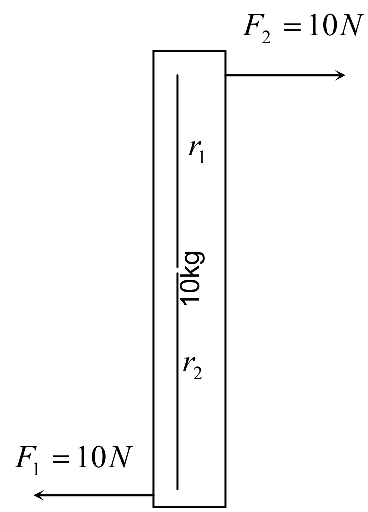
Consider the following static equilibrium.



One can that the system willl not accelerate based on the FBD



Consider the follow situation. Although the net force on the system is zero, the system will rotate. In this situation the forces are in equilibrium but the system will experience angular acceleration. This type of motion is cause by forces that tend to cause rotation. This is **Torque**



Torque is defined by the following equation

$\tau = \vec{r} \times \vec{F}$. Where τ is the torque in $N \cdot m$, r this length between the force and the center of gravity and is in m and F is in N

This is formula uses what is called the *cross product*. The mathematical technique to solve the cross product between two vectors is beyond the scope of this course so we will use the follow formula.

$\tau = r \cdot F \sin\theta$.

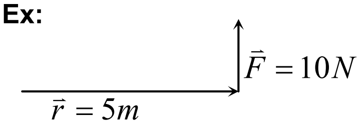
This formula implies that r and F must be at right angles in order to achieve maximum torque.

Note: By convention, torque is defined to be **positive** if the force **tends** to rotate the system in a **counter clockwise** direction or **negative** if the rotation **tends** to be **clockwise.**

$+\tau = [ccw]$

$-\tau = [cw]$

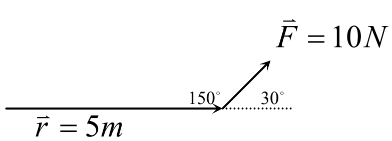
Ex:



$\tau = \vec{r} \times \vec{F}$ or $\tau = r \cdot F \sin\theta$ or $\tau = r_\perp \cdot F$

$$\begin{aligned} \tau &= (5)(10) \\ &= 50N \cdot m \\ \vec{\tau} &= +50N \cdot m \\ &\quad or \\ \vec{\tau} &= 50N \cdot m[ccw] \end{aligned}$$

Ex2 :



$\tau = \vec{r} \times \vec{F}$ or $\tau = r \cdot F \sin\theta$

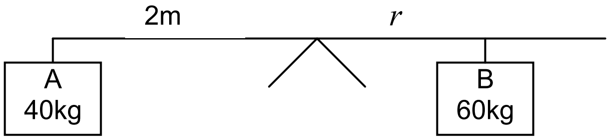
$\tau = r \cdot F \sin\theta$

$$\begin{aligned} \tau &= (5)(10)\sin(30^\circ) \\ &= 25N \cdot m \\ \vec{\tau} &= +25N \cdot m \\ &\quad or \\ \vec{\tau} &= 25N \cdot m[ccw] \end{aligned}$$

Problems:

1.

$m_{plank} = 20kg$

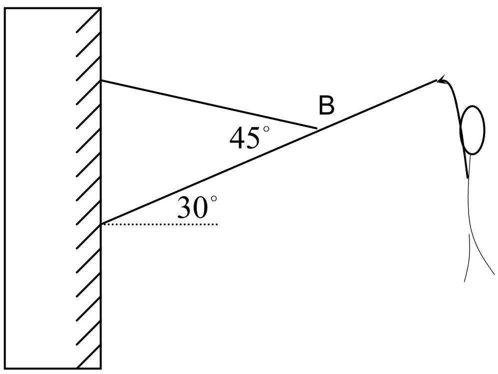


The teeter-totter is in static equilibrium and is not rotating

a) Find r
b) Find F_N

2. An 80kg man is walking on a 10m long wood plank that has a mass of 100kg. If the last 3m of the plank hangs over an edge, how far can he walk out before it tips over?

3. A stranded window washer of mass 80kg, hangs from the end of a 20kg flag pole as seen below. The flag pole is attatched to the wall by a pin. The pole is 12m long and is held up by a cable 4.0m from the end of the pole.

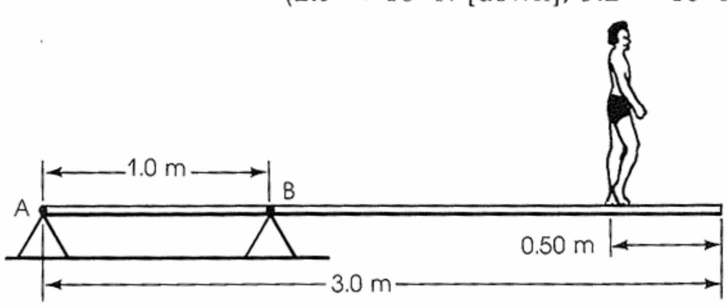


<u>Find</u>

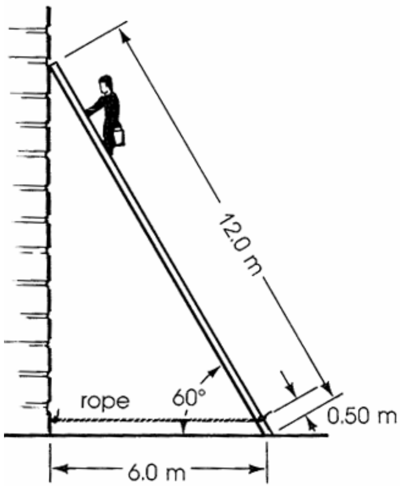
a) Tension in the cable
b) F_V and F_H at the pin

4.

A 3.0 m diving board with a mass of 26 kg is fastened securely at two points A and B, as illustrated. If a 46 kg diver stands 0.50 m from the end, find the forces at A and B.
(2.5×10^3 N [down], 3.2×10^3 N [up])



5.



A 12.0 m ladder, whose mass is 20 kg, is leaning against a wall, with its base 6.0 m from the wall and at a slope of 60° to the floor. Because both the wall and the floor are frictionless, a rope is tied horizontally 0.50 m from the bottom of the ladder to the wall. A 72 kg plasterer climbs three-quarters of the way up the ladder and stops. What is the tension in the rope and what are the reactive forces at the wall and the floor?

(3.8×10^2 N; 3.8×10^2 N, 9.0×10^2 N)

6.

One end of a meter stick is placed against a vertical wall, as in Fig. 3–22. The other end is held by a light cord making an angle θ with the stick. The coefficient of static friction between the end of the meter stick and the wall is 0.30.

a) What is the maximum value the angle θ can have if the stick is to remain in equilibrium?

b) Let the angle θ be 10°. A body of the same weight as the meter stick is suspended from the stick as shown by dotted lines, at a distance x from the wall. What is the minimum value of x for which the stick will remain in equilibrium?

c) When θ = 10°, how large must the coefficient of static friction be so that the body can be attached at the left end of the stick without causing it to slip?

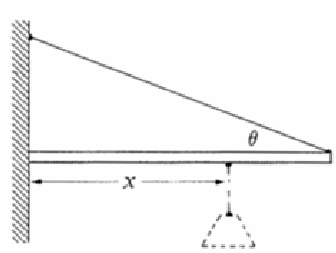


Fig. 3–22