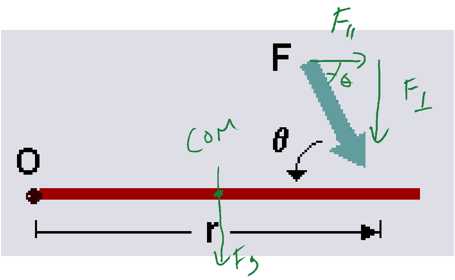
Torques

October 15, 2015 4:30 PM

***Torque* is a measure of how much a force acting on an object causes that object to rotate.** The object rotates about an axis, which we will call the **pivot point**. The distance from the pivot point to the point where the force acts is called the **moment arm.**



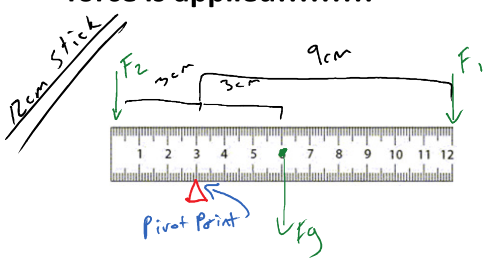
$\tau = r \times F_{\perp}$

r: distance to the pivot point

Torque is defined as **τ = r × F⊥ = r·Fsin(Θ)**

The S.I. unit for torque is **N·m**. (it is a vector)

r is the distance from the pivot point to where the force is applied!!!!!!!!!



The rulers mass is 400 grams. $F_1 = 30$ N. What is F_2 if this ruler is in equilibrium.

$\Sigma \tau_{ccw} = \Sigma \tau_{cw}$

$F_2 \cdot (0.03) = F_g \cdot (0.03) + F_1 \cdot (0.09)$

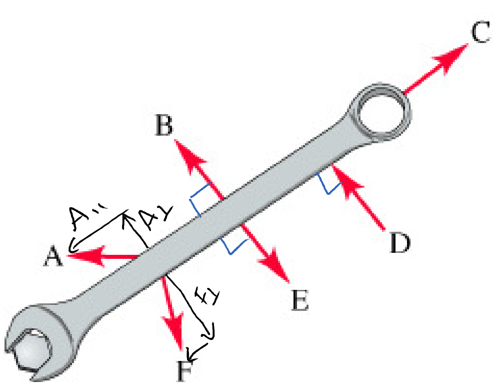
$F_2 = \dfrac{(0.4)(9.8)(0.03) + 30 \cdot (0.09)}{0.03}$

$F_2 = 94$ N

The **moment arm's** center of gravity/mass is located at the center, assuming the object is uniform in density. That is $C_{of}G$ is length/2.

Rank these forces (A through F) on the basis of the magnitude (FROM SMALLEST TO LARGEST) of the torque they apply to the wrench, measured about an axis centered on the bolt.

Assume all forces are equal



Smallest

F_C

F_A

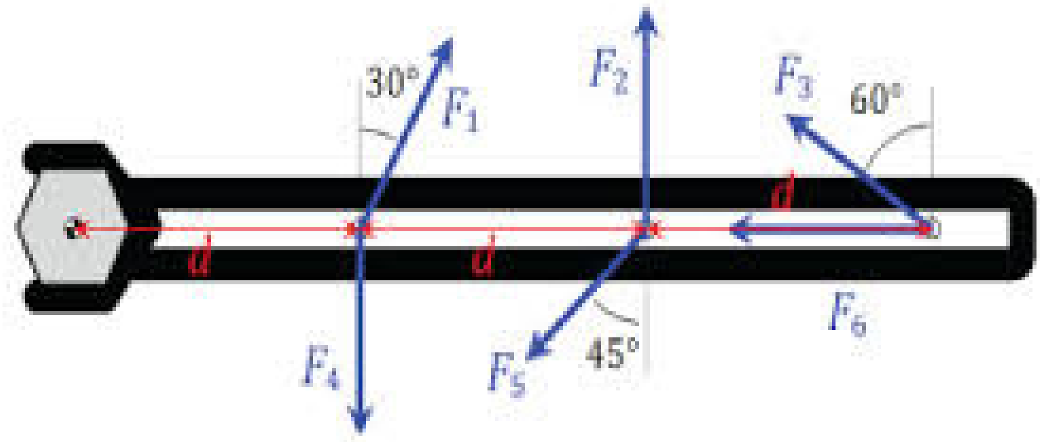
F_F

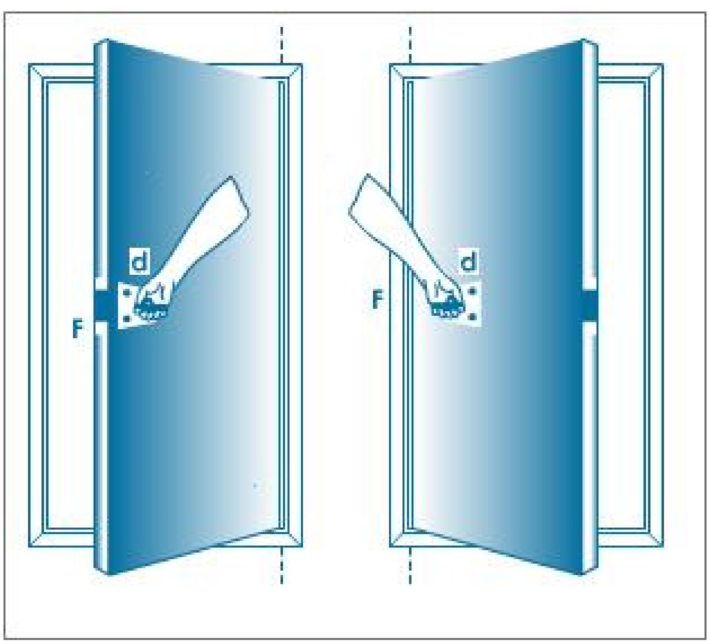
F_B, F_E

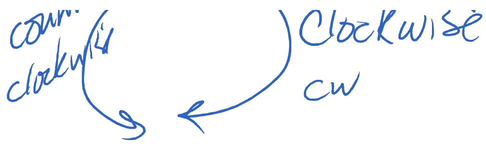
F_D

Largest

Rank these forces on the basis of the magnitude (FROM SMALLEST TO LARGEST) of the torque they apply to the wrench, measured about an axis centered on the bolt.

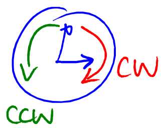


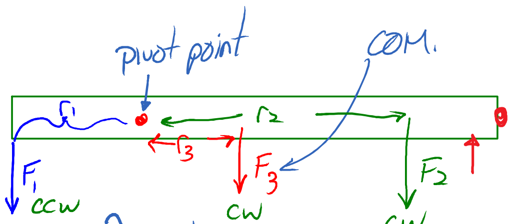




2nd Condition of Equilibrium is $\sum \tau = 0$

$\sum \tau_{clockwise} = \sum \tau_{counterclockwise}$

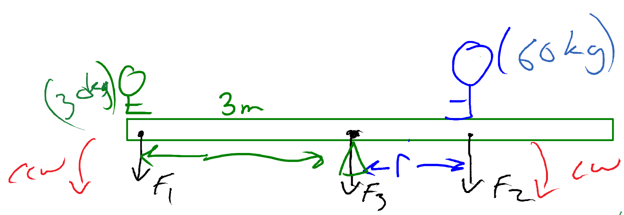




$\tau_{CW} = \tau_{CCW}$

$r_1 \cdot F_1 = r_2 \cdot F_2 + r_3 \cdot F_3$ (if this works, it doesn't spin)

ex)



Find r to keep the 6m beam balanced (assume a massless beam)

$\sum \tau_{ccw} = \sum \tau_{cw}$

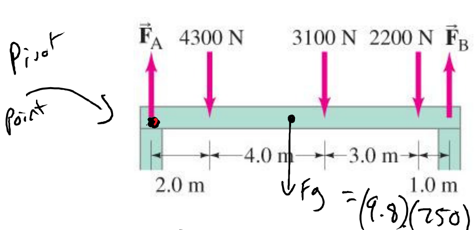
$F_1 r_1 = F_2 r_2$

$(30)(9.8)(3) = (60)(9.8) r$

$\frac{(30)(3)}{60} = \frac{60 r}{60}$

$1.5m = r$

Calculate F_A and F_B for the 250 kg beam shown below.



From our first law

$\sum F_y = 0$

$F_A + F_B - 4300 - 3100 - 2200 - F_g = 0$

$F_A + F_B = 12050$

Second Law

$\sum \tau_{ccw} = \sum \tau_{cw}$

$F_B \cdot (10) + F_A (0) = (4300)(2) + (9.8)(250)(5) + (3100)(6) + (2200)(9)$

$\frac{10 F_B}{10} = \frac{59250}{10}$

$F_B = 5925 N$

You can pick where the pivot point goes. But, be smart about it.

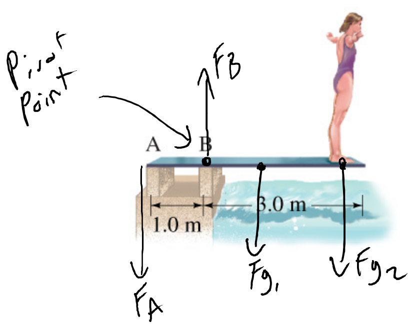
Try to eliminate an unknown force.

$F_A + F_B = 12050$ ← Sub

$F_A + 5925 = 12050$

$F_A = 6125\text{ N}$

Calculate the forces A and B that the supports exert on the 35-kg diving board when a 60-kg person stands at its tip.



$\sum \tau_{ccw} = \sum \tau_{cw}$

$F_A(1) = F_{g_1}(1) + F_{g_2}(3)$

$F_A = (35)(9.8)(1) + (60)(9.8)(3)$

$F_A = 2107\text{ N}$ down

$\sum F_y = 0$

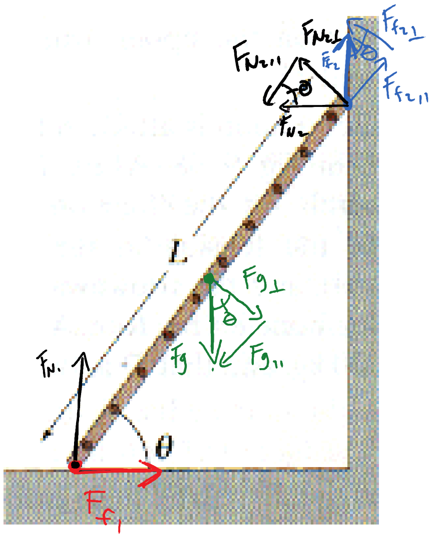
$F_B - F_A - F_{g_1} - F_{g_2} = 0$

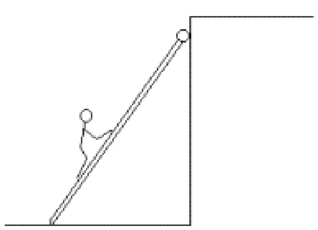
$F_B = F_A + (35)(9.8) + (60)(9.8)$

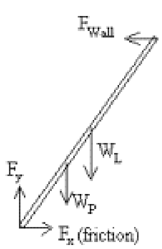
$F_B = F_A + 931$

$F_B = 2107 + 931$

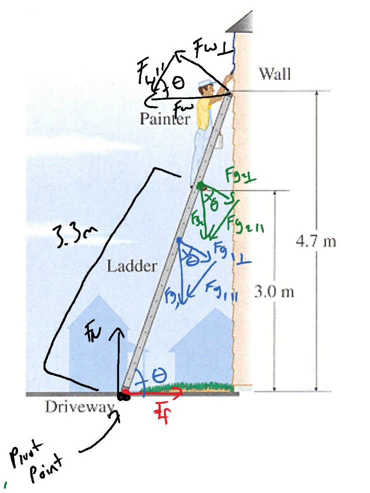
$F_B = 3038\text{ N}$ up







A house painter stands 3 m above the ground on a 5.1 m long ladder that leans against the wall at a point 4.7 m above the ground. The painter weighs 651 N and the ladder weighs 137 N. Assuming no friction between the house and the upper end of the ladder, find the force of friction that the driveway exerts on the bottom of the ladder. Magnitude in N



$\sin\theta = \frac{4.7}{5.1}$

$\theta = 67.2°$

$\sin 67.2 = \frac{3}{x}$

$x = 3.3\,m$

$F_{g_1\perp} = F_{g_1}\cos\theta = 137\cos(67.2)$

$F_{g_2\perp} = F_{g_2}\cos\theta = 651\cos(67.2)$

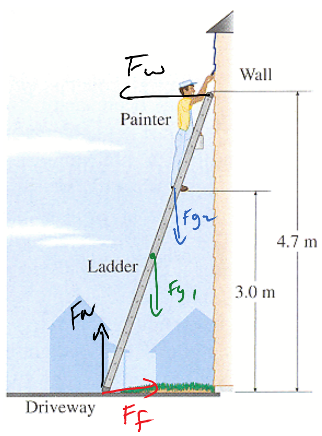
$F_{w\perp} = F_w \sin\theta = F_w \sin(67.2)$

$\Sigma\tau_{ccw} = \Sigma\tau_{cw}$

$F_{w\perp}(5.1) = F_{g_2\perp}(3.3) + F_{g_1\perp}\left(\frac{5.1}{2}\right)$

$F_w \sin(67.2)(5.1) = 651\cos(67.2)(3.3) + 137\cos(67.2)\left(\frac{5.1}{2}\right)$

$F_w = 206\,N$



$\Sigma F_x = 0$

$F_f - F_w = 0$

$F_f = F_w$

$F_f = 206\,N$ right

If the mass of the ladder is 12.0kg, the mass of the painter is 60.0kg, and the ladder begins to slip at its base when she is 70 percent of the way up the length of the ladder, what is the coefficient of static friction between the ladder and the floor? Again assume the wall is frictionless. A free-body diagram is shown in Fig. 9-63.

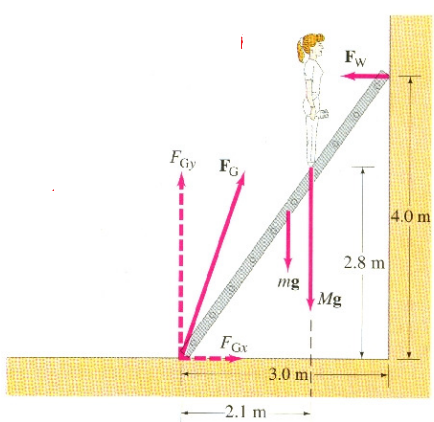


FIGURE 9–63 Problem 31.

An 8.3 m 270 N uniform ladder rests against a smooth wall. The coefficient of static friction between the ladder and the ground is 0.6, and the ladder makes a 50 degree angle with the ground. How far up the ladder can a 700 N person climb before the ladder begins to slip?