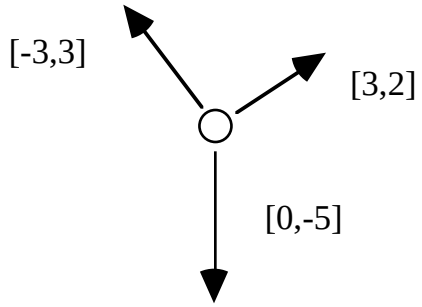
Phys12 Equilibrium : Notes-10

If a body is at equilibrium, then the sum of the forces on it equals zero. This assumes that all of the forces act through the **center of mass**.

If we have a book sitting on a table, it is said to be in **static equilibrium**. The net force on the book is zero. The downward force of gravity is equal and opposite to the upward **normal** force that is exerted by the table.

Another example is the one shown below. An object with a weight of 5 Newtons is supported by the two forces shown. The sum of the three forces equals zero. That is: [-3,3] + [3,2] + [0,-5] = [0,0].

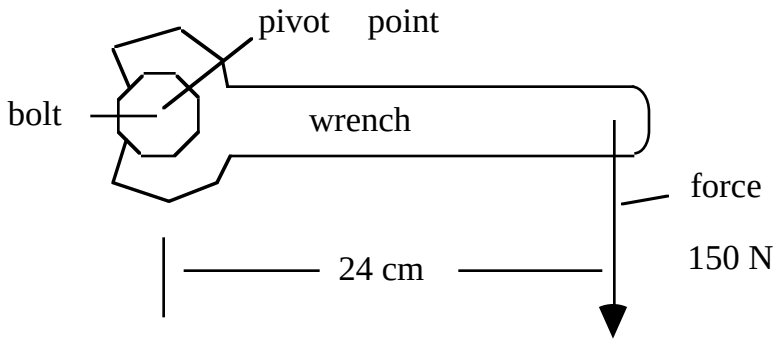


The sum (Σ sigma) of the X components equals zero. The same is true of the Y components. This is the first condition for static equilibrium. This is written mathematically as:

$$\sum F_x = 0 \qquad \text{and} \qquad \sum F_y = 0$$

These conditions hold even if the forces do not act through the center of mass.

If the forces do not act through the center of mass of a body, there are **torques** acting on the body. We apply a torque when we tighten a bolt with a wrench.



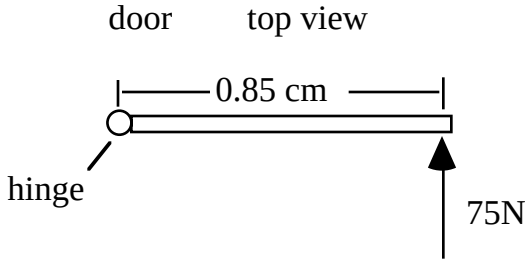
Using the arm, a torque is applied to the bolt. The torque (symbol τ tau) about the pivot point equals the perpendicular component of the force multiplied by the distance to the pivot point. The torque is 150x0.24 = -36 Nm. The units for torque are Newton-meters.

Torques can be negative (clockwise) or positive (counterclockwise). If the total torque is zero, there will be no rotation. The second condition for static equilibrium is:

$$\sum \tau = 0$$

Examples:

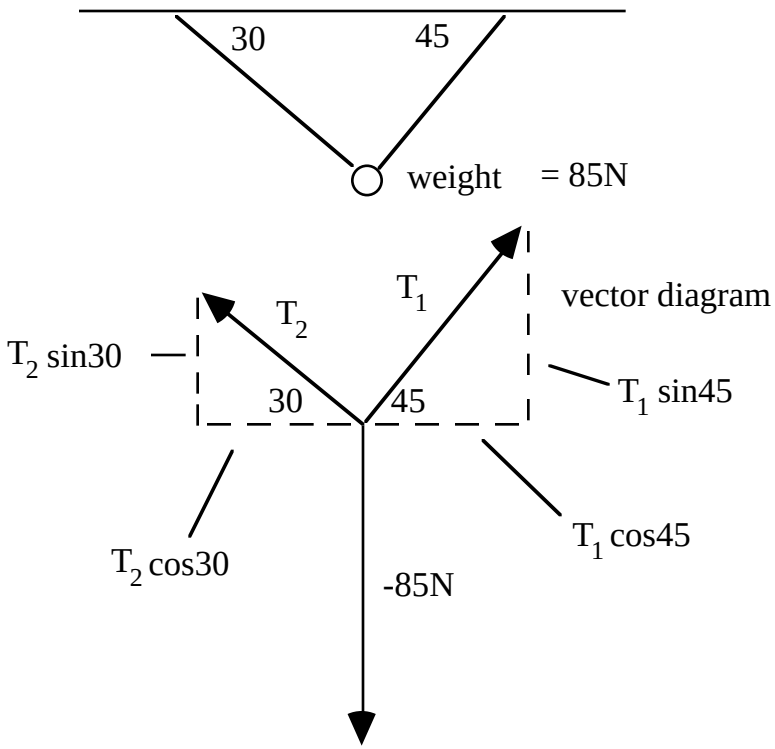
1)



torque = 75x0.85 = 64Nm

The torque above is counter clockwise and therefore positive. The net torque is 64Nm so the door will rotate.

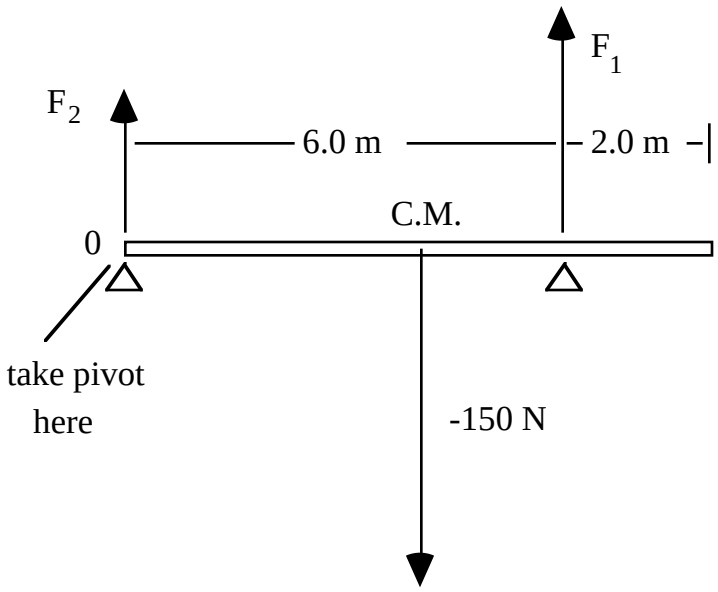
2) A ball is suspended by two wires as shown. Find the tensions in the two wires. The angles are given.



In the above situation, the ball is at equilibrium. There are no torques. All forces act through the center of mass.

The sum of the x components of the forces equals zero. So, $-T_2\cos30 + T_1\cos45 = 0$. The sum of the y components of the forces equals zero. So $T_2\sin30 + T_1\sin45 - 85N = 0$. These two equations for two unknowns can be solved for T_1 and T_2. $T_1 = 76N$ and $T_2 = 62N$.

3) The board has a weight of 150N and is at equilibrium. Find F_1 and F_2.



There are no x components of the forces. The sum of the y components is zero. $F_2 + F_1 - 150 = 0$. The sum of the torques is zero. We take the pivot at the left end. Therefore, $-150 \times 4.0 + F_1 \times 6.0 = 0$. $F_1 = 1.0 \times 10^2 N$. $F_2 = 50N$. It is important to note, that it doesn't matter where you take the pivot point. The answer will still be the same.