Physics 151 Class Exercise: Torque 1

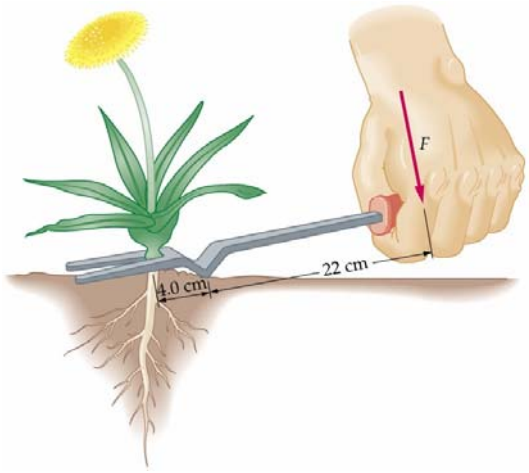
1. Straightforward Torque Problems

(a) A person slowly lowers a 3.3 kg crab trap over the side of a dock as shown. What torque does the trap exert about the person's shoulders?

To counteract the torque created by the weight of the trap (and neglecting the weight of the arm and rope), the torque exerted about the shoulder must be

$$\tau = r_{\perp} mg = (0.70\ \text{m})(3.3\ \text{kg})\left(9.81\ \frac{\text{m}}{\text{s}^2}\right) = \boxed{23\ \text{N}\cdot\text{m}}$$

(b) The gardening tool shown here is used to pull weeds. If a 1.23 N·m torque is required to pull a given weed, what force did the weed exert on the tool?



We need to think about Newton's third law here. If the tool is exerting a force on the weed, the week is exerting an equal and opposite force on the tool.

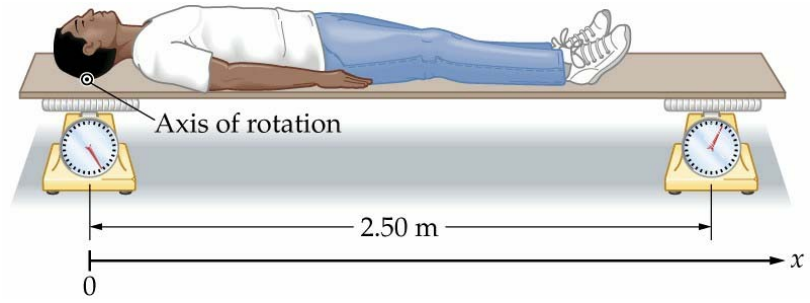
Just before the weed comes out, the system is in static equilibrium. So summing torques about the pivot point where the tool touches the ground yields:

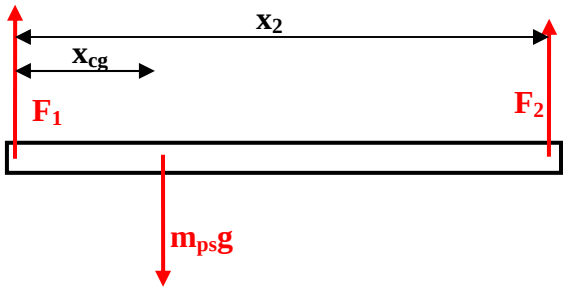
$$\sum \tau_{pivot} = F_{\text{w}}(0.040\ \text{m}) - 1.23\ \text{N}\cdot\text{m} = 0$$

$$F_{\text{w}} = \frac{1.23\ \text{N}\cdot\text{m}}{0.040\ \text{m}} = \boxed{31\ \text{N}}$$

Note that we are assuming that static equilibrium prevails. The force the gardener exerts on the tool and the force the weed exerts on the tool cause equal and opposite torques about the pivot. Thus, if the gardener pulled just a little bit harder the weed would come out.

2. To determine the location of this center of mass, a physics student lies on a lightweight plank supported by two scales 2.50 m apart as shown below. If the left scale reads 290 N, and the right scale reads 122N, find (a) the student's mass and (b) the distance from the student's head to his center of mass.





(a)

$$\sum F_y = F_1 + F_2 - mg = 0$$

$$m = \frac{F_1 + F_2}{g} = \frac{290\text{ N} + 122\text{ N}}{9.81\ \frac{\text{m}}{\text{s}^2}} = \boxed{42\text{ kg}}$$

(b)

$$\sum \tau_{leftend} = x_2 F_2 - x_{cg} mg = 0$$

$$x_{cg} = \frac{x_2 F_2}{mg} = \frac{(2.50\text{ m})(122\text{ N})}{(42\text{ kg})\left(9.81\ \frac{\text{m}}{\text{s}^2}\right)} = \boxed{0.74\text{ m}}$$