Worksheet rotation: angular dynamics solutions

**1.** What situation will result in the greatest torque? Circle the correct answer.

a) A force of 5N is applied in a way that results in there being no lever arm.

b) A force of 5N is applied in a way that results in there being a large level arm.

c) A force of 5N is applied in a way that results in there being a small lever arm.

**2.** A 40 kg boy and 30 kg girl are sitting on either end of a seesaw which is currently at equilibrium. The boy is sitting 3m from the pivot in the middle of the seesaw. How far away must the girl be sitting from the pivot in order for the system to maintain equilibrium?

$ΣF\_{x}=0$ $ΣF\_{y}=0=F\_{N}-F\_{gboard}-F\_{g girl}-F\_{g boy}$

As it turns out, only the torque equation was needed:

$$∑τ=0$$

$$τ\_{boy}- τ\_{girl}=0$$

$$τ\_{boy}=τ\_{girl}$$

$$F\_{g boy}l\_{boy}=F\_{g girl}l\_{girl}$$

$$m\_{boy} g l\_{boy}=m\_{girl} g l\_{girl}$$

$$l\_{girl}=\frac{m\_{boy} l\_{boy}}{m\_{girl}}=\frac{\left(40kg\right)\left(3m\right)}{30kg}=4m$$

**3.** A solid 11 kg cylinder is rotating about a central axis with an angular acceleration of 3.5 rad/s2. The radius of the cylinder is 0.2 m and the length of cylinder is 0.75 m. The equation for the moment of inertia for this geometrical scenario is $I=\frac{1}{2}mL^{2}$.

a) What torque is being applied to the cylinder?
$$τ=Iα=\frac{1}{2}mL^{2}α=\frac{\left(11kg\right)\left(0.75m\right)^{2}\left(3.5\frac{rad}{s^{2}}\right)}{2}=10.8Nm$$

b) What force (applied to the outer edge) is needed to result in such a torque?

The important insight here is that the lever arm is the distance between the axis of rotation and the line of action. Note that the axis of rotation is through the center of the cylinder and the line of action must be on the outer edge of the cylinder where the force is, thus the lever arm is the radius in this case.

$$τ=Fl\rightarrow F=\frac{τ}{l}=\frac{10.8Nm}{0.2m}=54.1N$$