Friday Warm Up: Unit 6: Fixed axis rotation

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1 Memory Bank

- $\vec{s} = \vec{\theta} \times \vec{r}$
- $\vec{v} = \vec{\omega} \times \vec{r}$
- $F_C = mr\omega^2$
- $\hat{i} \times \hat{j} = \hat{k}$, $\hat{k} \times \hat{i} = \hat{j}$, $\hat{j} \times \hat{k} = \hat{i}$
- $\hat{j} \times \hat{i} = -\hat{k}$, $\hat{i} \times \hat{k} = -\hat{j}$, $\hat{k} \times \hat{j} = -\hat{i}$
- $\hat{i} \times \hat{i} = 0$, $\hat{j} \times \hat{j} = 0$, $\hat{k} \times \hat{k} = 0$
- $\vec{\tau} = \vec{r} \times \vec{F}$ ... The relationship between *torque*, $\vec{\tau}$, the *moment arm*, $\vec{r}$, and the *force*, $\vec{F}$.

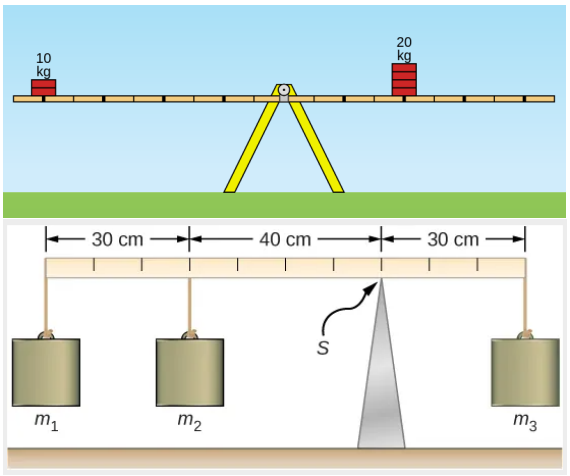

Figure 1: (Top) A balance between bricks of different masses. (Bottom) A torque balance.

2 Fixed Axis Rotation, and Torque

1. Suppose a vehicle takes a circular turn with $\vec{v} = 90\hat{j}$ km hr^{-1}. (a) If $\vec{r} = 110\hat{i}$ m, what is $\vec{\omega}$? (b) If $\vec{\omega} \to 2\vec{\omega}$, but $\vec{r}$ remains constant, what is $\vec{v}$?

2. Suppose a jet fighter complex a 180 degree turn in 15 seconds, with a turn radius of 1500 m. (a) What is the tangential velocity? (b) Suppose the motion circles the origin in the xy-plane. What is ω? (c) If the jet fighter weighs 19,500 kg, what is F_C?

3. Suppose a bolt needs to be unstuck from a flat bulkhead. Let the bolt be centered at the origin, and let the xy-plane represent the bulkhead. We must twist it *counterclockwise* to loosen it. (a) Suppose we have a wrench with length $\vec{r} = 5\hat{i} + 5\hat{j}$ cm attached to the bolt. If we push on the end of the wrench with $\vec{F} = -10\hat{i} + 10\hat{j}$ N of force, what is the *torque* we generate? (b) Why, physically, does the torque vector have the direction we find? (c) List two ways to generate more torque. (d) Sketch $\vec{r}$, $\vec{F}$, and $\vec{\tau}$ below.

4. Consider the balanced system in Fig. 1 (top). Calculate the net torque due to the masses, assuming a unit of distance along the balance.

5. Solve for the mass m_3 in Fig. 1 (bottom), if $m_1 = 50$ grams, $m_2 = 75$ grams, and the mass of the meter stick is 150 grams.