10/30 In Class – Torque, Rotational KE, and angular momentum

Summary

$$\tau = \vec{r} \times \vec{F} = rF\sin\theta = r_\perp F$$

$$\sum \tau = I\alpha$$

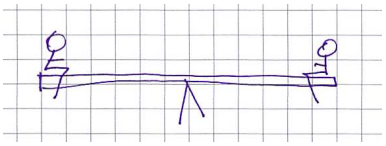
$$I = \sum m_i r_i^2$$

For solid objects, look up moments of inertia.

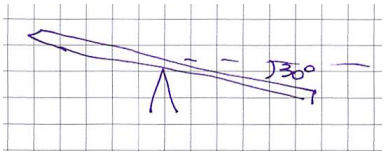
1. A teeter totter consists of a wood plank that is 3m long that is free to pivot around the middle. It starts out completely balanced (horizontally) and then at the same time, a 25kg child sits on the right end, and a 30kg child sits on the left end.

   (a) What torque do the two kids cause? Do you need to worry about the mass of the plank for this part?

   (b) The plank has a mass of 10kg, uniformly distributed. Look up its moment of inertia. What is the angular acceleration of the plank at that moment, when the plank is still horizontal?



2. Repeat the last problem, but assume the plank starts with the right end 30° below the horizontal.

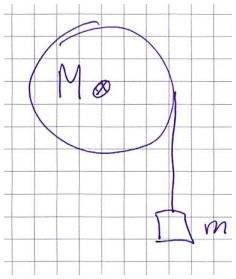


   Rotational Kinetic Energy

   You can use your translation table ($m \to I$ and $v \to \omega$) to get that rotational kinetic energy is $KE = \frac{1}{2}I\omega^2$ This is correct. If you have pure rotational motion (fixed axis of rotation), this is the only KE term you need.

3. A disk of mass 15 g and radius 10 cm spins at a constant rate of 33 rpm. What is its rotational kinetic energy?

4. A cylinder of mass 5kg and radius 25cm is wrapped with string. The cylinder is free to rotate around its center, but that center is fixed (kind of like the bicycle wheel bolted to the table). A 1.5 kg mass is tied to one end of the string. As the mass falls, the spool unwinds. Assume it starts from rest with the hanging mass (1.5kg) at a height of 2m above ground.



   (a) Use conservation of energy to find the speed of the mass just before it hits the ground.

   (b) Repeat using torque and then the rotational kinematic equations.

   Angular momentum, L

$$L \equiv \vec{r} \times \vec{p} = rmv \sin\theta = r_\perp p$$

5. Calculate the angular momentum of a 1.5 kg mass spun in a circle of radius 20cm at a rate of 10 rpm.

6. You can calculate the angular momentum of things moving in a straight line. Calculate the angular momentum of a 1.5kg mass moving in a straight line with constant velocity 5m/s in the $+x$ direction at a height of 2m above the origin. Hint: draw at least two positions of the mass from the origin. Label r and $r_\perp$.