- worksheet: `positron.hep.upenn.edu/p8/files/ws19.pdf`
- 4 problems + 2 XC. 3 equilibrium problems, 1 work/rotation problem. XC 1 equilibrium, 1 rotation.
- A short **actual reading assignment** is due this Wednesday (**Giancoli** ch09, see Canvas.) I think you will find it enjoyable & helpful for equilibrium problems.
- Then another **skimming** assignment is due this Friday (Onouye/Kane ch1+2). Mainly look at the illustrations!
- In the next few weeks, we will **skim** 7 or 8 chapters of a beautifully illustrated [see `onouye_ch01.pdf`] book by Onouye & Kane, "Statics & Strength of Materials for Architecture & Building Construction. You can find your own copy (any edition will do), or you can venmo me $10 for one of my used copies. At the end of the term, you can either keep it or return it to me for a full $10 refund.
- Email **in advance** & file a CAR if you need to miss class.

An extended object has both translational and rotational KE:

$$K = \frac{1}{2} m v_{\rm cm}^2 + \frac{1}{2} I \omega^2$$

hoop: $I = mR^2$. disk: $I = \frac{1}{2} mR^2$. rod about CoM: $I = \frac{1}{12} m\ell^2$.
rod about end: $I = \frac{1}{3} m\ell^2$. solid sphere: $I = \frac{2}{5} mR^2$.

angular momentum: $L = I\omega \qquad L = mv\ r_\perp$

torque (lever arm $\times$ force): $\tau = r_{\rm perp}\ F$

For equilibrium: $\sum F_x = 0 \quad \sum F_y = 0 \quad \sum_{\circlearrowleft P}\ \tau = 0.$

Usual torque convention: CCW minus CW. In choosing pivot P, note forces whose lines-of-action pass through P drop out of $\sum \tau$.

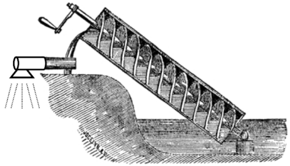
1*. A seesaw consists of a 9.0 kg plank balanced at its center on a very narrow support. A 40 kg child sits 1.0 m away from the center toward one end of the board, and a 20 kg child sits toward the opposite end so the see-saw is balanced. (a) What is the magnitude of the upward force exerted by the support? (Don't forget the factor $g = 9.8\ \mathrm{m/s^2}$.) (b) Where should the smaller child sit?

2*. Suppose a single force (that is not cancelled by any other forces) acts on an object. (a) Is it possible for this single force to change both the object's linear momentum and its angular momentum (about its CoM)? Explain. (b) Is it possible for this single force to change the object's linear momentum without changing its angular momentum (about its CoM)? Explain.

3*. A 50 kg box is suspended from the right end of a horizontal rod that has a very small mass. The left end of the rod is affixed to a wall by a pin. A wire connects the right end of the rod to the wall directly above the pin, making an angle of 30° with the rod. (a) Find the tension in the wire. (b) Determine the horizontal and vertical components of the reaction force that the pivot exerts on the rod.

(c) Repeat parts (a) and (b) if the rod has a mass of 25 kg.

4. Archimedes's screw, one of the first mechanical devices for lifting water, consists of a very large screw surrounded by a hollow, tight-fitting shaft (shown below). The bottom end of the device is placed in a pool of water. As the screw is turned, water is carried up along its ridges and comes out the top of the shaft and into a storage tank. As the handle is turned, work done by the torque exerted on the handle is converted to gravitational potential energy of the water-Earth system. Let's say you want to take a shower using this device. You figure your shower will consume 50 liters of water (what is the mass of a liter of water?), and so you have to raise this amount of water to the storage tank 2.0 m above the pool, so it can fall down on you. When you turn the handle, you apply a torque of 10 $\mathrm{N \cdot m}$. How many times must you turn the handle? (Hint: work done by a torque τ is $W = \tau \Delta\theta$, with $\Delta\theta$ measured in radians.)



5XC*. A horizontal 5.0 kg rod is 6.0 m long. It has a 10.0 kg block suspended from its left end and a 5.0 kg block suspended from its right end. (a) Find the magnitude and direction of the single extra force necessary to keep the rod in equilibrium. (b) At what distance from the left end of the rod must this force be applied?

6XC*. A 30 kg child stands on the edge of a 300 kg playground merry-go-round that is turning at the rate of 1 revolution every 2.0 s. She then walks to the center of the platform. If radius of the platform is 1.0 m, what is the platform's rotational speed once the child arrives at the center? (Treat the merry-go-round as a solid cylinder. Think carefully about which conservation law to use. Also, be careful how you turn the given information into an initial value for rotational speed ω.)