**Your Name:** ______________________________

**Teammates:** ______________________________________________

# Physics 8, Fall 2023, Worksheet #19.

http://positron.hep.upenn.edu/p8/files/ws19.pdf

Upload PDF (smartphone scan or tablet edit) to Canvas shortly after class on Mon, Nov 6, 2023.

*Problems marked with (*) must include your own drawing or graph representing the problem and at least one complete sentence describing your reasoning.*

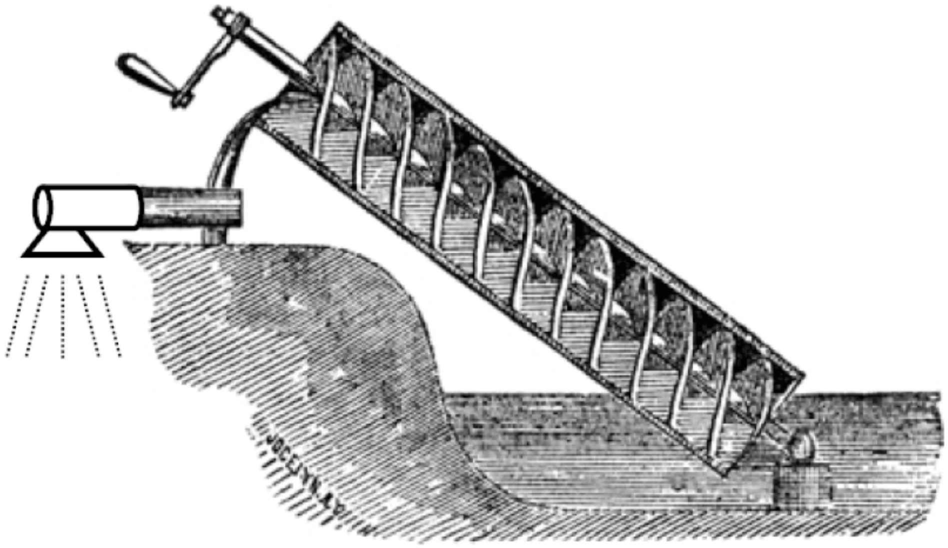
Discuss each problem with your teammates, then write up your own solution. Be sure to compare final results with your teammates, as a way to catch mistakes. It can also be very interesting when you and a teammate use different methods to arrive at a result. Do not hesitate to ask for help from other students or from the instructors — but don't just copy down other people's results!

**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 N $\cdot$ m. How many times must you turn the handle? (Hint: work done by a torque $\tau$ is $W = \tau\Delta\theta$, with $\Delta\theta$ measured in radians.)



**5*. Optional/extra-credit.** 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?

**6*. Optional/extra-credit.** 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 $\omega$.)