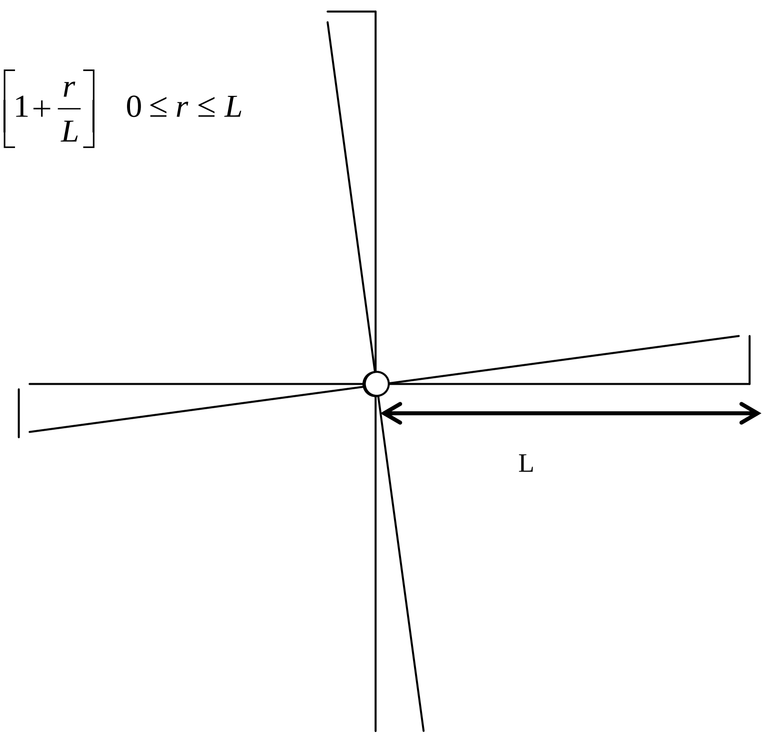
Workshop module 9 - Physics 113, Fall 2013

1. Whoosh! Graduation comes and goes. After blowing your last dollar during your post-graduation celebratory trip to Webster, reality sinks in and you decide to get a job. Ce la vie. Given your AMAZING physics skills, you land a job in the airplane design division of Al's Aerospace Emporium. How cool is that?! For your first assignment, Al asks you to calculate the moment of inertia of a new airplane propeller design. He supplies you with the sketch shown below of the propeller and an equation (also given below) for the linear mass density of each propeller blade as a function of distance, r, from the propeller axis. Determine an expression for the moment of inertia of the propeller in terms of the total mass M of the propeller and the length of each blade L. *Ignore the moment of inertia of the small circular part in the center that holds the end of each of the blades.*

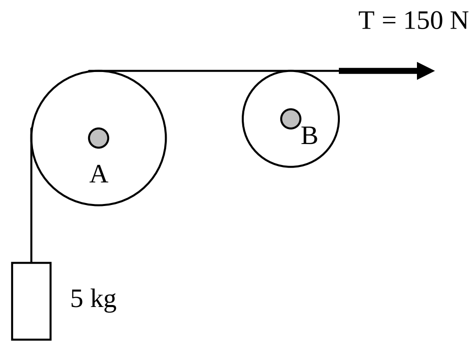
$$\lambda = \lambda_o \left[1 + \frac{r}{L} \right] \quad 0 \le r \le L$$



2. Each member of the workshop should make up a "cross-product problem" by drawing two vectors (A and B) oriented somehow in 3 dimensions. The rest of the workshop should figure out the direction of AxB. Try to be tricky. (It's fair to put vectors at angles and in and out of the board or give them a magnitude of zero!) Do the same thing for forces applied at different points to rotating objects (they already have an angular velocity … which might be zero). The rest of the workshop should be able to tell you the direction of the torque as well as the direction of the angular velocity and angular acceleration vectors.

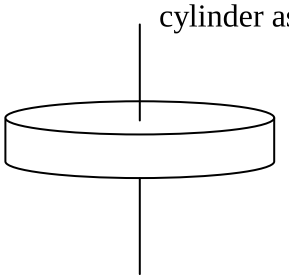
3. Consider a car that moves quickly past you from left to right, accelerating as it goes. Please state the direction of the following vectors for the right front wheel or its center-of-mass as the car's motion brings the wheel directly in front of you: velocity, momentum, angular velocity, angular acceleration, angular momentum, torque.

4. A 5 kg mass is attached to a massless rope that passes without slipping across two pulley wheels, A and B. The rope is pulled with a tension of 150 N. Pulley wheel A has a mass of 2 kg and a radius of 0.3 m. Pulley wheel B has a radius of 0.15 m. Consider each pulley wheel as a solid, uniform cylinder. The 5 kg mass moves upward with an acceleration of 2 m/s^2. Calculate the mass of pulley wheel B.



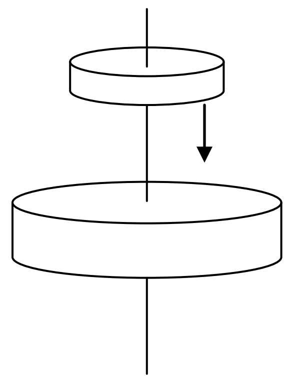
5. The pilot of a propeller-driven airplane decides to descend abruptly. The propeller is at the front of the airplane and rotates clockwise as seen by the pilot. She lowers the nose of the airplane from a horizontal attitude to one in which the nose is pointed well below the horizontal. As she does this, the nose of the airplane also swings to the left (as seen by the pilot). Explain why this happens.

6. (a) A solid, uniform cylinder has a mass of 2 kg and a radius of 10 cm. What is the moment of inertia of this cylinder about an axis passing through the center of the cylinder as shown in the drawing?



(b) Suppose this cylinder experiences a torque that provides a constant angular acceleration of 1 rad/s^2 that begins at t=0. What is the size of this torque and at what time will the cylinder reach a rotational rate of 100 rad/s?

(c) What is the final kinetic energy of the cylinder in part (b)?



(d) Suppose the cylinder in part (a) rotates about a vertical, frictionless axle with angular speed 100 radians/second. A second cylinder that has a moment of inertia of 0.005 kg-m^2 and initially is not rotating drops onto the first cylinder. Because of friction between the surfaces, the two eventually reach the same angular speed ω_f. What is the final angular speed?