Assignment IX, PHYS 111 (General Physics I)
Fall 2018
Due 11/9/18 at start of class

As always, please put your clearly written answers on separate paper.

1. A standard, hinged door can be treated as a 2-dimensional plate with dimensions h and w (for height and width, respectively). The moment of inertia of a flat rectangular plate like this with respect to its hinged side would be $I = \frac{1}{3}mw^2$. Let us say that, for a real door, this moment of inertia ends up being equal to 25 kg m^2, and the door has a width of 1.3 meters.

   a) What is the mass of the door? (They're not all hard!)

   b) Neglecting friction, what steady force – applied at its outer edge and perpendicular to the surface of the door – can move the door from rest through an angle of $\pi/2$ radians in 1.4 seconds?

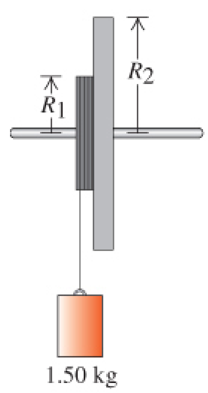
   c) If the force was applied to a position 0.5 meters from the hinges (but still perpendicular to the surface of the door), what steady force would have needed to be applied in order to move the door from rest through an angle of $pi/2$ radians in 1.4 seconds?

2. The moment of inertia of a compound object is equal to the sum of the moments of inertia of each piece. The moment of inertia of a disk about its center is $\frac{1}{2}MR^2$ where M is the mass of the disk and R is the radius of the disk. Two uniform metal disks with masses m_1 and m_2 and radii R_1 and R_2 (respectively) are welded together and mounted on a frictionless axis through their common center as show in the figure below.

   a) What is the total moment of inertial of the two disks with respect to the axis shown?

   b) Let $R_1 = 7.00$ cm and $R_2 = 11.0$ cm. Let $m_1 = 1.35$ kg and $m_2 = 4.23$ kg. A massless, inextensible string is wrapped around the edge of the smaller disk and a 1.50 kg block is suspended from the free end of the string. If the block is released from rest a distance 10.00 m above the floor, what is the speed of the block just before it strikes the floor?

   c) Repeat your calculation in part (b) above if the string is wrapped around the edge of the larger disk instead.

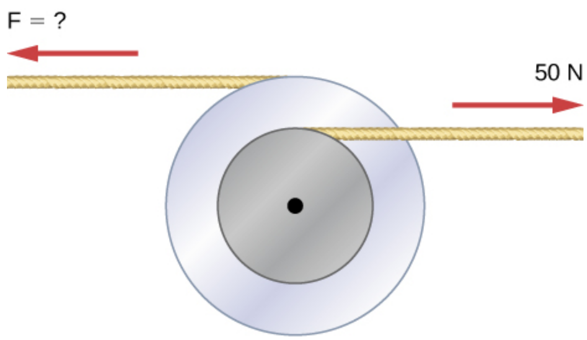


3. Consider the system displayed below. The mass distribution in both wheels is not uniform, but rather weighted towards the outside – so the moment of inertia of each of these wheels is not $\frac{1}{2}MR^2$ like it would be for a uniform disk, but rather $\frac{3}{4}MR^2$. The wheels are welded together and – as shown – a 50 N force is applied from a rope to the right connected to the smaller wheel. The mass and radius of the smaller wheel are 2.5 kg and 35 cm, respectively. The mass and radius of the larger wheel are 5.2 kg and 45 cm, respectively.

   a) How large must the force on the larger rope be to hold the system from rotating?

   b) How large must the force on the larger rope to be if the system goes from rest to completing 5 full rotations counter-clockwise in 18.0 seconds?

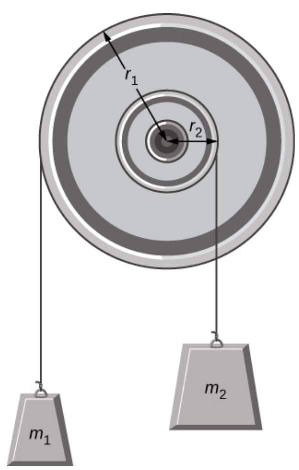
   c) Continuing on from part (b) above, what would be the angular momentum of the system after 18.0 seconds?



4. Examine the figure below. The pulley has moment of inertia I.

   a) Find m_2 in terms of a, m_1, r_1, r_2, I, and g if m_2 accelerates downwards with acceleration a.

   b) Find m_2 in terms of a, m_1, r_1, r_2, I, and g if m_2 accelerates upwards with acceleration a.



5. A force of $(30\hat{i} - 25\hat{j} + 10\hat{k})$N is applied at $\vec{r} = (4\hat{i} + 3\hat{j} - 2\hat{k})$m. What is the magnitude and direction of the torque of this force about the origin?

6. A force of 35N at $\pi/7$ radians with respect to the $+x$ axis is applied to the edge of a large wheel with radius 7 m centered at the origin. The force is applied at the position on the edge of the wheel an angle of $6\pi/5$ radians with respect to the $+x$ axis. What is the magnitude of the torque from this force?

7. Under certain circumstances, a star can collapse into an extremely dense object called a neutron star. (1 tablespoon full of a neutron star has approximately the same mass as the whole Earth). Let's talk about a start that has an initial radius 9×10^8 m and collapsed down into a neutron star that has a radius of about 2×10^4 m. You may assume that the mass of each star is uniformly distributed throughout its volume.

   a) If no mass is lost in this process, what is the rotational period of the neutron star if the original star had a rotational period of 2 weeks?

   b) Find the ratio $\frac{[v_{\text{rim}}]_{\text{neutron star}}}{[v_{\text{rim}}]_{\text{original star}}}$, where v_{rim} corresponds to the velocity of a piece of the star at the surface and on the equator of the rotating star.