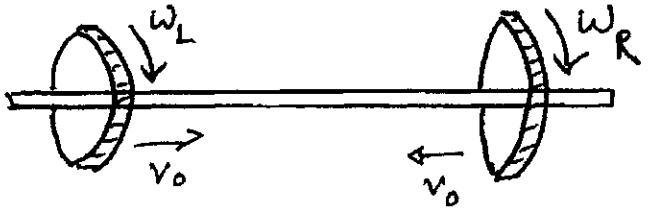
1. (25 points)Derive the expressions for the $\vec{i}_r$ and $\vec{i}_\theta$ components of the velocity and acceleration.

2. A very small object, mass m, is attracted to the origin by a force of magnitude kr^3 where r is the distance from the origin and k is a known constant.

a. (20 points) What velocity would the object have to be given in order for it to move in a circle if it was originally a distance D from the origin?

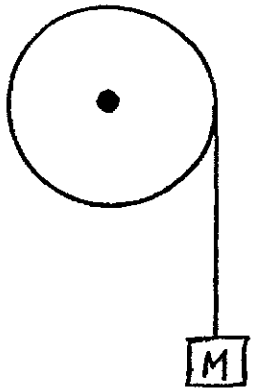
b. (5 points)What work would this force do if the object somehow moved from the point with $r = A, \theta = 0$ to the point $r = B, \theta = \pi$?

3. Two disks are spinning on a frictionless axle. The one on the left has mass M, radius R_L, and moment of inertia about the axle I_L. It is spinning with ω_L in the direction shown. It is moving to the right with velocity of magnitude v_0. The one on the right has mass M, radius R_R, and moment of inertia about the axle I_R. It is spinning with ω_R in the direction shown. It is moving to the left with velocity of magnitude v_0. When the two disks collide they stick together. What is the velocity and the angular velocity of the combined system after the collision?



4. A pulley has mass M_p, radius R and moment of inertia about an axis through its center I_p. A mass M is hung from a rope that moves without slipping on the pulley. A motor supplies a torque of constant magnitude τ_0 to the pulley which tends to make it rotate clockwise about a horizontal axle.

a. If the axle is frictionless, find the acceleration of the mass M.



b. Suppose there is a friction force at the axle which exerts a torque, opposing the rotation and that this torque is proportional to the angular velocity, with magnitude $\beta\omega$ where β is a known constant. The pulley will then reach a certain constant angular velocity. What is this constant value of ω?

5 (25 points) You and a friend are in a boat of mass M_B at rest on a frictionless ice pond. You are a distance D from shore, stuck without a paddle. Your mass is m and the friend's mass is m_f. You throw your friend from the boat with a velocity of magnitude v_f as shown. a.How long before you reach the shore?

b. In twenty five words or less discuss whether or not the method of solution you used in part a. would work if the pond melted so that the boat was in water instead of on ice.