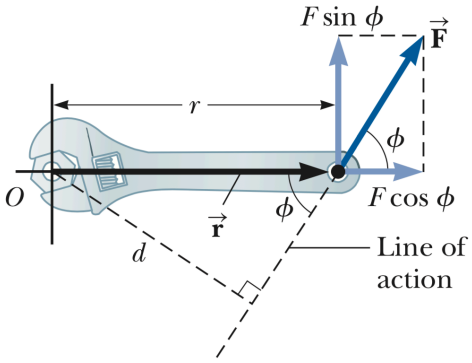
Physics 120

Worksheet 10 Rotational Dynamics

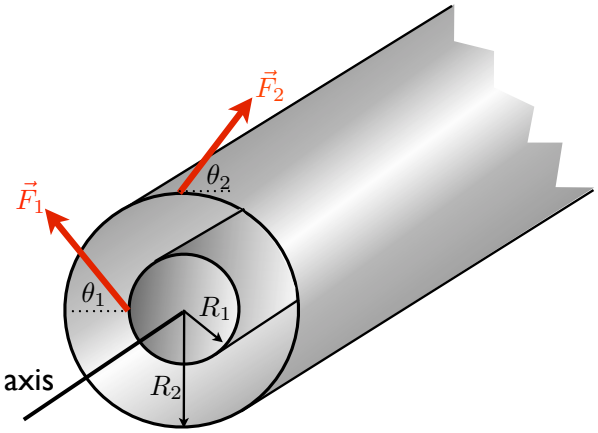
Problem 1

As shown in the right figure, one applies a force $\vec{F}$ with an angle ϕ with respect to the handle of the wrench at a point with a distance r away from the screw. Find the torque τ applied by the force. Does it make the screw rotate counterclockwise (CCW) or clockwise (CW)?



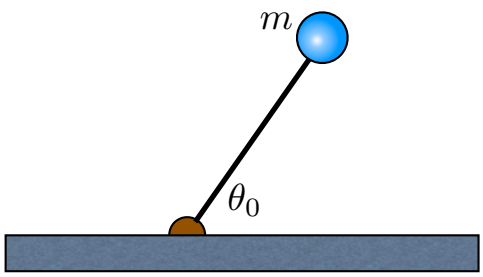
Problem 2

Consider an object with an co-axial structure, where the inner axis has a radius R_1 and the outer radius is R_2 as shown in the right figure. Suppose a force $\vec{F}_1$ is applied to the inner axis at a point shown in the figure and has a direction with an angle θ_1 with respect to the horizontal line; another force $\vec{F}_2$ is applied on the outer radius at a point and direction shown in the figure, which has an angle θ_2 with respect to the horizontal line. The object is fixed so that it cannot move translationally, but is allowed to rotate about its central axis that is perpendicular to the radii. Suppose the object has a rotational inertia I with respect to the central axis, find the angular acceleration of the object. Specify both the magnitude and direction (CCW or CW).



Problem 3

As shown in the right figure, a small sphere of mass m is attached to a boom of length L (assume to have negligible mass) and is released from rest with an initial angle θ_0.



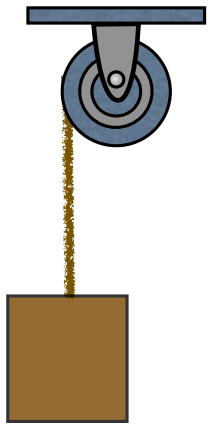
(a) Find the torque exerted by gravity on the small sphere with respect to the hinge when it was released.

(b) Show that the kinetic energy of the small sphere due to its translational motion is the same as its rotational kinetic energy with respect to the hinge.

(c) Find the speed of the small sphere right before it hits the ground.

Problem 4

A pulley of mass m_1 and radius R is fixed on the ceiling. The rotational inertial of the pulley is given by $I = \frac{1}{2}m_1R^2$. A block of mass m_2 is hang by a rope (assuming mass is negligible) that wraps around the pulley. Assume the rope does not slip on the pulley.



(a) Find the constraint relation between the angular acceleration of the pulley and the vertical acceleration of the block.

(b) Find the tension of the rope.

(c) Find the acceleration of the block.

(d) When the block falls a distance Δy, what is the angular speed of the pulley?

Problem 5

This problem describes one experimental method for determining the rotational inertia of an irregularly shaped object such as the payload for a satellite. The right figure shows a counterweight of mass m suspended by a cord wound around a spool of radius r, forming part of a turntable supporting the object. The turntable can rotate without friction. When the counterweight is released from rest, it descends through a distance h, acquiring a speed v. Find the rotational inertia of the rotating apparatus in terms of r, v, h, m and g. (A problem and figure from Serway's textbook.)