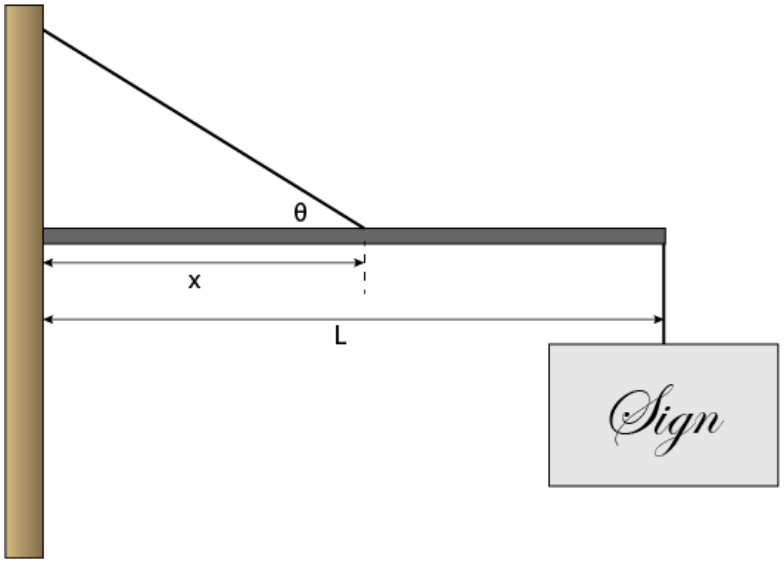
Rotational Dynamics Examples

1. A gyroscope slows from an initial rate of 32.0 rad s^{-1} at a rate of 0.700 rad s^{-2}.
   (a) How long does it take to come to rest?
   (b) How many revolutions does it make before stopping?

2. The triceps muscle in the back of the upper arm extends the forearm. This muscle in a professional boxer exerts a force of 2.00×10^3 N with an effective perpendicular lever arm of 3.00 cm, producing an angular acceleration of the forearm of 120 rad s^{-2}. What is the moment of inertia of the boxer's forearm?

3. Suppose you exert a force of 180 N tangential to a 0.280 m radius 75.0 kg grindstone (a solid disk $I = \frac{1}{2}MR^2$).
   (a) What torque is exerted?
   (b) What is the angular acceleration assuming negligible opposing friction?
   (c) What is the angular acceleration if there is an opposing frictional force of 20.0 N exerted 1.50 cm from the axis?

4. A sign of mass M is attached to a wall as shown.



   Derive an equation for the tension in the wire such that the system is in rotational equilibrium.

5. Three children are riding on the edge of a merry-go-round ($I = \frac{1}{2}MR^2$) that is 100 kg, has a 1.60 m radius, and is spinning at 20.0 rpm. The children have masses of 22.0, 28.0, and 33.0 kg. If the child who has a mass of 28.0 kg moves to the center of the merry-go-round, what is the new frequency in rpm?

6. Suppose a star of radius R_1 has a period of 20 days. The star suddenly collapses to a radius R_2 which is smaller by a factor of 10000 without losing mass. You may assume that the moment of inertia of the star is that of a solid sphere ($I = \frac{2}{5}MR^2$).
   (a) What is the new period of the star?
   (b) Compare the ratio of kinetic energy before and after the collapse.

7. A baseball pitcher throws the ball in a motion where there is rotation of the forearm about the elbow joint as well as other movements. If the linear velocity of the ball relative to the elbow joint is 20.0 ms^{-1} at a distance of 0.480 m from the joint and the moment of inertia of the forearm is 0.500 $kg \cdot m^2$, what is the rotational kinetic energy of the forearm?

8. A solid wheel ($I = \frac{1}{2}MR^2$) is rolled along a horizontal surface at a constant velocity v without slipping. Find the total kinetic energy of the system.

9. An ice skater spinning at 6.00 rev s^{-1} has a moment of inertia is 0.400 $kg \cdot m^2$.
   (a) Calculate his angular momentum.
   (b) He reduces his rate of spin (his angular velocity) by extending his arms and increasing his moment of inertia. Find the value of his moment of inertia if his angular velocity decreases to 1.25 rev s^{-1}.
   (c) Suppose instead he keeps his arms in and allows friction of the ice to slow him to 3.00 rev s^{-1}. What average torque was exerted if this takes 15.0 s?