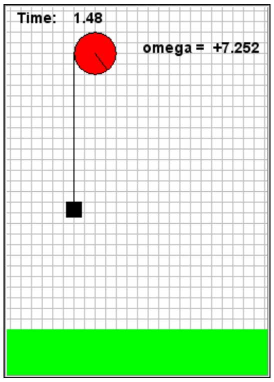
Worksheet for Exploration 10.3: Torque and Moment of Inertia



A mass (between 0.01 kg and 1 kg) is hung by a string from the edge of a massive (between 0 kg and 2 kg) disk-shaped pulley (with a radius between 0.1 and 4 meters) as shown **(position given in meters, time given in seconds, and angular velocity given in radians/second)**.

For a, b, and c, set the hanging mass to 0.25 kg, the radius of the pulley to 2 m, and **vary the mass of the pulley**.

a. How does the magnitude of the angular acceleration of the pulley depend on the mass (and therefore moment of inertia) of the pulley?
   i. As the mass of the pulley increases, the angular acceleration
      INCREASES or DECREASES

b. How does the magnitude of the acceleration of the hanging mass depend on the mass (and therefore moment of inertia) of the pulley?
   i. As the mass of the pulley increases, the acceleration
      INCREASES or DECREASES

c. How are your answers to (a) and (b) related?
   i. Give a specific relation between angular acceleration and acceleration. Keep careful track of signs.

For d, e, and f set the mass of the pulley to 0.5 kg, the radius of the pulley to 2 m, and **vary the hanging mass.**

d. How does the magnitude of angular acceleration of the pulley depend on the hanging mass?
   i. As the hanging mass increases, the angular acceleration
      INCREASES or DECREASES

e. How does the magnitude of acceleration of the hanging mass depend on the hanging mass?
   i. As the hanging mass increases, the angular acceleration
      INCREASES or DECREASES

f. How are your answers to (d) and (e) related?

For g, h, and i set the hanging mass to 0.25 kg, the mass of the pulley to 0.5 kg, and **vary the radius** of the pulley.

g. How does the magnitude of angular acceleration of the pulley depend on the radius of the pulley?
   i. You should note a specific functional relation here. Take measurements at several values for R to determine this relation.

h. How does the magnitude of acceleration of the hanging mass depend on the radius of the pulley?
   i. Again you should get a specific relation. Here this should be apparent after only a couple of measurements.

i. How are your answers to (g) and (h) related?

For j, k, and l set the mass of the pulley to 0.5 kg, the hanging mass to 0.25 kg, and the radius of the pulley to 2 m. Use measurements from the simulation to answer the following questions.

j. Determine the acceleration of the hanging mass and the angular acceleration of the pulley.
   i. Use measurements of displacement and time to determine this.

k. From Newton's second law, determine the (magnitude of) tension in the string.
   i. If you are not sure what to do, you may want to draw a free body diagram for the hanging mass.

l. How much torque does this tension provide to the pulley?
   i. Now that you know the tension, you can calculate the torque by using the definition (force times lever arm).

Additional Question

As a last part of E10.3 you may want to see if you can write out a theoretical prediction for the motion of this system. Many texts will derive this for you, but see if you can do it. Here is a brief outline of what you need. Write out an equation for Newton's second law for the hanging mass. Write out an equation for the torque acting on the pulley/disk. Write out a third equation relating angular acceleration, and the acceleration of the hanging mass. Be careful with signs. You should have "Tension, the two masses, the radius, acceleration, and angular acceleration". Assume the system properties are known (masses and radius).