Rotation of a rigid body: examples

Example 1

A high speed drill reaches 2000 rpm in 0.50 s.
    a) What is the drill angular acceleration?
    b) Through how many revolutions does it turn during this first 0.50 s?
    c) If the drill bit has a diameter of 5mm, what are the linear velocity and acceleration of a point on the edge of the drill bit at 0.5 s?
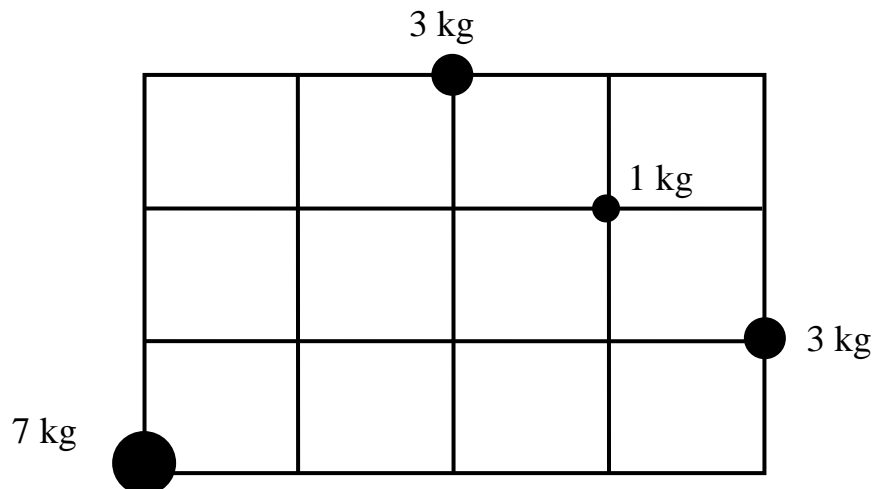
Example 2

An 18-cm-long bicycle crank arm, with a pedal at one end is attached to a 20-cm-diameter sprocket, the toothed disk around which the chain moves. A cyclist riding this bike increases her pedaling rate from 60 rpm to 90 rpm in 10 s.


    a) What is the tangential acceleration of the pedal?
    b) What is the radial acceleration when the pedaling rate is 90 rpm?
    c) What length of chain passes over the top of the sprocket during this interval?

Example 3

Where is the center of mass of the system of particles shown in the diagram is at point? (The grid is drawn for better visualization and is not part of the system of particles).
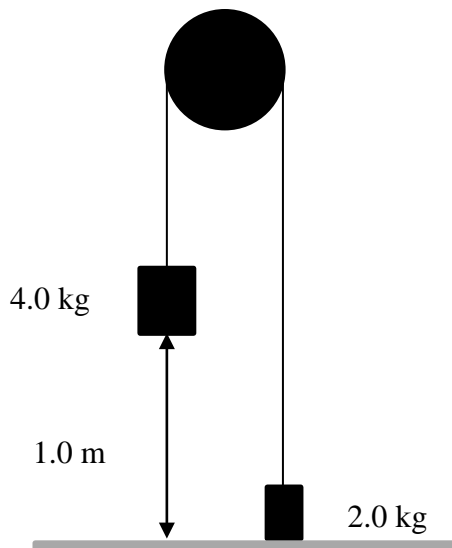
Example 4

20 cm

10 cm

10 cm

y

x
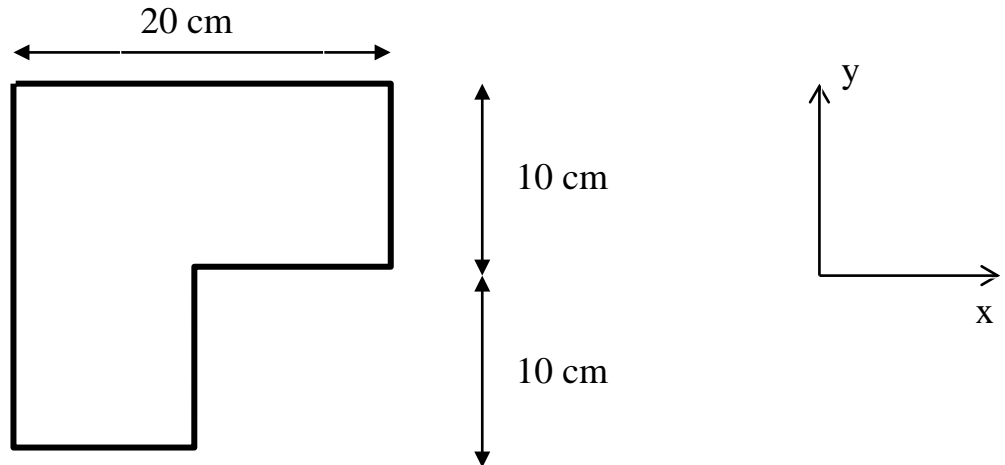
a) What is the location of the center of the mass of the uniform steel plate shown above?

b) What is the moment of inertia of the plate about a z-axis going through the top left corner? The plate has a uniform thickness of 1cm. The density of steel is 8000 kg/m^3.
Note: The moment of inertia of a rectangular plate of mass m, length a and width b about a perpendicular axis going through its center is
$I_{CM} = \frac{m}{12}(a^2 + b^2)$.

c) What is the moment of inertia of the plate about a z-axis going through its center of mas?

Example 5

Two blocks are connecting by a massless rope that passes over a pulley. The pulley is 12 cm in diameter and has a mass of 2 kg. As the pulley turns, friction at the axle exerts a torque of magnitude 0.50 N.m. If the blocks start from rest, how long does it take for the 4.0 kg block to reach the floor?

4.0 kg

1.0 m

2.0 kg

Example 6

A 3.0-m-long rigid beam with a mass of 100 kg is supported each end by force plate. An 80 kg student stands 2.0 m from the left plate. What are the readings of the two plates?

2 m   1 m
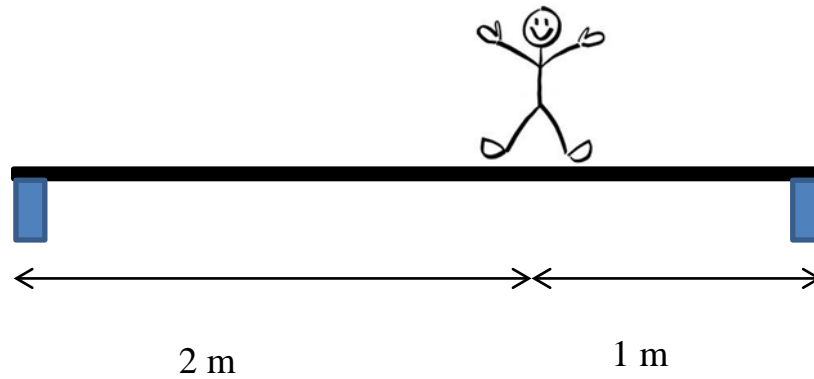
Example 7

A hoop and a solid disk are released from rest side by side at the top of an incline. The hoop and the disk have the same radius R. The mass of the hoop, M_h, is greater than the mass of the mass of the disk, M_d. The angle of the incline is α and the length of the incline is L.
  a) Compute the time it takes for each object to get to the bottom of the incline. Which one arrives first?
  b) Compare the kinetic energies of the two objects at the bottom of the ramp.

Length L

Mass M_d
Radius R

α

Mass $M_h > M_d$
Radius R
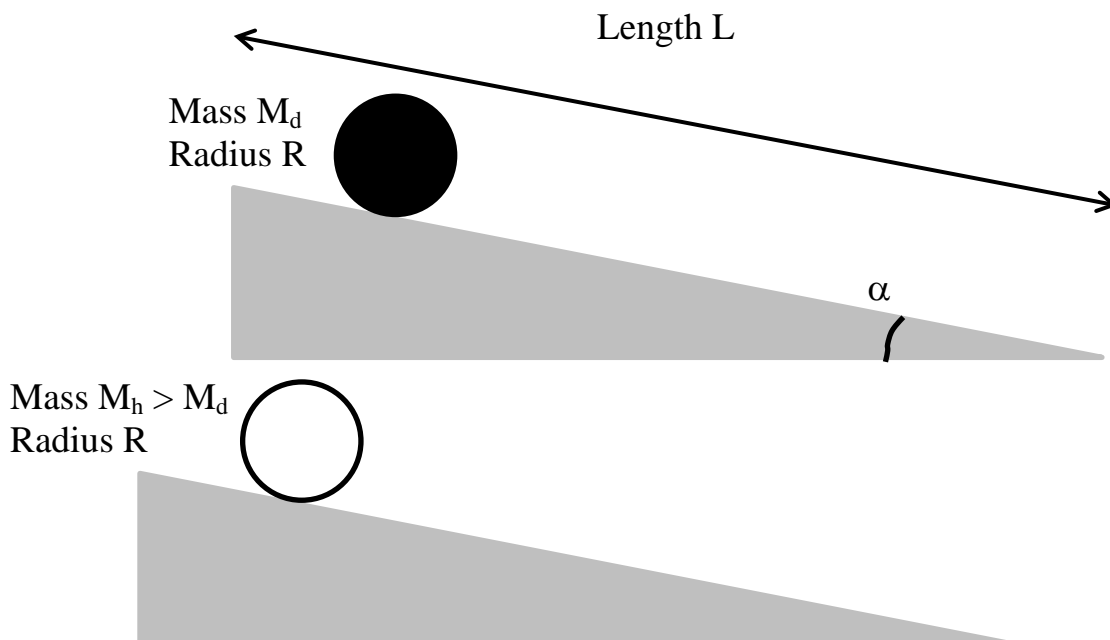
Example 8

A student sits on a freely rotating stool holding two weights, each of mass 3.0 kg. When her arms are extended horizontally, the weights are 1.0 m from the axis of rotation and she rotates with an angular speed of 0.75 rad/s. The moment of inertia of the student plus stool is 3.0 kg.m^2 and is assumed to be constant. The student pulls the weights inward horizontally to a position 0.3 m from the rotation axis.
   a) Find the new angular speed of the student
   b) Find the kinetic energy of the rotating system before and after she pulls the weights inward.