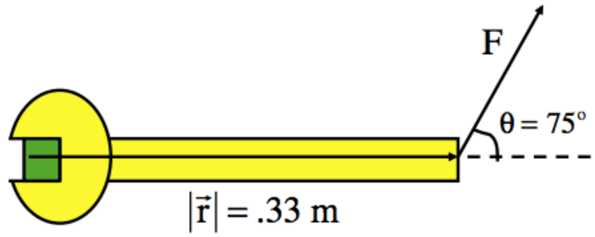
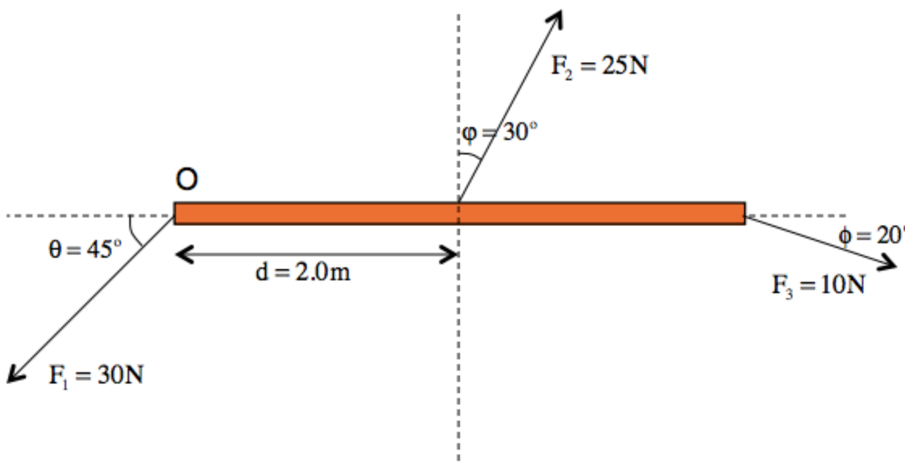
Chapter 8 XtraWrk – Rotational dynamics

8.2) Lugnuts on a car can handle 65 N·m of torque. For the situation shown, what is the maximum force that can be applied without damaging the lugnut?

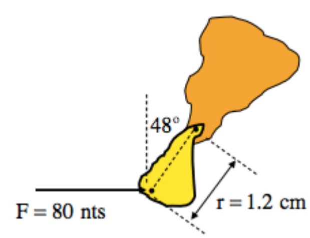


8.3) For the system shown:

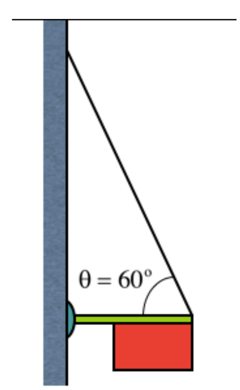
a) Derive an expression for the net torque about "O" about an axis perpendicular to the page
b) Derive an expression for the net torque about "C" (the center of mass) about an axis perpendicular to the page.

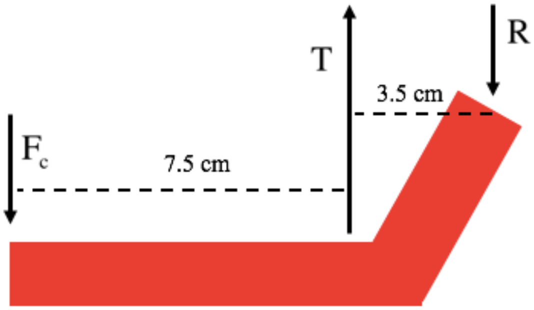


8.4) An 80 N force is applied as shown to a tooth. What is the torque applied about the tooth contact with the gum?



8.19) A 500-N wooden sign (4 m by 3 m in size) is suspended by a hinged rod that is 6 meters long and weighs 100 N. The end of the rod is connected to a thin wire that makes a 60º angle with the hinged rod and connects to the wall above. What's the tension in the line?

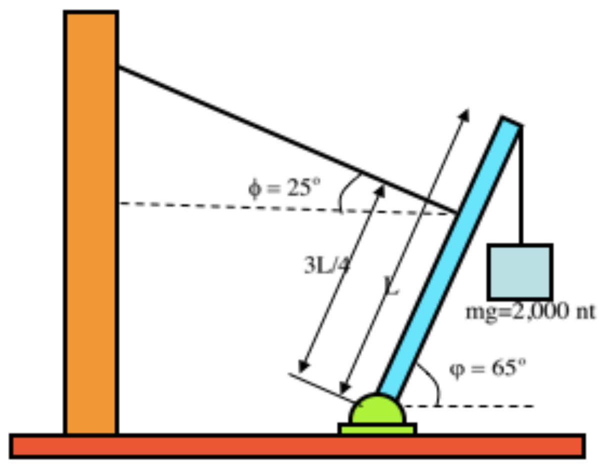


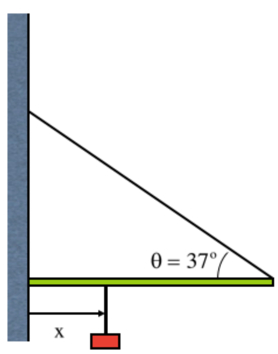


8.27) The image to the left is a schematic of the jaw and chewing muscle in the human body. T is the force provided by the chewing muscle, F_c is the force generated by chewing food, and R is the force provided by the jawbone joint itself. If $F_c = 50$ N, the distance between F_c and T is 7.5 cm, and the horizontal distance between R and T is 3.5 cm, how big are R and T?

8.28) A 1200-N beam of length *l* is pinned to the floor as shown at a 65º angle. A 2000-N crate hangs from the end of the beam. At a point ¾ *l* from the bottom of the beam, a cable supports the beam by attaching to a nearby wall. The cable makes an angle of 25º with the horizontal.

a) What is the tension in the cable?
b) What are the forces acting at the pin?

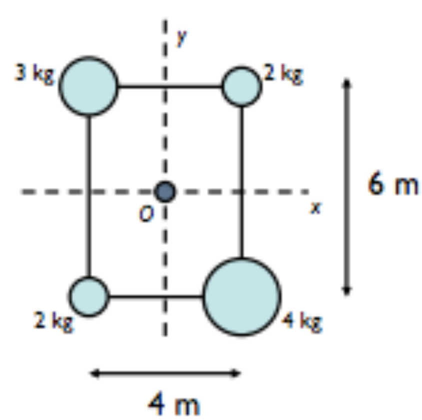


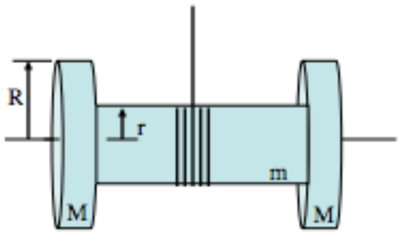


8.30) A sack of flour of weight *w* hangs from a 4-m long rod, also of weight *w*, that has a wire at one end and is held by friction against the wall at the other. If the coefficient of static friction between the wall and the rod is $\mu_s = 0.5$, at what minimum distance *x* can the sack be placed and have the rod stay put?

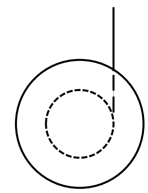
8.32) For the system shown here, what torque will produce an angular acceleration of 1.5 rad/s^2 about the

a) X axis
b) Y axis
c) Z axis



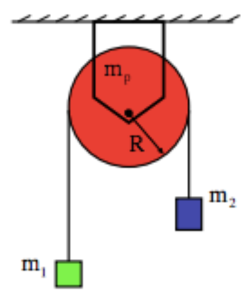


8.34) A basic yo-yo consists of two flat cylinders (each of mass *M* and radius *R*) on either end of a longer cylinder (mass *m* and radius *r*). A string winds around the center of the longer cylinder as shown. Take the positive direction to the left along the central axis of the yo-yo.



a) What's the momentum of inertia about the central axis?
b) What torque is generated about the central axis due to gravity?
c) Taking downward to be negative,
   i) What's the direction of the torque due to tension?
   ii) What's the direction of the angular acceleration?
   iii) What's the direction of the yo-yo's (translational) acceleration?
d) Write an expression relating the angular acceleration of the yo-yo with the translational acceleration of the yo-yo's center of mass.
e) Write out Newton's 2nd Law for the translational motion of the yo-yo.
f) Write out Newton's 2nd Law for the rotational motion of the yo-yo.
g) Derive an expression for the acceleration of the yo-yo's center of mass in terms of *m, M, g, r,* and *R.* (hint: substitute for T and eliminate α).
h) If $M = 2.00$ kg, $R = 10.0$ cm, $m = 1.00$ kg, and $r = 4.00$ cm, what's the numerical value of the acceleration?
i) What's the tension?
j) How long does it take the yo-yo to drop one meter?

8.40) Consider the Atwood machine with a massive pulley shown to the right. The system starts at rest, and as m_2 drops, the string turns the pulley without slipping.

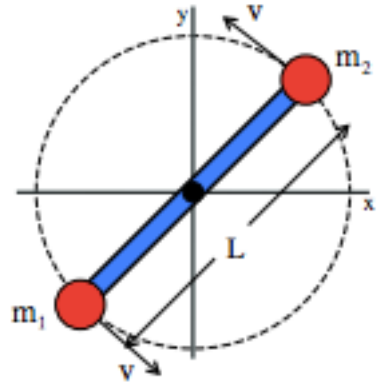


a) Why must the tensions be different?
b) Assuming no friction, what's the system's acceleration?
c) What are T_1 and T_2?

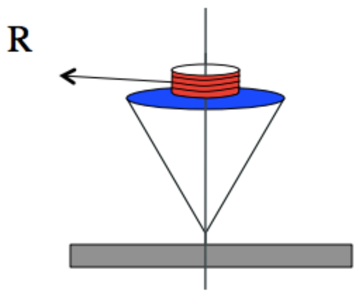
8.44) A classic physics demo involves multiple objects of identical mass and radius rolling down a hill from rest. Consider a hoop, solid cylinder, solid sphere, and thin spherical sphere.

a) What is the moment of inertia for each one?
b) Assuming all four start at the same point on the hill, rank the translational speed at the bottom of the hill for each one from highest to lowest.
c) Rank their rotational kinetic energies from highest to lowest at that same point.

8.45) A gymnast spins a baton that consists of a light rod of L = 1.00 m with two rubber balls (m_1 = 4 kg and m_2 = 3 kg) on either end. The baton spins about an axis through its center and perpendicular to its length as shown.

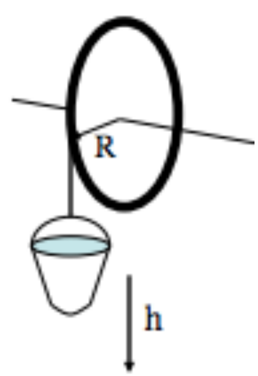


a) What is the system's kinetic energy when ω = 2.5 rad/sec?
b) What would the system's kinetic energy be if the rod has a mass of 2 kg? (note: the moment of inertia of a rod about its center of mass is $1/12ML^2$)



8.49) A child's spinning top starts at rest, and is put into motion by pulling with a constant 5.57 N of force on a string about its central axis. If its moment of inertia is 4.0×10^{-4} kg·m^2 and there is no slippage between the string and top, what will the top's angular speed be after 0.80 m of string have been pulled off?

8.52) An old-fashioned well has a pail of water suspended from a large pulley by a light rope. The pulley ($I = ½ MR^2$) has a mass of 5.0 kg and a radius of 0.60 m. The 3.0 kg pail is released from rest and falls a distance *h* = 4.0 m. Assuming the rope doesn't slip on the pulley, what's the speed of the pail after falling that distance?



a) Use conservation of energy to derive your answer.
b) Use Newton's 2nd Law and kinematics to derive your answer.

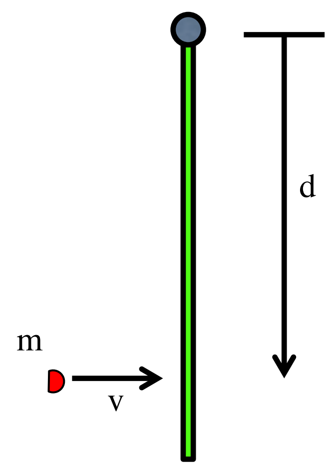
8.53) A giant pendulum consists of a 365 kg, 10-m long arm pinned on one end at the top with a "massless" seat its other end (at the bottom).

a) Relative to the seat at its lowest point, where's the center of mass of the arm? Treat the arm like a rod ($I_{cm} = 1/12\ ML^2$).
b) What's the potential energy when the arm is raised to a 45º angle? (recall that gravitational potential energy is calculated for the center of mass…)
c) What's the speed at the bottom of the arc if the arm is released from rest at the 45º angle in part (b)?

8.54) Find the angular momentum for each of the following objects, all of which have m = 2.4 kg, r = 0.18 m and are rotating about their center of mass with angular velocity 35 rad/sec.

a) A hoop
b) A solid cylinder
c) A solid sphere
d) A hollow spherical shell

8.56) A projectile of mass *m* moving with velocity *v* hits a meter stick of mass *M* and length *L* that is pinned to a frictionless table at one end. The projectile strikes the meter stick at a distance *d* from the hinge.



a) Before it hits the meter stick, does the ball have angular momentum relative to the axis of rotation for the meter stick? Explain.
b) Is mechanical energy conserved in this collision? Explain.
c) Derive an expression for the angular velocity ω of the meter stick after the collision, assuming the ball of clay sticks to the meter stick.