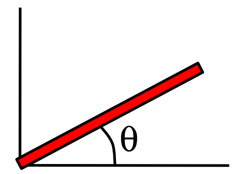
10-Series Problem

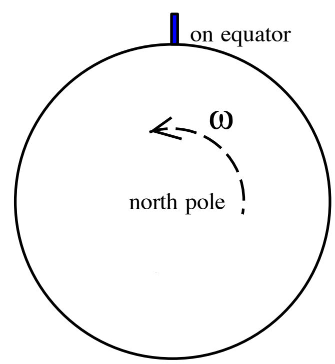
10.1) The earth clearly rotates about its axis.
- a.) Determine its angular speed about its axis.
- b.) How does this motion affect the earth's general form?



10.3) A door swings as shown in the sketch. If it's angular position is defined by the relationship $\theta = 5.00 + 10.0t + 2.00t^2$, where θ is in radians and *t* is in seconds. Determine the door's angular position, angular speed and angular acceleration at:
- a.) t = 0 seconds;
- b.) t = 3.00 seconds.

10.5) In 3.00 seconds, a wheel angularly accelerates from rest to 12.0 rad/sec. If the angular acceleration is constant:
- a.) What is the angular acceleration's magnitude?
- b.) Also, through how many radians did the wheel rotate during the acceleration?

10.7) An electric motor attached to a wheel rotating at 100 rev/min is turned off. If the magnitude of the wheel's constant angular acceleration as it comes to rest is 2.00 rad/sec/sec:
- a.) How long does it take to come to rest?
- b.) Through how many radians does it turn during that time interval?



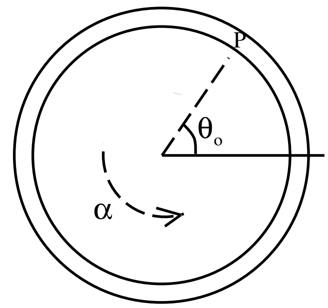
10.11) An incredibly tall building of height *h* sits on the earth's equator. A somewhat obscure example of what is called the *Coriolis effect* maintains that because a ball dropped from rest from the top of the building will have a greater tangential speed than the speed of the ground at the base of the building (both points have the same angular velocity, but one is farther from the axis of rotation), the ball will not appear to drop in the vertical (relative to the building) but, rather, will land to the east of the building's bottom. Assuming the acceleration of gravity is constant, there is no air friction and the angular velocity of the earth is ω:
- a.) Derive an expression for where the ball will land, relative to the building? (In other words, come up with an expression that tells you how far to the east the ball will land, relative to the building). This should be in terms of *h*, *g* and ω.
- b.) If *h = 50.0 meters*, what would that displacement be?
- c.) For the height quoted in *Part b,* would you be justified in ignoring the *Coriolis effect* in doing free fall problems associated with this building?
- d.) Assume that with time, the earth's angular speed was to decrease slowly at a constant rate. What would happen easterly drop displacement as this happened?

10.13) A race car traveling at a constant 45.0 m/s takes a circular, 250 meter curve.

a.) Determine its angular speed;

b.) Derive an expression for its acceleration as a vector.

10.17) A *point P* located on a 2.00 meter diameter rim is, at $t = 0$, oriented at an angle 53^{o} relative to a horizontal reference line (see sketch). If the rim begins from rest and angularly accelerates at a rate of 4.00 rad/sec^2:



a.) What's the angular speed of the rim $t = 2.00$ *seconds*?

b.) What is the velocity of *Point P* at $t = 2.00$ *seconds*?

c.) What is the total acceleration of *Point P* at $t = 2.00$ *seconds*?

d.) What is the angular position of *Point P* at $t = 2.00$ *seconds*?

10.18) It takes 9.00 seconds for a car wheel (diameter 58.0 cm) to uniformly accelerate from rest to 22.0 m/s.

a.) Assuming no slippage, how many revolutions does the tire make during this acceleration?

b.) In revolutions per second, determine the angular speed of the wheel at the end of the acceleration.

10.21) In manufacturing, the rotation of a motorized roller is governed by the relationship $\theta = 2.50t^2 - 0.600t^3$. If θ is in radians, t is in seconds and the roller's diameter is 1.00 meters:

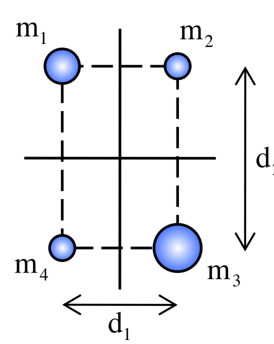
a.) What maximum angular speed will the roller attain?

b.) What maximum tangential speed will a point on its edge (the rim) attain?

c.) How long can the roller's motor be activated and not have the roller reverse its direction?

d.) If the roller started from rest, through how many rotations will it turn before the motor has to be turned off to keep the roller from reversing itself?

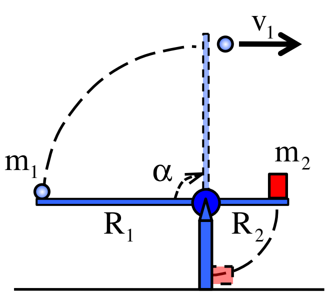
10.25) Consider the system of masses connected by "massless" bars as shown in the sketch to the right. If the system rotates with an angular speed of 6.00 rad/sec about an axis perpendicular to the page and through the origin of the coordinate system:



a.) Derive an expression for the system's *moment of inertia* about the rotational axis.

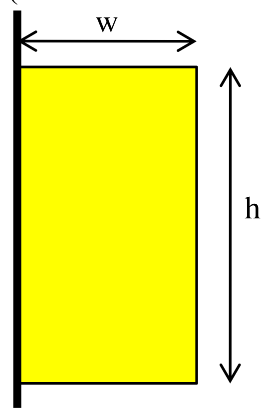
b.) The system's rotational kinetic energy.

10.27) A medieval slingshot called a trebuchet is composed of disparate masses at the end of a relatively light (we'll take it to be massless) beam that can pivot about a horizontal pin. Assume the pivot is frictionless, the beam is 3.00 meters long, the masses are $m_1 = 0.120$ kg (this is what is being flung) and $m_2 = 60.0$ kg and a distance of $R_2 = 14$ cm between the pin and the larger mass. With all that in mind, if the trebuchet is released from rest when the beam is in the horizontal:



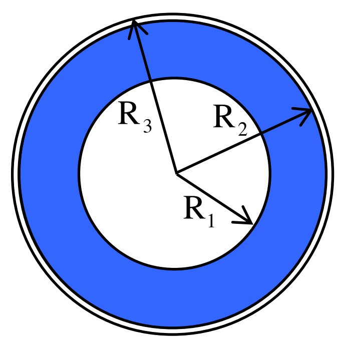
a.) What is the maximum speed of the mass being flung (m_1)?
b.) Does the flung mass accelerate at a constant rate while executing the motion shown in the sketch?
c.) Does the flung mass have constant *tangential* acceleration while executing the motion shown in the sketch?
d.) Is the trebuchet's angular acceleration constant?
e.) Does the trebuchet experience constant momentum?
f.) If you take "the system" to be the trebuchet and the earth, is energy conserved (constant mechanical energy) during the motion?

10.29) You have a door of known mass $m = 23.0$ kg, height $h = 2.20$ m and width $w = 0.870$ m.

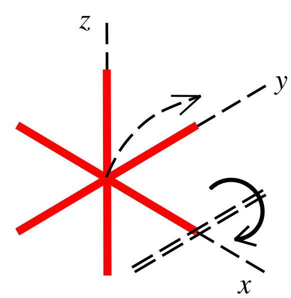


a.) Derive an expression for its *moment of inertia* about its hinges.
b.) Note which, if any, of the given parameters are unnecessary for that calculation?

10.31) Think of a tire as being made up of two sidewalls of uniform thickness .0635 cm and a street-contact tread-wall of width 20.0 cm and uniform thickness 2.50 cm. If the rubber's density is $1.10\text{x}10^3$ kg/m^3, and if $R_1 = 16.5$ cm, $R_2 = 30.5$ cm and $R_3 = 33.0$ cm, what is the *moment of inertia* about the central axis of the tire, perpendicular to the page?



10.33) Three rods of length "L" are each welded to one another at their centers and at right angles as shown in the sketch. Someone wants to rotate the system about an axis that is at the end of one bar, parallel to the *y-axis* and perpendicular to the *x-axis* (this is shown with a double dashed line in the sketch). What is the *moment of inertia* of the system about this axis or rotation?



10.34) Consider the following vectors:

$\vec{A} = 3\hat{i} - 6\hat{k}$, $\vec{B} = -2\hat{i} - 8\hat{j} + 2\hat{k}$, $\vec{C} = 5\measuredangle -20^\circ$, and $\vec{D} = 9\measuredangle 100^\circ$

Determine:

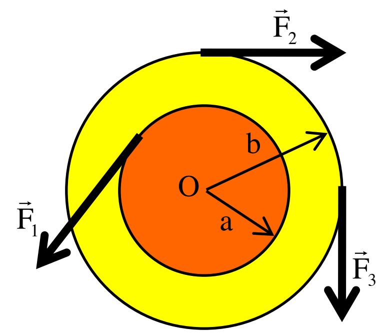
a.) $\vec{A} \times \vec{B}$

b.) $\vec{B} \times \vec{A}$

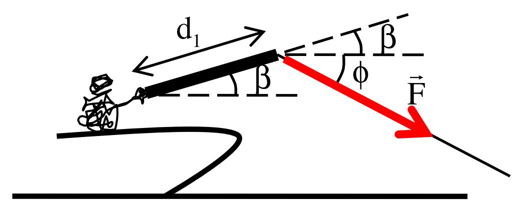
c.) $\vec{C} \times \vec{D}$

d.) $\vec{D} \times \vec{C}$

10.35) In the sketch, *a = 10.0 cm* and *b = 25.0 cm.* Determine the net torque on the wheel if $\vec{F}_1 = (12\ \text{N})\measuredangle 210^\circ$ (relative to the +x axis), $F_2 = 10.0$ N and $F_3 = 9.00$ N



10.36) A fisherman holding a fishing rod has hooked a fish. The rod has length d_1, and the situation is shown in the sketch. What is the torque the fish applies to the man's hands if $\beta = 20.0^\circ$, $\phi = 37.0^\circ$, $d_1 = 2.00$ m and F = 100 N.



10.38) A constant torque of 0.600 N•m is applied to a solid disk of mass 2.00 kg and radius 7.00 cm.

a.) If the disk starts from rest and accelerates to 1200 rev/min, how long will that take?

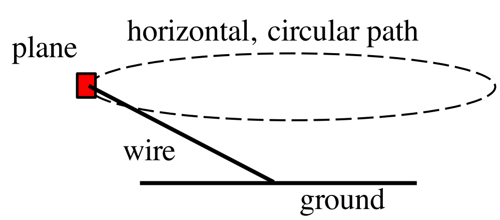
b.) During the acceleration, through how many revolutions will the disk rotate?

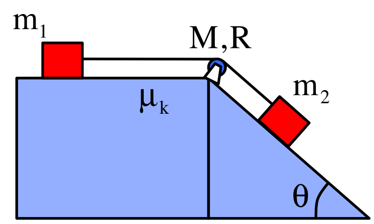
10.39) A model airplane flies in a horizontal, 30.0 m circle due to being attached to a wire secured to the ground. The plane's mass is 0.750 kg and its engine provides 0.800 N of thrust perpendicular to the wire.

a.) Determine the torque the thrust provides, relative to the wire's contact point with the ground.

b.) What is the plane's angular acceleration?

c.) What is the plane's tangential acceleration?

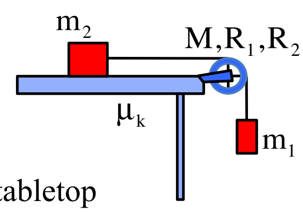




10.40) A string threaded over a massive, frictionless pulley (radius R = 0.250 m; mass M = 10.0 kg) mounted on a combination plane/incline has attached to one end a mass $m_1 = 2.00$ kg and at the other end a mass $m_2 = 6.00$ kg. The angle of the incline is $\theta = 30^o$ and the *coefficient of kinetic friction* between the blocks and the supporting surfaces is 0.360.

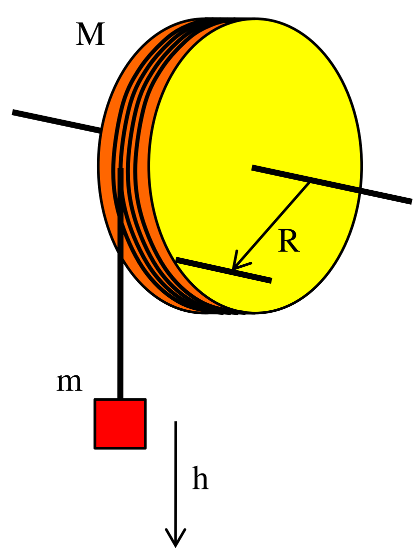
a.) Draw free body diagrams for the blocks and the pulley.
b.) Derive an expression for the acceleration of the system;
c.) Determine the tension on both sides of the pulley.

10.45) Determine the total rotational kinetic energy of the hands of London's Parliamentary clock if its *hour-hand* has a length of 2.70 meters with mass 60.0 kg and its *minute hand* has a length of 4.50 meters and mass 100 kg. (Hint: Think of the hands as long rods and assume their motion is that of objects that make one revolution every 60 minutes and 12 hours, respectively.)



10.49) A massive, frictionless pulley of mass M = 0.350 kg that resembles a wheel with inside radius $R_1 = 0.020$ m and outside radius $R_2 = 0.030$ meters has a string threaded over it with a mass $m_2 = 0.850$ kg sitting on a tabletop attached at one end and a hanging mass $m_1 = 0.420$ kg attached to the other end. Ignoring the wheel/pulley's spokes, taking the coefficient of friction between the tabletop and the mass to be 0.250 and assuming that as m_2 passes "the origin" it is observed to be moving with velocity 0.820 m/s toward the pulley:

a.) Use energy considerations to determine how fast m_2 is moving once it has traveled 0.700 meters.
b.) Determine the pulley's angular speed at the point alluded to in *Part a*.



10.51) A massive, frictionless pulley of radius $R = 0.250$ m and mass M = 3.00 kg (assumed to be a disk) has a rope wrapped around it with a mass m = 5.10 kg attached to its free end. The system is released from rest:

a.) Derive an expression for the tension in the string during the acceleration.
b.) Determine the acceleration of the hanging mass during the acceleration.
c and d.) Derive an expression for the velocity of the hanging mass after it has "fallen" through a height of *h = 6.00 meters*. Execute this derivation TWO WAYS (hence *Parts c* and *d*).

10.55) The center of mass of a solid 10.0 kg cylinder that is rolling without slippage on a horizontal surface is 10.0 m/s.

a.) Determine the cylinder's translational kinetic energy.
b.) Determine the cylinder's rotational kinetic energy.
c.) Determine the cylinder's total kinetic energy.

10.57) You are given an incline of known angle θ.

a.) Derive an expression for the acceleration of the center of mass of a uniform disk rolling down the incline.
b.) Derive an expression for the acceleration of the center of mass of a hoop rolling down the incline. Compare this to the acceleration expression derived in *Part a*.
c.) To maintain a pure roll for the disk, what is the minimum coefficient of friction required between the disk and the incline?

10.61) A can of soup concentrate rolls from rest down the length of a 3.00 meter long, 25^{o} incline plane in 1.50 seconds. If the can's mass is 215 grams, its diameter is 6.38 cm and its height is 10.8 cm:

a.) Use *energy considerations* to derive an expression for the can's *moment of inertia*.
b.) Which pieces of given information are not needed to do the calculation requested in *Part a*?
c.) You can't use $I = \frac{1}{2}mR^2$ to determine the can's *moment of inertia*. Why not?