Name_____
Period___Date_____

Rotation: Worksheet 7 Newton's 2nd Law

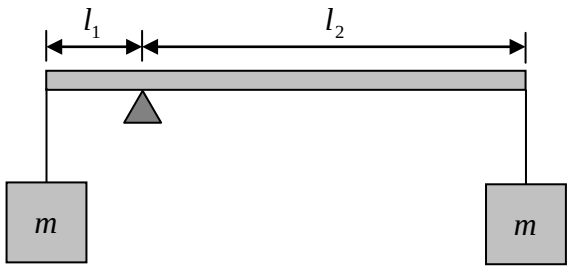
1. The length of a bicycle pedal arm is $0.152\ m$, and a downward force of $111\ N$ is applied by the foot. Calculate the magnitude of the torque about the pivot point when the arm makes the following angle with the vertical.
   a. $30.°$ b. $90.°$ c. $180°$

2. When a torque of $32.0\ Nm$ is applied to a certain wheel of mass $3.25\ kg$, it acquires an angular acceleration of $25.0\ rad/s^2$.
   a. What is the rotational inertia of the wheel?
   b. If the wheel can be approximated as a hoop, what is its radius?
   c. What would the wheel's radius be if it must be approximated as a disk?

3. A cord is wrapped around the rim of a wheel $0.25\ m$ in radius, and a steady pull of $40.\ N$ is exerted on the cord. The wheel is mounted on frictionless bearings on a horizontal shaft through its center. The rotational inertia of the wheel about this shaft is $5.0\ kgm^2$.
   a. What torque acts on the wheel?
   b. Compute the angular acceleration of the wheel.

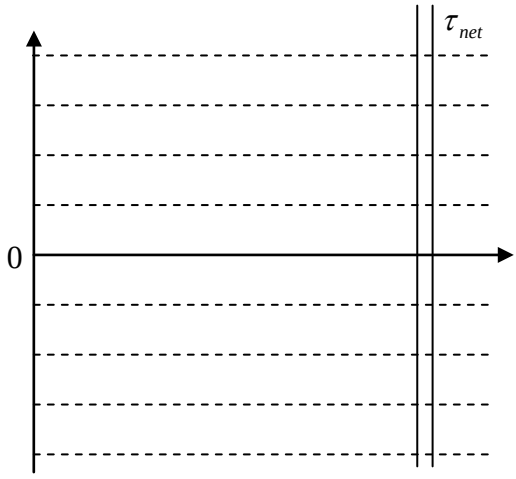
4. A thin spherical shell $\left(I = \frac{2}{3}MR^2 \right)$ has a radius of $1.90\,m$. An applied torque of $960\,Nm$ imparts to the shell an angular acceleration equal to $6.20\,{}^{rad}/_{s^2}$ about an axis through the center of the shell.
   a. What is the rotational inertia of the shell about the axis of rotation?
   b. Calculate the mass of the shell.

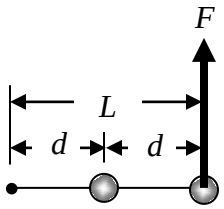
5. Two blocks, each of mass $0.25\,kg$, are suspended from the ends of a rigid, weightless rod of length $l_1 + l_2$, with $l_1 = 20.\,cm$ and $l_2 = 80.\,cm$. The rod is held in the horizontal position shown and then released.



   a. Draw an extended force diagram of the rod in the position shown.
   b. Find the rotational inertia of the system. (Treat the two masses as point particles located at the ends of the rod.)

   c. Complete the torque bar graph quantitatively. Be sure to show all possible torques, even if the force exerts no torque around the chosen axis of rotation, and show the net torque acting on the object. Then calculate the angular acceleration of the rod the instant it is released.





6. A constant force F is applied to the rightmost ball of a two ball object, each of mass m, connected by a massless rod. The force is applied in such a way that it always acts perpendicular to the rod as the object rotates in the horizontal plane from rest with no friction. Express your answers in terms of M, L, t and F only.
   a. What is the rotational inertia of the object?
   b. What torque acts on the object?
   c. What is the resulting angular acceleration of the object?

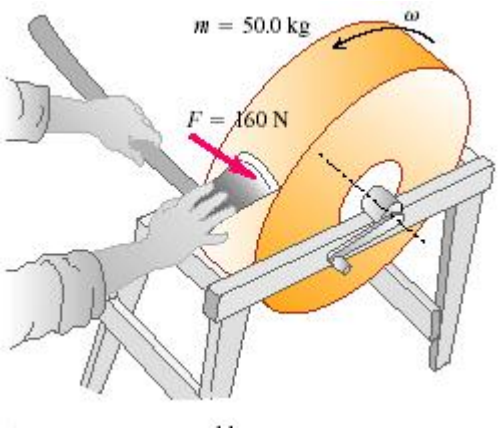
   The object rotates for a time t.

   c. What is the angular velocity of the rightmost ball?
   d. What is the angular velocity of the leftmost ball?
   e. What is the linear velocity of each ball?

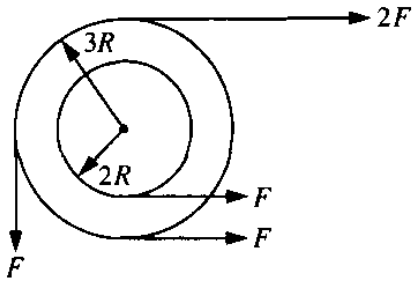
   f. What is the radial acceleration of each ball?
   g. What is the tangential acceleration of each ball?

7. A pottery wheel, initially at rest, is assumed to be a uniform disk of mass $3.0\ kg$ and radius $20.0\ cm$. A $25.0\ N$ force is applied tangentially to the rim.
   a. Determine the angular acceleration of this pottery wheel.
   b. If the force is applied for $30.0\ s$, find the instantaneous angular velocity at $30.0\ s$.
   c. Calculate the angular displacement for this wheel for the first $30\ s$?

8. A grindstone in the shape of a solid disk with diameter $0.52\ m$ and a mass of $50.\ kg$ is rotating at $89\ {}^{rad}/_{s}$. You press an ax against the rim with a normal force of $160\ N$ as in the figure below, and the grindstone comes to rest in $7.5\ s$. There is negligible friction in the bearings.
   a. What is the angular acceleration of the grindstone?



   b. What is the rotational inertia of the solid disk?
   c. What is the force of friction acting between the ax and the grindstone?
   d. Find the coefficient of kinetic friction between the ax and the grindstone.



9. A system of two wheels fixed to each other is free to rotate about a frictionless axis through the common center of the wheels and perpendicular to the page. Four forces are exerted tangentially to the rims of the wheels, as shown above. What is the net torque acting on the wheels?

10. A mass is attached to a string which is wrapped around a pulley which acts like a hoop of mass $5.0\ kg$ and radius $0.30\ m$. When the mass is allowed to fall a $20.\ N$ force of tension is measured in the string.
    a. Calculate the rotational inertia of the pulley.
    b. What torque is applied to the pulley?
    c. What is the resulting angular acceleration of the pulley?
    d. If the string does not slip on the pulley, what is the linear acceleration of the masses?
    e. Draw a force diagram of the masses as they fall. How do the forces compare? Why?
    f. What mass was hung from the string?