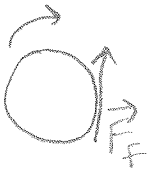
Kinematics, Torque & Moment of Inertia

1. There are two spheres of the same diameter, but one has twice the mass of the other. How much larger is the larger sphere's moment of inertia? ($\mathbf{I_{sphere} = 2/5\ mr^2}$)

2. A wheel has a moment of inertia of 3.00 kg m^2. It is subjected to a 3.50 N*m of torque. What angular acceleration does it experience? $\tau = I \cdot \alpha \rightarrow \alpha = \tau / I = \frac{3.50\ N\cdot m}{3.00\ kg\ m^2} = 1.17\ rad/s^2$

3. Mr. Henning's pottery wheel has angular velocity of 15 rad/sec. Then Mr. Henning begins to use his hands to form the clay into a beautiful vase. The friction between the clay and his hands is 2.00 N. The clay has a radius of .15 m and the wheel with clay has a moment of inertia of .11 kg m^2.



   a. What is the torque produced on the clay and wheel by the friction from Mr. Henning's hands?

$\tau = \vec{F} d = (2.00N)(.15m) = 30\ N\cdot m$

   b. How much time will it take for the clay and wheel to stop spinning?

need $\alpha \rightarrow \tau = I\alpha \rightarrow \alpha = \frac{\tau}{I} = \frac{.30\ N\cdot m}{.11\ kg\ m^2} = 2.727\ rad/s^2$

$\Delta\theta$	
ω_0	15 rad/s
ω	0 rad/s
α	2.727 rad/s^2
Δt	?

$t = 5.5s$ $0 = 15\ rad/s + (2.727\ rad/s^2)t \leftarrow \omega = \omega_0 + \alpha\Delta t$

4. A rope is wrapped around a solid cylinder of mass 10 kg with a radius of 1.5 m. What is the angular acceleration of the cylinder if a force of 5.00 N is applied parallel to the edge of the wheel? ($I_{disk} = \frac{1}{2}\ mr^2$)

$\alpha = \frac{\tau}{I} = \frac{F\cdot d}{\frac{1}{2}mr^2} = \frac{5.00\ N\cdot 1.5m}{\frac{1}{2}(10kg)(1.5m)^2} = .67\ rad/s^2$

5. Chris' rad bicycle wheel has a radius of 38 cm and is given an angular acceleration of 2.67 rad/s^2 by applying a force of 0.35 N on the edge of the wheel. What is the wheel's moment of inertia?

$I = \frac{\tau}{\alpha} = \frac{.35N\cdot.38m}{2.67\ rad/s^2} = .050\ kg\ m^2$

6. A toy top has a rod with a mass of 0.125 kg and diameter of 0.35 m. The top is spun in 1.50 s by wrapping a string around the rod and pulling it from rest to a velocity of 3.0 m/s. What torque must be applied to the system to create the velocity of 3.0 m/s? ($I_{top}=1/2mr^2$)

7. A seesaw is made from a 5.0 meter long 56.0 kg rod of uniform mass distribution which rests on a fulcrum located in the center of the rod. If a 42 kg child sits so that his center of mass is located 2.20m away from the pivot point,

   a. What is the moment of inertia of the seesaw and child? ($I_{rod}=1/12mr^2$) $I_{child} = mr^2$

$I_{tot} = I_{child} + I_{seesaw} = (mr^2) + (\frac{1}{12}mr^2) = (42kg\cdot(2.20m)^2) + \frac{1}{12}(56kg)(2.5m)^2$

   b. How much torque would be needed to cause an angular acceleration of 0.15 rad/s^2

$\tau = I\cdot\alpha = (320\ kg\ m^2)\cdot(.15\ rad/s^2) = 48\ N\cdot m$ $I_{tot} = 320$

Answers: (1) Twice as much, (2) 1.17 rad/s^2, (3a) .30 Nm, (3b) 5.5 s,
(4) 0.67rad/s^2, (5) 0.050 kgm^2, (6) 0.0218 N*m, (7a) 320 kgm^2, (7b) 48. N*m

$\alpha \rightarrow$

$\Delta\theta$	
ω_0	0 rad/s
ω	17.1 rad/s
α	?
Δt	1.5s

$V = 3.0\ m/s$ $V = r\omega$ $\omega = \frac{V}{r} = \frac{3.0\ m/s}{.175} = 17.1$

$\omega = \omega_0 + \alpha\Delta t$

$17.1\ rad/s = \alpha(1.5s)$

$\alpha = 11.43\ rad/s^2$

$\tau = I\cdot\alpha = (\frac{1}{2}mr^2)\cdot(11.43\ rad/s^2)$

$\tau = \frac{1}{2}(.125kg)(.175m)^2\cdot 11.43\ rad/s^2$

$\tau = .0219\ N\cdot m$