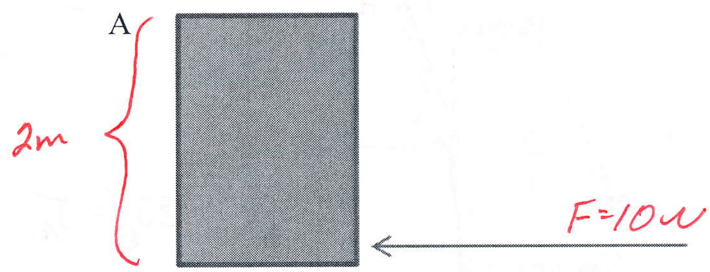
Rotational Dynamics

AT Rotational Dynamics(11)

Solve the following problems showing ALL work and CIRCLING your answers. Each is worth 5 points.

1)



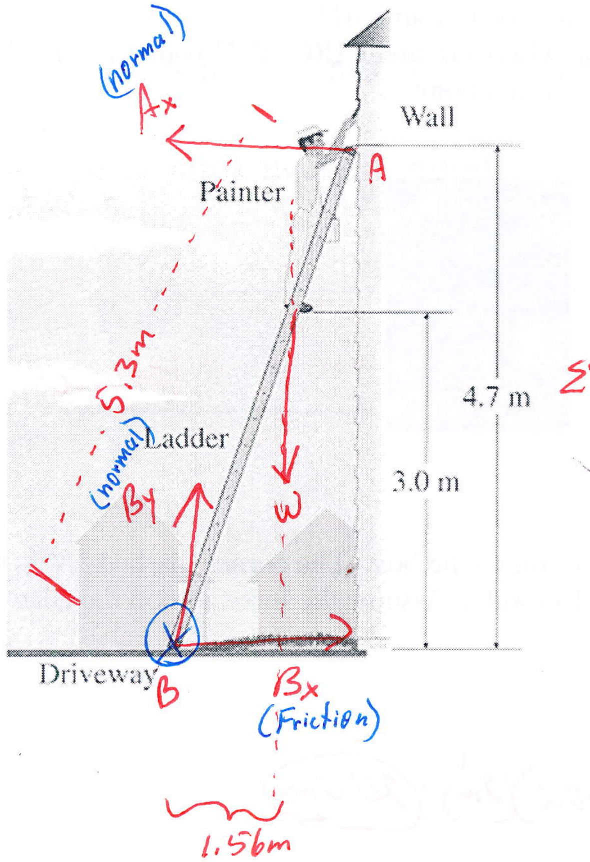
Determine the torque applied to the to the box. The corner marked "A" is the axis. The box is 2 m tall and 1 m wide. Assume the force acts on the edge F=10N

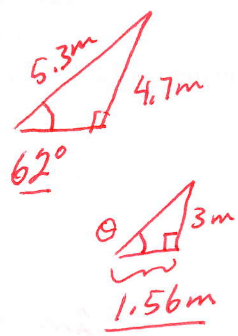
$\tau = F_{\perp} r = (10N)(2m) = 20Nm$

m = 65kg

2) From the diagram below, know that the ladder/wall contact point can be considered frictionless. Also, the ladder is 5.3m long. Determine the following items:

   a. The reaction between the wall and the ladder.
   b. The reaction between the ladder and the driveway.
   c. The minimum coefficient of friction between the ladder and the driveway.
   d. Explain if it is wise to consider the wall/ladder contact point to be frictionless.





$\tan\theta = \frac{Opp}{Adj}$

$Adj = \frac{Opp}{\tan\theta} = \frac{3m}{\tan 62°}$

$\Sigma \tau_B = \tau_A - \tau_W = 0$

$\tau_A = \tau_W$

$(A)(4.7m) = (W)(1.56m)$

$A = \frac{(65kg)(9.8 m/s^2)(1.56m)}{4.7m}$

$A = 212 N$

$\Sigma F_x = A_x - B_x = 0$

$A_x = B_x = 212 N$

$\Sigma F_y = B_y - W = 0$

$B_y = W = mg = (65kg)(9.8 m/s^2) = 637 N = B_y$

It Is Wise To Assume The Ladder/Wall Contact Is Frictionless. The Normal At "A" Is Small Compared To The Normal At "B". Any Friction At "A" Would Be Nearly Insignificant; This Friction Would Only help To Ensure The Ladder Will Not Fall.

$B_x \Rightarrow$ Friction

$B_y \Rightarrow$ Normal

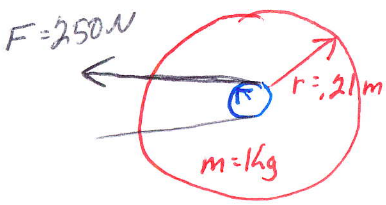
$F_f = \mu N$

$B_x = \mu B_y$

$\frac{B_x}{B_y} = \mu = \frac{212N}{637N} = .33 = \mu$

$t = 10s$

3) A wheel is constructed as a solid cylinder with a radius of 21 cm and a mass of 8 kg. A cog is attached to the center of the wheel such that the outer edge of the cog is 3 cm from the center of the wheel. A chain is attached to the cog, and is able to apply a force of 250 N to the cog (Think: like a bicycle wheel). The wheel is able to roll on a smooth level surface. Determine how far the wheel will roll if the wheel started at rest.



$r_{cog} = 3cm$

$\omega_0 = \text{Zero} \Rightarrow v_0$

$\alpha = ? \Rightarrow a$

$I = ? \Rightarrow m$

$\theta = ? \Rightarrow x$

$\tau = ? \Rightarrow F$

$x = v_0 t + \frac{1}{2} a t^2$

$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

$\theta = \frac{1}{2}\alpha t^2$

$F = ma$

$\tau = I\alpha$

$\theta = \frac{1}{2}\frac{\tau}{I}t^2$

$\theta = \frac{\tau t^2}{2I}$

$I = \frac{1}{2}mr^2$

$\theta = \frac{\tau t^2}{2(\frac{1}{2}mr^2)}$

$s = \theta r$

$\frac{s}{r} = \theta$

$\frac{s}{r} = \frac{\tau t^2}{(\frac{2}{2}mr^2)}$

$s = \frac{\tau t^2}{mr}$

$\tau = Fr = (250N)(.03m)$

$s = \frac{(250N)(.03m)(10s)^2}{(8kg)(.21m)}$

$s = 446m$

Unit Analysis

$\frac{Nms^2}{kg\,m}$

$\downarrow$

$\frac{Ns^2}{kg}$

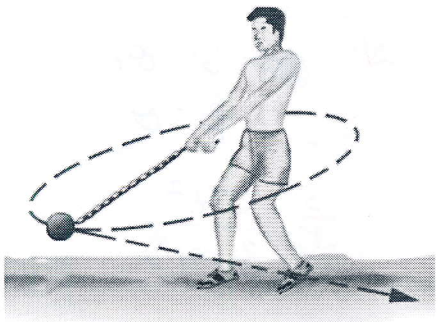
$\downarrow$

$\frac{(kg\,m/s^2)s^2}{kg}$

$\downarrow$

m

4) The hammer throw (shown below) is an Olympic event. The hammer (The metal ball at the end) has a mass of 6kg (as researched online) The chain that is shown is 39 inches long, and can be assumed to be massless when compared to the mass of the hammer. The ball has a radius of 4 cm. Determine the rotational inertia of the hammer. There are 2.54 cm in an inch.



$I = mr^2$ (particle)

$I = (6kg)\left[(39in)\left(\frac{2.54cm}{1in}\right)\left(\frac{1m}{1000cm}\right)\right]^2$

$I = 5.89\ kg\ m^2$

$I = mr^2$ (particle)

$I = 6kg)\left[(39in\left(\frac{2.54cm}{1in}\right)\left(\frac{1m}{1000m}\right)\right]^2$

5) A set of keys are attached to a lanyard that is 0.6 m long. These keys are spun at the full length of the lanyard at a rate of 2 revs per second. The lanyard is then shortened (like by allowing it to wrap around your fingers) determine the linear speed of the keys when they are just 3 cm from your hand.

$L_0 = L$

$I_0 \omega_0 = I \omega$

$m r_0^2 2\pi f_0 = m r^2 \cancel{2\pi f} \frac{v}{r}$

$m r_0^2 2\pi f_0 = m r v$

$2\pi r_0^2 f_0 = r v$

$\frac{2\pi f_0 r_0^2}{r} = v = \frac{2\pi (2 \text{ Rev/s})(.6m)^2}{(.03m)} = v = 151 \text{ m/s}$

$r_0 = .6m$

$f_0 = 2 \text{ Rev/s}$

$r = .03m$

6) For those of you going to Six Flags, you will be treated to a really neat example of conservation of Angular Momentum on Nitro. Near the end of the ride, there will be a double helix spiraling upward. (If you don't know what a "helix" is... please ask) While going uphill, you (at least seem to) gain speed. What is done to the design of the track to make this happen? There are no energy sources within the track. Respond in a few statements.

The Radius of the helix Decreases, so Just Like In the Prior "Lanyard" Problem, Conservation of Angular Momentum, Speed Increases.

7) A wheel with a rotational inertia of 14.8.kgm2 is spinning at 14 RPM. Determine the angular acceleration of the wheel of a torque of 120Nm are applied to the wheel.

$F = ma$

$\tau = I\alpha$

$\frac{\tau}{I} = \alpha = \cancel{14.8\,kgm^2} = \frac{120\,Nm}{14.8\,kgm^2} = 8.1\ rad/s^2$