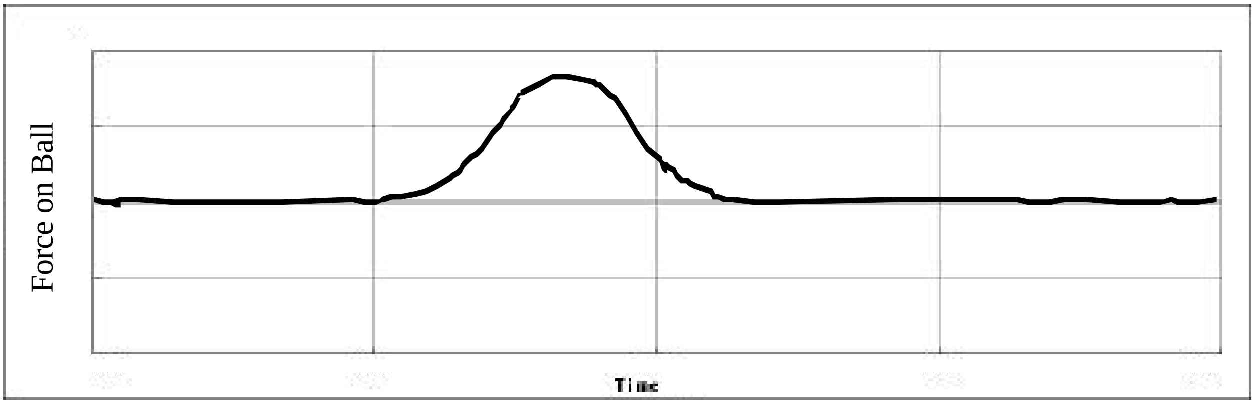
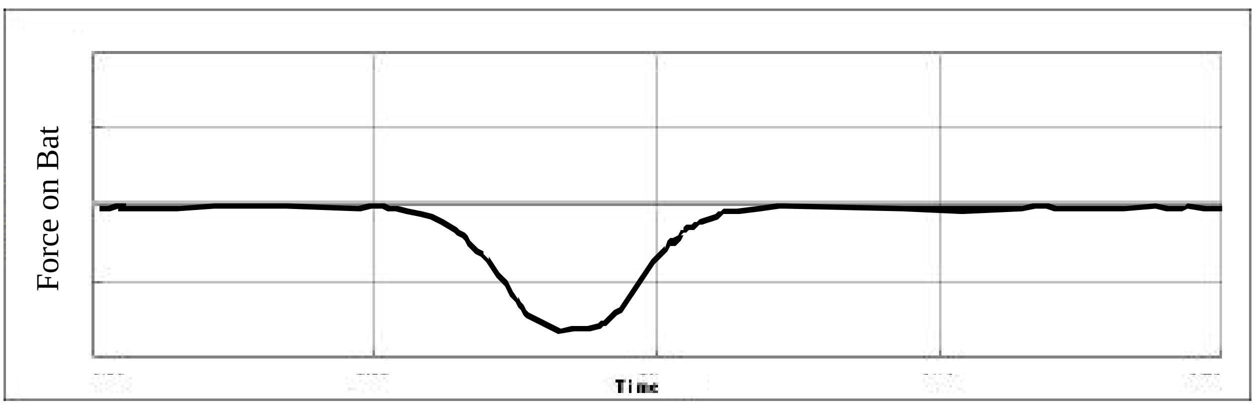
Name:____

Solve the following problems in the space provided. Use the back of the page if needed. Each problem is worth 20 points. You must show your work in a logical fashion starting with the correctly applied physical principles shown on the last page. Your score will be maximized if your work is easy to follow because partial credit will be awarded.

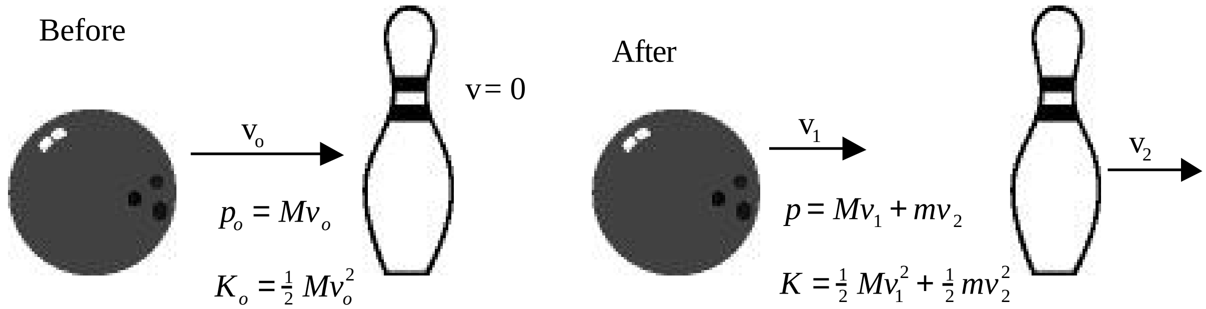
1. A 0.145kg baseball collides with a 1.10kg baseball bat. (a)On the upper graph below sketch the force felt by the ball as a function of time. (b)On the lower graph sketch the force felt by the bat as a function of time. (c)Explain your thinking as well as the important features of your curves.





The key idea is Newton's Third Law. At every instant during the short time of the collision, the forces are equal and opposite. Other features of the graph include the fact that the force is probably not constant during the collision and the force lasts for only a short time.

2. A 7.00kg bowling ball traveling at 5.00m/s make a head-on elastic collision with 2.00kg bowling pin initially at rest. Find (a)the speed of the ball after the collision and (b)the speed of the pin after the collision.



Using the Law of Conservation of Momentum, $p_o = p$ $\quad Mv_o = Mv_1 + mv_2$ $\quad v_2 = \frac{M}{m}(v_o - v_1)$

Require that the collision be elastic, $K_o = K$ $\quad \frac{1}{2}Mv_o^2 = \frac{1}{2}Mv_1^2 + \frac{1}{2}mv_2^2$ $\quad \frac{M}{m}(v_o^2 - v_1^2) = v_2^2$.

Substituting the momentum result into the elasticity result, $\frac{M}{m}(v_o^2 - v_1^2) = \left(\frac{M}{m}\right)^2 (v_o - v_1)^2$.

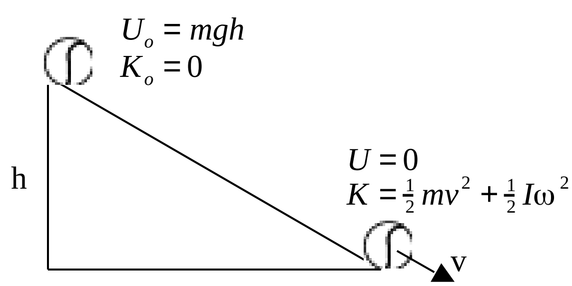
This gives a quadratic equation, $v_1^2 - 2\frac{M}{M+m}v_o v_1 + \frac{M-m}{M+m}v_o^2 = 0$.

The solution is, $v_1 = v_o$ or $v_1 = \frac{M-m}{M+m}v_o$. The first solution is the no collision case.

We want the second solution, $v_1 = \frac{7-2}{7+2}5$ $\quad \boxed{v_1 = 2.78m/s}$.

Subbing back into the momentum result, $v_2 = \frac{M}{m}(v_o - v_1) = \frac{7}{2}(5 - 2.78)$ $\quad \boxed{v_2 = 7.78m/s}$.

3. A 0.145kg baseball starts near rest and rolls without slipping down a 55.0cm high pitchers mound. Find the speed of the ball at the bottom.



Using the Law of Conservation of Energy,
$\Delta U + \Delta K = 0 \qquad (0 - mgh) + (\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2) = 0$

Since the ball rolls without slipping, $\omega = \frac{v}{r}$.

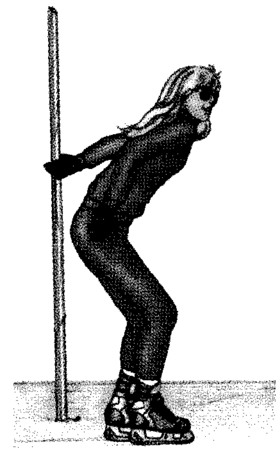
The rotational inertia of a sphere is, $I = \frac{2}{5}mr^2$.

Substituting into the Conservation of Energy equation,

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}(\frac{2}{5}mr^2)\frac{v^2}{r^2} \qquad mgh = \frac{1}{2}mv^2 + \frac{1}{5}mv^2 \qquad mgh = \frac{7}{10}mv^2.$$

Canceling the mass and solving for the speed,
$v = \sqrt{\frac{10}{7}gh} = \sqrt{\frac{10}{7}(9.80)(0.550)}$ $\quad \boxed{v = 2.77m/s}$.

4. A 60.0kg ice skater moving at 4.00m/s reaches out and grabs a 10.0cm diameter pole to reverse direction. Assume that as she rotates around the pole her center of mass is 75.0cm from the center of the pole. She releases the pole after 0.500s heading back the way she came at 3.50m/s. Find (a)her initial angular momentum relative to the center of the pole, (b)her final angular momentum relative to the center of the pole and (c)the average frictional force between her hand and the pole.



(a)The angular momentum for a point mass is, $\vec{L} = \vec{r} \times \vec{p} \quad L_o = rmv_o$

Plugging in the numbers, $L_o = (0.750)(60.0)(4.00)$ $\boxed{L_o = 180 kg\ \ m^2/s}$.

(b)Again, $\vec{L} = \vec{r} \times \vec{p} \quad L = rmv = (0.75)(60.0)(3.50)$ $\boxed{L = 158 kg\ \ m^2/s}$.

(c)Using the Second Law for Rotation,

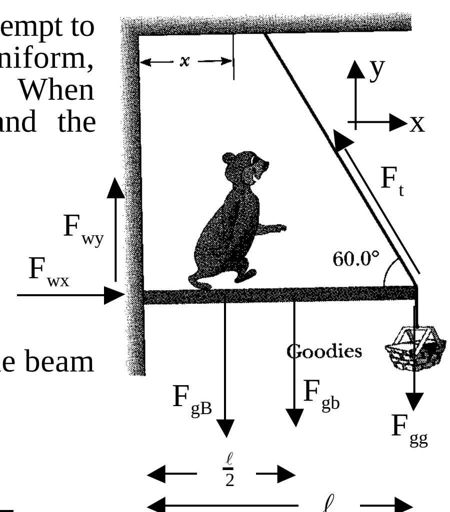
$$\Sigma\tau = \frac{dL}{dt} \quad \tau_{fr} = \frac{\Delta L}{\Delta t} \quad \tau_{fr} = \frac{L - L_o}{t}.$$

According to the definition of torque, the frictional torque is the radius of the pole times the frictional force.

$$\vec{\tau} = \vec{r} \times \vec{F} \quad \tau_{fr} = r_p F_{fr} \quad r_p F_{fr} = \frac{L - L_o}{t} \quad F_{fr} = \frac{L - L_o}{t r_p}.$$

Putting in the numbers, $F_{fr} = \dfrac{180 - 158}{(0.500)(0.0500)}$ $\boxed{F_{fr} = 880N}$.

5. A hungry bear weighing 700N walks out on a beam in an attempt to retrieve a basket of food hanging at the end. The beam is uniform, weights 200N, and is 6.00m long. The basket weighs 80.0N. When the bears is at x=2.00m, find the tension in the wire and the components of the force exerted by the wall on the beam.



Applying Newton's Second Law,

$$\Sigma F_x = ma_x \quad F_{wx} - F_t \cos 60^\circ = 0$$

$$\Sigma F_y = ma_y \quad F_{wy} + F_t \sin 60^\circ - F_{gB} - F_{gb} - F_{gg} = 0.$$

Apply the Second Law for Rotation about the point where the beam connects to the wall,

$$\Sigma\tau = I\alpha \quad \ell F_t \sin 60^\circ - xF_{gB} - \tfrac{\ell}{2} F_{gb} - \ell F_{gg} = 0$$

Solving for the tension,

$$F_t = \frac{\frac{x}{\ell} F_{gB} + \frac{1}{2} F_{gb} + F_{gg}}{\sin 60^\circ} = \frac{\frac{2.00}{6.00}(700) + \frac{1}{2}(200) + 80}{\sin 60^\circ} \quad \boxed{F_t = 477N}.$$

Substituting back into the x and y equations,

$$F_{wx} = F_t \cos 60^\circ = (477)\cos 60^\circ \quad \boxed{F_{wx} = 239N}.$$

$$F_{wy} = F_{gB} + F_{gb} + F_{gg} - F_t \sin 60^\circ = 700 + 200 + 80.0 - (477)\sin 60^\circ \quad \boxed{F_{wy} = 567N}.$$