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. The equations you need are on the equation sheet. Your score will be maximized if your work is easy to follow because partial credit will be awarded.

1. A girl jumps upward from Earth as shown at the right. Consider only the situation while she is at the top of her flight.
(a)State the Law of Conservation of Linear Momentum. It can be in your own words.

The linear momentum of an isolated system of objects remains constant.

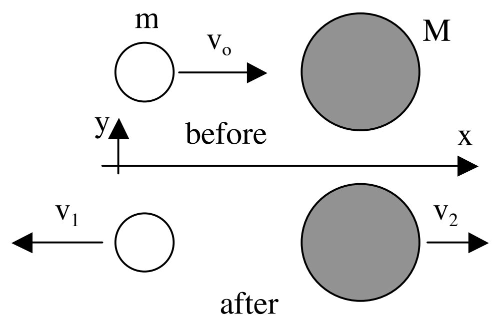
(b)Does the girl, alone as a system, obey the Law of Conservation of Linear Momentum? Explain fully.

A law is a law! The girl as a system must obey the law. However, she is not isolated. She feels an external force exerted by Earth and therefore, her linear momentum will not remain constant. It will change as she speeds up toward the ground. This is her way of obeying the Law of Conservation of Linear Momentum.

(c)Does the girl and Earth, together as a system, obey the Law of Conservation of Linear Momentum? Explain.

Again, a law is a law. This time however, the system of the girl and Earth is isolated and the total momentum of the system will not change. The force that Earth exerts on the girl and the force that the girl exerts on Earth are equal and opposite according to the Third Law. These forces are internal to the system. The girl moves downward and Earth moves upward in such a way that the total momentum remains zero. The Law of Conservation of Linear Momentum is obeyed and the total momentum of the system will remain constant.

2. A rude spectator at a hockey game throws an 85.0g coin that skids across the ice. The coin collides head-on at a speed of 3.00m/s with a 350g hockey puck at rest. After the collision, the puck heads off in the same direction that the coin came from at a speed of 1.00m/s. (a)Find the velocity of the coin after the collision and (b)determine if the collision is elastic.

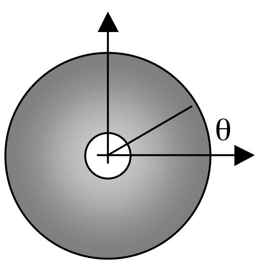


(a)The initial momentum is just due to the coin, $p_o = mv_o$.
The final momentum is $p = Mv_2 - mv_1$.
Applying the Law of Conservation of Linear Momentum,
$Mv_2 - mv_1 = mv_o \Rightarrow v_1 = \frac{M}{m}v_2 - v_o$.
Plugging in the numbers,
$v_1 = \frac{350}{85.0}(1.00) - 3.00 \Rightarrow \boxed{v_1 = 1.12m/s}$.
The coin bounces off in the opposite direction as shown.

(b)To check for elasticity, we must compare the initial kinetic energy with the final kinetic energy,
$K_o = \frac{1}{2}mv_o^2 = \frac{1}{2}(0.0850)(3.00)^2 \Rightarrow K_o = 0.383J$.
$K = \frac{1}{2}mv_1^2 + \frac{1}{2}Mv_2^2 = \frac{1}{2}(0.0850)(1.12)^2 + \frac{1}{2}(0.350)(1.00)^2 \Rightarrow K = 0.228J$.

Since the kinetic energy is less after the collision than before, the collision is $\boxed{\text{inelastic}}$.

3. After turning off the DVD player, the disc slows from 27.5rad/s to a stop at a constant rate of 10.0rad/s^2. Find (a)the time needed to bring the disc to rest and (b)the angle through which it rotates.



$\theta_o = 0$
$\theta = ?$
$\omega_o = 27.5$rad/s
$\omega = 0$
$\alpha = -10.0$rad/s^2
$t = ?$

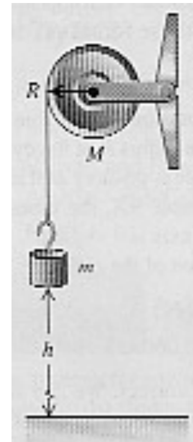
(a) Using the rotational kinematic equation without the final angle,

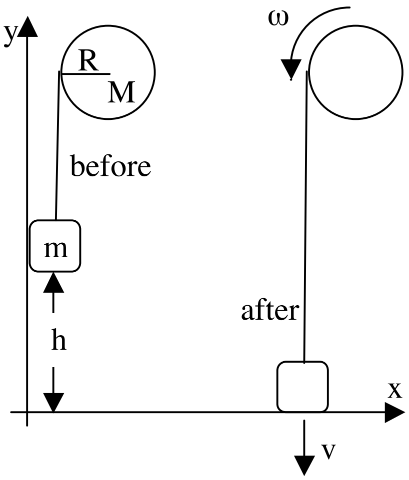
$$\omega = \omega_o + \alpha t \Rightarrow t = \frac{\omega_o}{-\alpha} = \frac{27.5}{10.0} \Rightarrow \boxed{t = 2.75s}.$$

(b) Using the rotational kinematic equation without the time,

$$\omega^2 = \omega_o^2 + 2\alpha(\theta - \theta_o) \Rightarrow \theta = \frac{\omega_o^2}{-2\alpha} = \frac{(27.5)^2}{2(10.0)} \Rightarrow \boxed{\theta = 37.8rad}.$$

4. A light cable is wrapped around a drum several times. The drum is a solid cylinder with a mass of 10.0kg and radius 10.0cm. The other end of the cable is connected to a 1.00kg mass that is at rest a distance 2.00m above the floor when the drum is released and allowed to spin. Find the speed of the mass when it strikes the floor.





Initially, the kinetic energy is zero and the hanging mass has some gravitational potential energy, $K_o = 0$ and $U_o = mgh$.

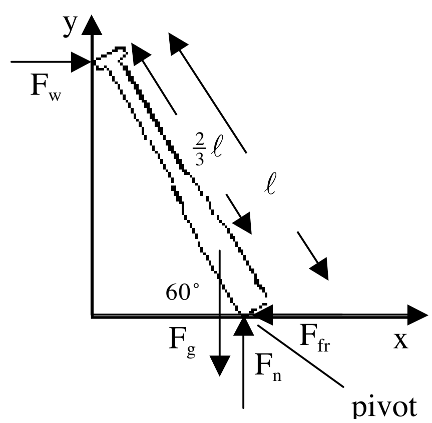
At the bottom, the potential energy is gone and there is kinetic energy in the motion of both the hanging mass and rotating cylinder, $K = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$ and $U = 0$.

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

The rotational inertia of a cylinder is, $I = \frac{1}{2}MR^2$.
The tangential velocity of the cylinder must equal the velocity of the hanging mass so, $v = R\omega$.
Substituting into the energy equation, $mgh = \frac{1}{2}mv^2 + \frac{1}{2}(\frac{1}{2}MR^2)\frac{v^2}{R^2} = \frac{1}{2}mv^2 + \frac{1}{4}Mv^2 = \left(\frac{1}{2}m + \frac{1}{4}M\right)v^2$.

Solving for the speed, $v = \sqrt{\dfrac{mgh}{\frac{1}{2}m + \frac{1}{4}M}} = \sqrt{\dfrac{(1.00)(9.80)(2.00)}{\frac{1}{2}(1.00) + \frac{1}{4}(10.0)}} \Rightarrow \boxed{v = 2.56 m/s}$.

5. A baseball bat leans against a smooth wall making a 60° angle with the ground. The center of mass is two-thirds of the way down the bat. Find the minimum coefficient of static friction needed to keep the bat in place.



Applying Newton's Second Law,
$\Sigma F_x = ma_x \Rightarrow F_w - F_{fr} = 0 \Rightarrow F_{fr} = F_w$
$\Sigma F_y = ma_y \Rightarrow F_n - F_g = 0 \Rightarrow F_n = F_g$
$\Sigma \tau_p = I\alpha \Rightarrow F_g \frac{\ell}{3}\cos 60° - F_w \ell \sin 60° = 0 \Rightarrow F_w \ell \sin 60° = F_g \frac{\ell}{3}\cos 60°$

The definition of the COSF is, $\mu = \dfrac{F_{fr}}{F_n}$.

Using the force equations, $\mu = \dfrac{F_{fr}}{F_n} = \dfrac{F_w}{F_g}$

Using the torque equation, $\mu = \dfrac{F_w}{F_g} = \dfrac{\frac{\ell}{3}\cos 60°}{\ell \sin 60°} = \dfrac{1}{3\tan 60°} \Rightarrow \boxed{\mu = 0.192}$.