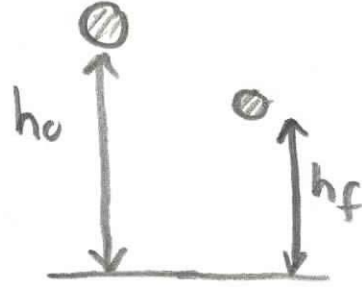


Part Two: Earlier Material

Problem 1: (Momentum and Impulse)

A superball of $m_1 = 0.08\text{kg}$, starting at rest, is dropped from a height falls $h_0 = 3.0\text{m}$ above the ground and bounces back up to a height of $h_f = 2.0\text{m}$. The collision with the ground occurs over $\Delta t_c = 5.0\text{ms}$.



- What is the momentum of the ball immediately before the collision?
- What is the momentum of the ball immediately after the collision?
- What is the average force of the table on the ball?
- What impulse is imparted to the ball?
- What is the change in the kinetic energy during the collision?
- Assume that the rubber has a specific heat capacity of $c_r = 0.48\text{cal} \cdot \text{g}^{-1} \cdot ^\circ\text{C}^{-1}$ and that all the lost mechanical energy goes into heating up the rubber. What is the change in temperature of the superball?

~~Problem 2: (Conservation of Energy and Momentum)~~

~~An object of mass $m_1 = 1.5\text{kg}$ is initially moving with a velocity v_0 . It collides completely inelastically with a block of mass $m_2 = 2.0\text{kg}$. The second block is attached to a spring with constant $k = 5.6 \times 10^3 \text{N} \cdot \text{m}^{-1}$. The block and spring lie on a frictionless horizontal surface. The spring compresses a distance $d = 2.0 \times 10^{-1} \text{m}$.~~

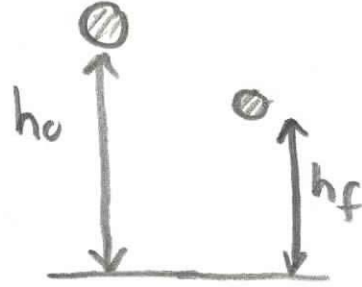


- ~~What is the velocity of the object of mass m_1 and the block immediately after the collision?~~

Part Two: Earlier Material

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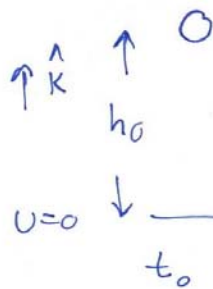
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$$U_0 = mgh_0, K_0 = 0$$

$$E_0 = mgh_0$$

$$U_1 = 0, K_1 = \frac{1}{2}mv_1^2$$

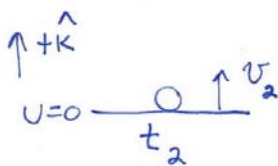
$$E_1 = \frac{1}{2}mv_1^2$$

Conservation of Energy: $E_0 = E_1 \Rightarrow$

$$mgh_0 = \frac{1}{2}mv_1^2 \Rightarrow v_1 = \sqrt{2gh_0}$$

$$\vec{P}_1 = -mv_1\hat{k} = m\sqrt{2gh_0}(-\hat{k}) = (0.08\text{ kg})(2)(9.8\frac{\text{m}}{\text{s}^2})(3.0\text{ m})^{1/2}(-\hat{k})$$

$$\vec{P}_1 = (6.1 \times 10^{-1} \text{ kg}\cdot\text{m}\cdot\text{s}^{-1})(-\hat{k})$$



$$U_2 = 0, K_2 = \frac{1}{2}mv_2^2, E_2 = \frac{1}{2}mv_2^2$$

$$U_f = mgh_f, K_f = 0, E_f = mgh_f$$

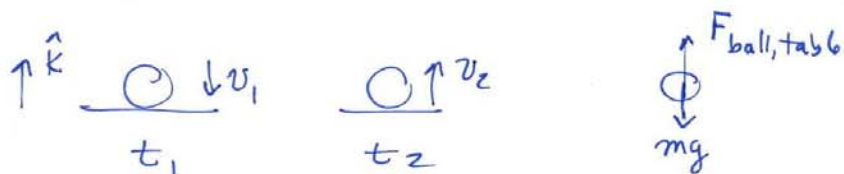
Conservation of Energy: $E_2 = E_f$

$$\frac{1}{2}mv_2^2 = mgh_f \Rightarrow v_2 = \sqrt{2gh_f}$$

$$\vec{P}_2 = mv_2\hat{k} = m\sqrt{2gh_f}\hat{k} =$$

$$\vec{P}_2 = 0.08\text{ kg} \sqrt{(2)(9.8\frac{\text{m}}{\text{s}^2})(2.0\text{ m})} \hat{k} = 5.0 \times 10^{-1} \text{ kg}\frac{\text{m}}{\text{s}} \hat{k}$$

During the collision: $\Delta t_c = t_2 - t_1$



$$\vec{F}_{\text{ext}} \Delta t_c = \Delta \vec{p}$$

$$\vec{F}_{\text{ball,table}} - mg = \left(m v_2 - (-m v_1) \right) \hat{k}$$

$$\vec{F}_{\text{ball,table}} = mg + m \frac{(v_2 + v_1)}{\Delta t_c} \hat{k} = m \left(g + \frac{(v_2 + v_1)}{\Delta t_c} \right) \hat{k}$$

$$\vec{F}_{\text{ball,table}} = (0.08 \text{ kg}) \left(9.8 \frac{\text{m}}{\text{s}^2} + \sqrt{2} \sqrt{9.8 \frac{\text{m}}{\text{s}^2}} \frac{(\sqrt{h_0} + \sqrt{h_f})}{(5.0 \times 10^{-3} \text{ s})} \right) = (2.2 \times 10^2 \text{ N}) \hat{k}$$

$$\begin{aligned} \text{Impulse} &= \Delta \vec{p} = m(v_2 + v_1) \hat{k} \\ &= (1.1 \text{ kg} \cdot \frac{\text{m}}{\text{s}}) \hat{k} \end{aligned}$$

$$\Delta K = \frac{1}{2} m v_2^2 - \frac{1}{2} m v_1^2 = mg(h_f - h_0) = (0.08 \text{ kg}) \left(9.8 \frac{\text{m}}{\text{s}^2} \right) (-1.0 \text{ m})$$

$$\Delta K = -0.78 \text{ J}$$

$$-\Delta K = c m \Delta T \Rightarrow \Delta T = \frac{-\Delta K}{c m} = \frac{mg(h_0 - h_f)}{c m}$$

$$1 \text{ cal} = 4.186 \text{ J}$$

$$\Delta T = \frac{(-0.78 \text{ J})}{(0.08 \text{ kg})(0.48 \text{ cal} \cdot \text{g}^{-1} \cdot ^\circ\text{C}^{-1})} = \frac{(-0.78 \text{ J}) \left(\frac{1 \text{ cal}}{4.186 \text{ J}} \right)}{(80 \text{ g})(0.48 \text{ cal} \cdot \text{g}^{-1} \cdot ^\circ\text{C}^{-1})}$$

$$\Delta T = 4.85 \times 10^{-3} \text{ } ^\circ\text{C}$$