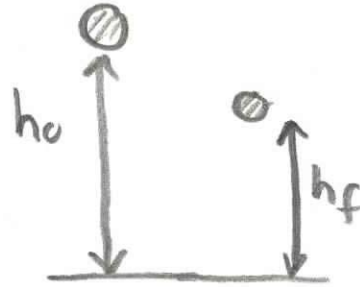


## Part Two: Earlier Material

### ~~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  $\Delta t_c = 5.0\text{ms}$ .~~



- ~~a) What is the momentum of the ball immediately before the collision?~~
- ~~b) What is the momentum of the ball immediately after the collision?~~
- ~~c) What is the average force of the table on the ball?~~
- ~~d) What impulse is imparted to the ball?~~
- ~~e) What is the change in the kinetic energy during the collision?~~
- ~~f) 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  $d = 2.0 \times 10^{-1}\text{m}$ .



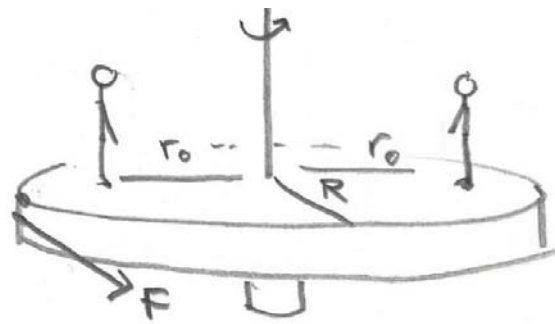
- a) What is the velocity of the object of mass  $m_1$  and the block immediately after the collision?

- b) What is the initial velocity of the object of mass  $m_1$  immediately before the collision?
- c) If the block were attached to a very long string and hung as a pendulum, how high would the block and object of mass  $m_1$  rise after the collision? Let  $g = 9.8 \text{ m} \cdot \text{s}^{-2}$ .

**Problem 3: (Angular Dynamics)**

A playground merry go round has a radius of  $R = 4.0 \text{ m}$  and has a moment of inertia  $I_{cm} = 7.0 \times 10^3 \text{ kg} \cdot \text{m}^2$  about an axis passing through the center of mass. There is negligible friction about its vertical axis. Two children each of mass  $m = 25 \text{ kg}$  were standing on opposite sides a distance  $r_0 = 3.0 \text{ m}$  from the central axis. The merry go round is initially at rest. A person on the ground applied a constant tangential force of

$F = 2.5 \times 10^2 \text{ N}$  at the rim of the merry go round for a time  $\Delta t = 1.0 \times 10^1 \text{ s}$ .



- a) What was the angular acceleration of the merry go round?
- b) What was the angular velocity of the merry go round when the person stopped applying the force?
- c) What average power did the person put out while pushing the merry go round?
- d) What was the rotational kinetic energy of the merry go round when the person stopped applying the force?

The two children then walked inward and stop a distance of  $r_1 = 1.0 \text{ m}$  from the central axis of the merry go round.

- e) What was the angular velocity of the merry go round when the children reached their final position?
- f) What was the change in rotational kinetic energy of the merry go round when the children reached their final position?

**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  $d = 2.0 \times 10^{-1} \text{ m}$ .



- a) What is the velocity of the object of mass  $m_1$  and the block immediately after the collision?
- b) What is the initial velocity of the object of mass  $m_1$  immediately before the collision?
- c) If the block were attached to a very long string and hung as a pendulum, how high would the block and object of mass  $m_1$  rise after the collision? Let  $g = 9.8 \text{ m} \cdot \text{s}^{-2}$ .

initial  $\boxed{m_1} \rightarrow v_{1,0}$   $\boxed{m_2} \leftarrow v_{2,0} = 0$   $\rightarrow \hat{i}$

after  $\boxed{m_1 m_2} \rightarrow v_f$   $\leftarrow \hat{i}$

$$\vec{p}_0 = \vec{p}_f \Rightarrow m_1 v_0 = (m_1 + m_2) v_f$$

$$v_f = \frac{m_1 v_0}{m_1 + m_2}$$

$$\frac{1}{2} (m_1 + m_2) v_f^2 = \frac{1}{2} k d^2$$

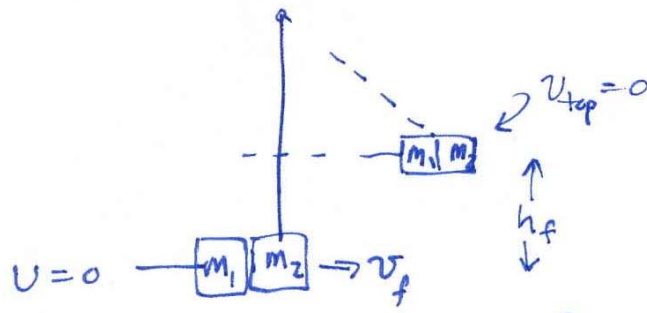
final  $\boxed{m_1 m_2} \leftarrow d \rightarrow$  compressed

$$\frac{1}{2} (m_1 + m_2) \left( \frac{m_1^2 v_0^2}{(m_1 + m_2)^2} \right) = \frac{1}{2} k d^2$$

$$v_0 = \left( \frac{(k d^2) (m_1 + m_2)}{m_1^2} \right)^{1/2}$$

$$v_0 = \left( \frac{(5.6 \times 10^3 \text{ N}\cdot\text{m}^{-1}) (2.0 \times 10^{-1} \text{ m})^2 (1.5 \text{ kg} + 2.0 \text{ kg})}{(1.5 \text{ kg})^2} \right)^{1/2}$$

$$v_0 = 1.87 \times 10^1 \text{ m}\cdot\text{s}^{-1}$$



$E_f = mgh_f$   
 $E_f = (m_1 + m_2)gh_f$   
 $(m_1 + m_2)gh_f$   
 $E_i = \frac{1}{2} (m_1 + m_2) v_f^2 = mgh_f = E_f$

$$\Rightarrow h_f = \frac{v_f^2}{2g} = \frac{1}{2g} \left( \frac{m_1 v_0}{m_1 + m_2} \right)^2$$

$$h_f = \frac{1}{2g} \frac{m_1^2}{(m_1 + m_2)^2} \frac{k d^2 (m_1 + m_2)}{m_1^2}$$

$$h_f = \frac{1}{2} \frac{k d^2}{g (m_1 + m_2)} = \left( \frac{1}{2} \right) \frac{(5.6 \times 10^3 \text{ N} \cdot \text{m}^{-1}) (2.0 \times 10^{-1} \text{ m})^2}{(2) (9.8 \frac{\text{m}}{\text{s}^2}) (1.5 \text{ kg} + 2.0 \text{ kg})}$$

$$h_f = 3.3 \text{ m}$$