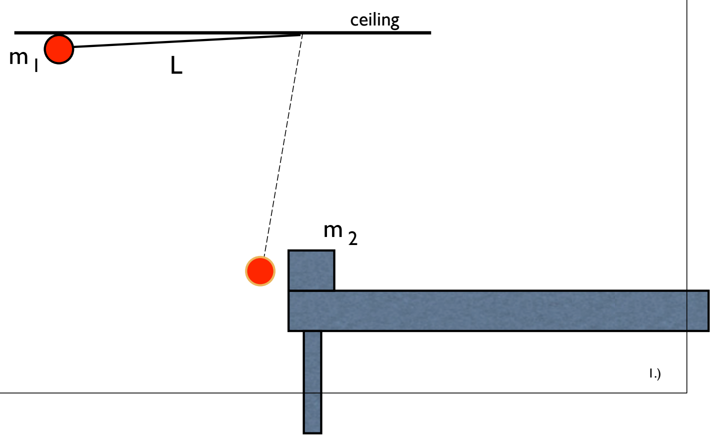
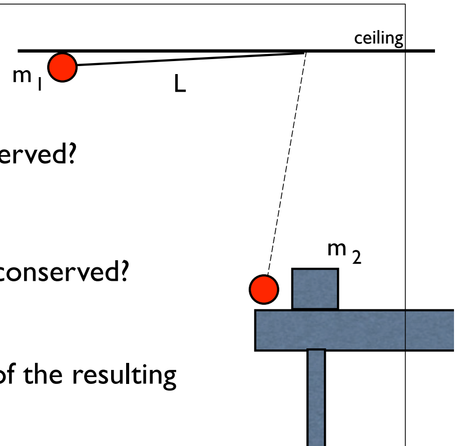
Swinging Ball Hits Block

Consider the set-up below:



Between the time the ball leaves the ceiling to after the collision:



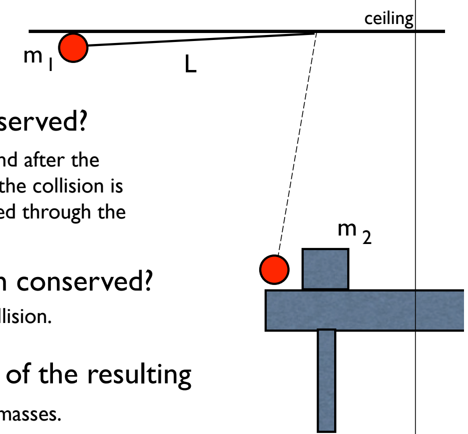
When, if at any time, is energy conserved?

When, if at any time, is momentum conserved?

What will determine the direction of the resulting velocities after the collision?

What sign-posts exist in this problem?

Between the time the ball leaves the ceiling to after the collision:



When, if at any time, is energy conserved?

From the ceiling to just before the collision, and after the collision. If the amount of energy lost during the collision is given, the modified c. of e. equation can be used through the collision.

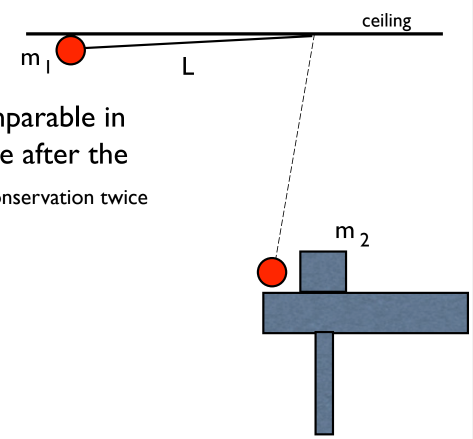
When, if at any time, is momentum conserved?

In the "x" direction, only THROUGH the collision.

What will determine the direction of the resulting velocities after the collision? The masses.

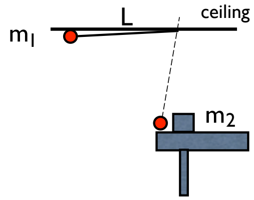
What sign-posts exist in this problem?

For energy, the fact that there is a falling body.
For momentum, the fact that there is a collision between two bodies that can freely respond to the internal impulse experienced.



Assuming the masses are comparable in size, what will the velocities be after the collision? You need to use energy conservation twice and momentum conservation once.

Assuming the masses are comparable in size, what will the velocities be after the collision?



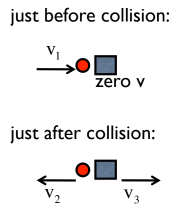
To determine the ball's velocity v_1 just before the collision:

$$\sum KE_1 + \sum U_1 + \sum W_{extraneous} = \sum KE_2 + \sum U_2$$

$$0 \quad + \; mgL \; + \quad 0 \quad = \frac{1}{2}m_1 v_1^2 + \quad 0$$

$$\Rightarrow \quad v_1 = (2gL)^{1/2}$$

To begin to make sense of the ball and block after collision:

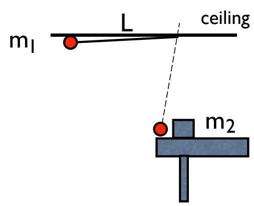


$$\sum p_{1,x} + \sum F_{ext,x}\Delta t = \sum p_{2,x}$$

$$m_1 v_1 \;+\; 0 \;= m_1 v_2 + m_2 v_3$$

We need one more equation. To get it, we would have to know something about the system's energy loss through the collision

As an example, you could be told that one-third of the kinetic energy of the system was lost during the collision. Then the modified conservation of energy relationship through the collision would look like:



$$\sum KE_1 + \sum U_1 + \sum W_{extraneous} = \sum KE_2 + \sum U_2$$

$$\frac{1}{2}m_1 v_1^2 + \quad 0 \quad + \left[-\frac{1}{3}\left(\frac{1}{2}m_1 v_1\right)\right] = \left(\frac{1}{2}m_1 v_2^2 + \frac{1}{2}m_2 v_3^2\right) + \quad 0$$

Or you could be told that two-thirds of the kinetic energy of the system was left after the collision. Then the modified conservation of energy relationship would still look like:

$$\sum KE_1 + \sum U_1 + \sum W_{extraneous} = \sum KE_2 + \sum U_2$$

$$\frac{1}{2}m_1 v_1^2 + \quad 0 \quad + \left[-\frac{1}{3}\left(\frac{1}{2}m_1 v_1\right)\right] = \left(\frac{1}{2}m_1 v_2^2 + \frac{1}{2}m_2 v_3^2\right) + \quad 0$$

Or you could be given a number that denotes how much energy was lost

$$\sum KE_1 + \sum U_1 + \sum W_{extraneous} = \sum KE_2 + \sum U_2$$

$$\frac{1}{2}m_1 v_1^2 + \quad 0 \quad + [-12 \text{ joules}] = \left(\frac{1}{2}m_1 v_2^2 + \frac{1}{2}m_2 v_3^2\right) + \quad 0$$

Any of these options would give us our last equation.