Question #58364, Physics / Mechanics | Relativity

A 0.024-kg bullet is fired vertically at 225m/s into a 0.15-kg baseball that is initially at rest. How high does the combined bullet and baseball rise after the collision, assuming the bullet embeds itself in the ball?

Solution:
When the bullet hits the baseball, its momentum is transferred to the baseball. So, the baseball and the bullet in it obtain speed and therefore kinetic energy, which allows them to reach specific height above original position.

1. When the bullet hits the block, conservation of momentum takes place:

$$m_b v_0 = (m_b + m_{bb})v;$$

$$v = \frac{m_b v_0}{(m_b + m_{bb})}; \quad (1)$$

m_b – bullet mass;
m_{bb} – baseball mass;
v_0 – initial bullet speed;
v – final speed of the system (baseball + bullet)

2. When the baseball starts moving with the bullet inside, energy conservation takes place. The kinetic energy of baseball & bullet is transformed to potential energy, as they reach maximum height:

$$\Delta E_k = \Delta PE;$$

$$\Delta E_k = \frac{(m_b + m_{bb})v^2}{2};$$

$$\Delta PE = (m_b + m_{bb})g\Delta h;$$

$$\frac{(m_b + m_{bb})v^2}{2} = (m_b + m_{bb})g\Delta h;$$

$$\Delta h = \frac{(m_b + m_{bb})v^2}{2(m_b + m_{bb})g} = \frac{v^2}{2g}; \quad (2)$$

Substituting (1) into (2):

$$\Delta h = \frac{m_b^2 v_0^2}{2g(m_b + m_{bb})^2};$$

$$\Delta h = \frac{0.024^2 \times 225^2}{2 \times 9.8(0.024 + 0.15)^2} = 49.14 \text{ m}$$

Answer: 49.14 m