Answer on Question 59235, Physics, Mechanics, Relativity

Question:

A $10\,g$ bullet of unknown speed is shot horizontally into a $2\,kg$ block of wood suspended from the ceiling by a cord. The bullet hits the block and becomes lodged in it. After the collision, the block and the bullet swing to a height $30\,cm$ above the original position. What was the speed of the bullet? (this device is called the ballistic pendulum). Take $g = 9.8\,ms^{-2}$.

Solution:

According to the Law of Conservation of Energy, the kinetic energy of the system of block of wood and the bullet must be equal to the change in potential energy of the system of block of wood and the bullet:

$$\frac{1}{2}(M_{block} + m_{bullet})v_1^2 = (M_{block} + m_{bullet})gh,$$

From this equation we can find the initial velocity of the system of block of wood and the bullet:

$$v_1 = \sqrt{2gh} = \sqrt{2 \cdot 9.8\ \frac{m}{s^2} \cdot 0.3\ m} = 2.42\ \frac{m}{s}.$$

Then, from the Law of Conservation of Momentum we can find the initial velocity of the bullet:

$$m_{bullet}v_{bullet} = (M_{block} + m_{bullet})v_1,$$

$$v_{bullet} = \frac{(M_{block} + m_{bullet})v_1}{m_{bullet}} = \frac{(2.0\ kg + 0.01\ kg) \cdot 2.42\ \frac{m}{s}}{0.01\ kg} = 486.42\ \frac{m}{s} \approx$$
$$\approx 487\ \frac{m}{s}.$$

Answer:

$$v_{bullet} = 487\ \frac{m}{s}.$$