Momentum Conservation: Ballistic Pendulum

Consider a ballistic pendulum where the block of wood has a mass $m_w=1.4kg$ and is struck by a bullet with a mass of $m_b=0.01kg$. After the bullet lodges itself into the block, the two swing up to a height of 0.263177m. What was the speed of the bullet just before the collision?

To solve this, we will work backwards, starting with the "conservation of energy" portion of the problem. The final energy is the gravitational potential energy of the bullet/block combination. The initial energy is the kinetic energy of the bullet/block combination (note that this is after the bullet is in the block). We ignore air resistance; there is no "waste".

$$E_3=E_2$$

$$(m_w+m_b)gy = \frac{1}{2}(m_w+m_b)v_{w+b}^2$$

$$v_{w+b} = \sqrt{2gh}$$

Now, this is the velocity of the wood/bullet system after the collision. We know that in a collision, momentum is conserved. This allows us to determine the velocity of the bullet before it is embedded in the wood:

$$p_2=p_1$$

$$(m_w+m_b)v_{w+b}=m_w v_w^{\,0}+m_b v_b$$

$$v_b = \frac{(m_w+m_b)v_{w+b}}{m_b}$$

$$= \frac{(m_w+m_b)v_{w+b}\sqrt{2gh}}{m_b}$$

$$= 320.4m/s$$