A bullet with mass $m_B$ is fired into a block of wood with mass $m_W$, suspended like a pendulum, and makes a completely inelastic collision with it. After the impact of the bullet, the block swings up to a maximum height $y$. Given the values of $y$, $m_b$, and $m_W$, what is the initial speed $v_i$ of the bullet?

Let's call speed of block+bullet just after collision as $v_2$

**Conservation of momentum**

\[ m_B v_i = (m_W + m_B) v_2 \]  \hspace{1cm} (I)

\[ \frac{1}{2} (m_W + m_B) v_2^2 = (m_W + m_B) g y \]

\[ v_2 = \sqrt{2gy} \]  \hspace{1cm} (II)

Insert (II) into (I):

**Yields**

\[ v_i = \frac{m_W + m_B}{m_B} \sqrt{2gy} \]  \hspace{1cm} (III)
Just before it is struck by a racket, a tennis ball weighing 0.56 N has a velocity of $20 \frac{m}{s} \hat{i} - 4 \frac{m}{s} \hat{j}$. During the 3 ms that the racket and ball are in contact, the net force on the ball is constant and equal to $-380 \text{ N} \hat{i} + 110 \text{ N} \hat{j}$. (a) What are the $x$ and $y$ components of the impulse of the net force applied to the ball? (b) What are the $x$ and $y$ components of the final velocity of the ball?

\[ \omega_{\text{ball}} = 0.56 \text{ N } = m \cdot g \]
\[ m = 0.057 \text{ kg } = 57 \text{ g} \]

\[ \begin{align*}
\begin{array}{c}
\text{a)} \\
\frac{\vec{F}}{F} \Delta t = (-380 \hat{i} + 110 \hat{j}) \times (3 \times 10^{-3}) = -1.14 \hat{i} + 0.33 \hat{j} \\
(Ns)
\end{array}
\end{align*} \]

\[ \frac{\vec{J}}{J} = \frac{\vec{p}_f - \vec{p}_i}{m} = 0.057 \left[ \vec{v}_2 - (20 \hat{i} - 4 \hat{j}) \right] = -1.14 \hat{i} + 0.33 \hat{j} \]

\[ \left( \vec{v}_2 - 20 \hat{i} + 4 \hat{j} \right) = -20 \hat{i} + 5.78 \hat{j} \]

\[ \vec{v}_2 = 1.78 \hat{j} \]
Car A with mass 1200 kg is moving along a straight highway at 12 m/s. Car B with mass 1800 kg and speed 20 m/s has its center of mass 40 m ahead of the center of mass of car A. Find the speed of the center of mass of the system.

\[
V_{cm} = \frac{m_A v_A + m_B v_B}{m_A + m_B}
\]

\[
V_{cm} = \frac{2m \cdot 12 + 3m \cdot 20}{2m + 3m} = \frac{84}{5} = 16.8 \text{ m/s}
\]
A shell is launched at an angle $\alpha$ above the horizontal with an initial speed $v_0$. When it is at its highest point, the shell exploded into two fragments, one three times heavier than the other. The two fragments reach the ground at the same time. Assume that air resistance can be ignored. If the heavier fragment lands back at the same point from which the shell was launched, what are the velocities of the two fragments just after the explosion? Express your answer in terms of $\alpha$ and $v_0$.

![Diagram](image)

**Conservation of momentum:**

$$4m\left(v_0 \cos \alpha\right) = 3m \cdot V_A + m \cdot V_B$$

We also know that object $A$ lands back at the same point.

$$V_A = -v_0 \cos \alpha \quad \text{...(II)}$$

Using (I) and (II), we find:

$$V_B = 7 \cdot v_0 \cos \alpha \quad \text{...(III)}$$
Blocks A (mass 2 kg) and B (mass 10 kg) move on a frictionless, horizontal surface. Initially, block B is at rest and block A is moving toward it at 2 m/s. The blocks are equipped with ideal spring bumpers that enable elastic collision. The elastic collision is head-on, so all motion before and after the collision is along a straight line. Find the velocity of each block after they have moved apart.

\[ V_A' = 2 \text{ m/s} \]

\[ m_A = 2 \text{ kg} \]

\[ m_B = 10 \text{ kg} \]

\[ (m_A - m_B) V_{A1} = (m_A + m_B) V_{A2} \]

\[ \text{velocity of A before collision} \]

\[ \text{velocity of A after collision} \]

you can see the derivation from the book, eq. (8.74, 8.75)

\[ V_{B2} = V_{A1} + V_{A2} \]

\[ \text{velocity of B after collision} \]

\[ V_{B2} = 2 - \frac{4}{3} = \frac{2}{3} \text{ m/s} \]