15-7. A hammer head $H$ having a weight of 0.25 lb is moving vertically downward at 40 ft/s when it strikes the head of a nail of negligible mass and drives it into a block of wood. Find the impulse on the nail if it is assumed that the grip at $A$ is loose, the handle has a negligible mass, and the hammer stays in contact with the nail while it comes to rest. Neglect the impulse caused by the weight of the hammer head during contact with the nail.

\[
\begin{align*}
\sum F_x &= m(v_x) \\
\frac{0.25}{32.2} \cdot 40 - \int F \, dt &= 0 \\
\int F \, dt &= 0.311 \text{ lb} \cdot \text{s} \quad \text{Ans}
\end{align*}
\]

15-18. The uniform beam has a weight of 5000 lb. Determine the average tension in each of the two cables $AB$ and $AC$ if the beam is given an upward speed of 8 ft/s in 1.5 s starting from rest. Neglect the mass of the cables.

\[
\begin{align*}
\sum F_x &= m(v_x) \\
\frac{0 + P_{mx} (1.5) - 5000 (1.5)}{32.2} &= 0 \\
P_{mx} &= 3926.157 - 751.82 = 0 \\
P_{mx} &= 3442.358 \text{ lb} = 3.04 \text{ kip} \quad \text{Ans}
\end{align*}
\]

15-34. The bus $B$ has a weight of 15 000 lb and is traveling to the right at 5 ft/s. Meanwhile a 3000-lb car $A$ is traveling at 4 ft/s to the left. If the vehicles crash head-on and become entangled, determine their common velocity just after the collision. Assume that the vehicles are free to roll during collision.

\[
\begin{align*}
m_A (v_A) + m_B (v_B) &= (m_A + m_B) v \\
15000 \cdot 5 + 3000 \cdot (4) &= 18000 \cdot v \\
v &= 3.5 \text{ ft/s} \quad \text{Ans}
\end{align*}
\]
The 2-kg ball is thrown at the suspended 20-kg block with a velocity of 4 m/s. If the time of impact between the ball and the block is 0.005 s, determine the average normal force exerted on the block during this time. Take $\epsilon = 0.8$.

**System:**

\[
(\epsilon) \quad \Sigma m_1 \dot{v}_1 = \Sigma m_1 \ddot{v}_1
\]

\[
(2)(4) + 0 = (2)(v_1 h + 20)(\dot{v}_1 h)
\]

\[
(v_1 h) + 10(\dot{v}_1 h) = 4
\]

\[
(\epsilon) \quad \epsilon = \frac{(v_2 h - v_1 h)}{(v_2 h - \dot{v}_1 h)}
\]

\[
0.8 = \frac{(v_2 h - v_1 h)}{4 - 0}
\]

\[
(v_2 h - v_1 h) = 3.2
\]

**Solving:**

\[
(v_1 h) = -2.545 \text{ m/s}
\]

\[
(v_2 h) = 0.6545 \text{ m/s}
\]

**Block:**

\[
(\epsilon) \quad m_1 \ddot{y} + \Sigma F = m_1 \ddot{y}
\]

\[
0 + F(0.005) = 20(0.6545)
\]

\[
F = 2618 \text{ N} = 2.62 \text{ kN} \quad \text{Ans}
\]
15-77. The cue ball A is given an initial velocity \( v_{A1} = 5 \text{ m/s} \). If it makes a direct collision with ball \( B (e = 0.8) \), determine the velocity of \( B \) and the angle \( \theta \) just after it rebounds from the cushion at \( C (e' = 0.6) \). Each ball has a mass of 0.4 kg. Neglect the size of each ball.

**Conservation of Momentum:** When ball \( A \) strikes ball \( B \), we have

\[
m_A(v_{A1}) + m_B(v_{B1}) = m_A(v_{A2}) + m_B(v_{B2})
\]

\[
(+) \quad 0.4(5) + 0 = 0.4(v_{A2}) + 0.4(v_{B2}) \quad [1]
\]

**Coefficient of Restitution:**

\[
e = \frac{(v_{B2}) - (v_{A1})}{(v_{A2}) - (v_{B1})}
\]

\[
(+) \quad 0.8 = \frac{(v_{B2}) - (v_{A1})}{5 - 0} \quad [2]
\]

Solving Eqs. [1] and [2] yields

\[
(v_{A2}) = 0.500 \text{ m/s} \quad (v_{B2}) = 4.50 \text{ m/s}
\]

**Conservation of "y" Momentum:** When ball \( B \) strikes the cushion at \( C \), we have

\[
m_B(v_{B1}) = m_B(v_{B2})
\]

\[
(+) \quad 0.4(4.50 \sin 30^\circ) = 0.4(v_{B2}) \sin \theta
\]

\[
(v_{B2}) \sin \theta = 2.25 \quad \text{Ans} \quad [3]
\]

**Coefficient of Restitution (x):**

\[
e = \frac{(v_{C2}) - (v_{B1})}{(v_{B2}) - (v_{C1})}
\]

\[
(+) \quad 0.6 = \frac{0 - [-(-(v_{B2}) \cos \theta)]}{4.50 \cos 30^\circ - 0} \quad [4]
\]

Solving Eqs. [1] and [2] yields

\[
(v_{B2}) = 3.24 \text{ m/s} \quad \theta = 43.9^\circ \quad \text{Ans}
\]