Coefficient of Restitution

<table>
<thead>
<tr>
<th>Type of Collision</th>
<th>Final Relative Velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perfectly Inelastic</td>
<td>Zero; objects move together</td>
</tr>
<tr>
<td>Real World</td>
<td>Between two limits; defined by coefficient of restitution</td>
</tr>
<tr>
<td>Perfectly Elastic</td>
<td>Same magnitude as original relative velocity; opposite sign</td>
</tr>
</tbody>
</table>

\[ e = \frac{- (v'_1 - v'_2)}{v_1 - v_2} \]

\[ e = 0 \] Perfectly ________

\[ e = 1 \] Perfectly ________

Coefficient of Restitution: Tennis Ball

**Given:** A regulation tennis ball has to bounce between a height of 53 to 56 inches when dropped from a height of 100 inches onto a concrete floor.

**Required:** Coefficient of restitution of regulation tennis ball

**Solution:**

\[ e = \frac{- (v'_1 - v'_2)}{v_1 - v_2} \]

Collisions in 2 dimensions

- Plane of _______
- Line of _______

x motion - _______
\[ v_{A_x} = v_{B_x} = \]

y motion: Forces and impulse
\[ m_A v_{A_y} + m_B v_{B_y} = m_A v'_{A_y} + m_B v'_{B_y} \]

\[ e = \frac{- (v'_{A_y} - v'_{B_y})}{v_{A_y} - v_{B_y}} \]

Car Crash

Two cars – same mass – collide head-on. After the collision the cars skid with their brakes locked as shown. Determine the speed of car B and the effective coefficient of restitution.

\[ v_A = 5 \text{ km/hr (1.389 m/s)} \text{ right} \]
\[ u_k = 0.3 \]
Example: Shooting Pool I

**Given:** The cue ball $A$ is given an initial speed of 5 m/s. It makes direct perfectly elastic impact with ball $B$, giving ball $B$ a speed of 5 m/s. Ball $B$ then makes contact with cushion $C$ ($e = 0.6$). Each ball has a mass of 0.4 kg. Neglect friction and the size of each ball.

**Required:** Determine the speed of ball $B$ and the angle $\theta$ after ball $B$ hits cushion $C$.

- If $e = 1$, will $\theta$ be:
  - A. $> 30^\circ$
  - B. $= 30^\circ$
  - C. $< 30^\circ$

- If $e = 0.6$, will $\theta$ be:
  - A. $> 30^\circ$
  - B. $= 30^\circ$
  - C. $< 30^\circ$

- If $e = 0$, will $\theta$ be:
  - A. $= 30^\circ$
  - B. $30^\circ < \theta < 90^\circ$
  - C. $= 90^\circ$

**Solution:**

Example: Shooting Pool II

**Given:** A pool ball moving with a speed of 5 m/s strikes a pool ball moving with a speed of 3 m/s. The coefficient of restitution is 0.90. The line of impact is the line connecting the centers of the two balls.

**Required:** Determine the velocity of both balls after impact.