**TP 4.2**

**Center of percussion of the cue ball**

from:
“The Illustrated Principles of Pool and Billiards”
[www.engr.colostate.edu/pool](http://www.engr.colostate.edu/pool)
by David G. Alciatore, PhD, PE ("Dr. Dave")

---

**Diagram:**

- **At impact:**
  - Force: $F$
  - Ball radius: $R$
  - Height: $h$
  - Distance: $a$

- **After impact:**
  - Velocity: $v = \omega R$
  - Angular velocity: $\omega$
  - Rolling without slipping

---

**Equations:**

- Ball mass: $m$
- Ball moment of inertia about its center: $I = \frac{2}{5} m R^2$

**Horizontal impulse between the cue stick and cue ball:**

$$F'$$

**Linear impulse equals the change in linear momentum:**

$$F' = mv$$  \hspace{1cm} (1)$$

**Angular impulse equals the change in angular momentum:**

$$F' \cdot a = I \cdot \omega$$  \hspace{1cm} (2)$$
For impact at the center of percussion, the ball rolls without slipping immediately, so:

\[ v = \omega \cdot R \]  \hspace{1cm} (3)

Using Equations 1 and 2 in Equation 3 gives:

\[ \frac{F'}{m} = \frac{F' \cdot a \cdot R}{I} \]  \hspace{1cm} (4)

Using the equation for I above in Equation 4 gives:

\[ a = \frac{2}{5} R \]

Therefore, the center of percussion is at:

\[ h = R + a = \frac{7}{5} R = \frac{7}{10} D \]