<u>**TP B.17**</u>

Maximum Drag-Enhanced Sidespin Tip Contact Point

technical proof

supporting:
"The Illustrated Principles of Pool and Billiards"
http://billiards.colostate.edu

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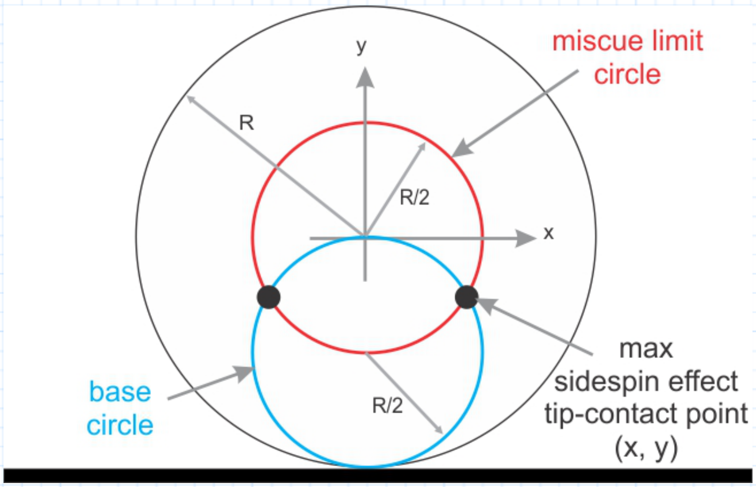

From TP A.12, right sidespin imparted to the CB, based on CB speed (v) is:

$$\omega_y = \frac{5 \cdot x \cdot v}{2 \cdot R^2}$$

and backspin imparted to the CB is:

$$\omega_x = \frac{-5 \cdot y \cdot v}{2 \cdot R^2}$$

From TP A.1, the final CB speed after the CB stops sliding (due to drag) and achieves natural foward roll is:

$$v' = \frac{5}{7} \cdot v - \frac{2}{7} \cdot R \cdot \omega_x = \frac{5}{7} \cdot v - \frac{2}{7} \cdot R \cdot \left(\frac{-5 \cdot y \cdot v}{2 \cdot R^2}\right) = \frac{5}{7} \cdot v \cdot \left(1 + \frac{y}{R}\right)$$

To get the largest effective sidespin, the spin-to-speed ratio after drag should be as high as possible. The final spin-speed ratio (AKA spin-rate-factor or SRF) is:

$$SRF = \frac{\omega_y}{\left(\frac{v'}{R}\right)} = \frac{\frac{5 \cdot x \cdot v}{2 \cdot R^2}}{\frac{\frac{5}{7} \cdot v \cdot \left(1 + \frac{y}{R}\right)}{R}} = \frac{7 \cdot x}{2 \cdot (R + y)}$$

For the maximum possible spin, the tip contact point must be at the miscue limit, which is a half-ball radius from center. In other words, the tip contact point must be on the miscue-limit circle given by the following equation:

$$x^2 + y^2 = \left(\frac{R}{2}\right)^2$$

Finding the maximum of the spin-speed ratio is equivalent to finding the maximum of the square of the spin-speed ratio (Z):

$$SRF^2 = \frac{7 \cdot x^2}{2 \cdot (R+y)^2} = \frac{7 \cdot \left(\left(\frac{R}{2}\right)^2 - y^2\right)}{2 \cdot (R+y)^2}$$

The maximum occurs where the derivative of SRF^2 is 0:

$$y := \left(\frac{d}{dy} \frac{7 \cdot \left(\left(\frac{R}{2}\right)^2 - y^2\right)}{2 \cdot (R+y)^2} = 0\right) \xrightarrow{solve, y} -\frac{R}{4}$$

The value of x corresponding to this is:

$$x := \sqrt{\left(\frac{R}{2}\right)^2 - y^2} \xrightarrow{simplify} \frac{\sqrt{3} \cdot \sqrt{R^2}}{4}$$

Per Ron Shepard's "Amateur Physics for the Amateur Pool Player" (Problem 3.7), it can be shown that this point (x, y) lies on a "base circle" through the resting point and center of the CB:

$$x^2 + \left(y + \frac{R}{2}\right)^2 \rightarrow \frac{R^2}{4}$$

Per the illustration above, the intersection of the miscue-limit and base circles provides and easy way to visualize the required tip contact point for maximum drag-enhanced-spin.