TP B.25

Percentage Sidespin Required for Maximum SIT at Any Cut Angle

supporting:
“The Illustrated Principles of Pool and Billiards”
http://billiards.colostate.edu
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From TP A.14, throw is calculated with the following, where speeds are in units of m/s:

\[
R = \frac{1.125 \text{ in}}{m} \begin{pmatrix} a \\ b \\ c \end{pmatrix} = \begin{pmatrix} 9.951 \times 10^{-3} \\ 0.108 \\ 1.088 \end{pmatrix} \quad \mu(v) := a + b \cdot e^{-c \cdot v}
\]

\[
v_{rel}(v, \omega_X, \omega_Z, \phi) := \sqrt{(v \cdot \sin(\phi) - R \cdot \omega_Z)^2 + (R \cdot \omega_X \cdot \cos(\phi))^2}
\]

\[
\theta_{\text{throw}}(v, \omega_X, \omega_Z, \phi) := \arctan \left( \frac{\min \left( \frac{\mu(v) v_{rel}(v, \omega_X, \omega_Z, \phi)}{v_{rel}(v, \omega_X, \omega_Z, \phi)} \cdot \cos(\phi), \frac{1}{7} \left( v \cdot \sin(\phi) - R \cdot \omega_Z \right) \right)}{v \cdot \cos(\phi)} \right)
\]

From http://billiards.colostate.edu/faq/speed/typical/, a typical range of shot speeds, converted to m/s is:

\[
v_{\text{slow}} := \frac{1 \text{ mph}}{m/s} = 0.447 \quad v_{\text{medium}} := \frac{3 \text{ mph}}{m/s} = 1.341 \quad v_{\text{fast}} := \frac{7 \text{ mph}}{m/s} = 3.129
\]

From TP A.25, percentage spin (PS) is related to spin rate \( \omega \) (rad/sec) with:

\[
\omega(v, \text{PS}) := \frac{5}{4} \frac{v}{R}, \text{PS}
\]

For a slow stun shot, where spin-induced throw (SIT) is maximum, SIT for a given percentage spin (PS) is:

\[
\theta_{\text{SIT}}(v, \text{PS}, \phi) := -\theta_{\text{throw}}(v, 0, \omega(v, \text{PS}), \phi)
\]
Here is how spin-induced throw (SIT) varies with percentage spin (PS) for slow and fast shots:

**straight shot:** \( \phi := 0 \)

\[
\theta_{\text{SIT}}(v_{\text{slow}}, PS, \phi) \quad \text{deg}
\]

\[
\theta_{\text{SIT}}(v_{\text{fast}}, PS, \phi) \quad \text{deg}
\]

**1/2-ball hit:** \( \phi := 30 \text{-deg} \)

\[
\theta_{\text{SIT}}(v_{\text{slow}}, PS, \phi) \quad \text{deg}
\]

\[
\theta_{\text{SIT}}(v_{\text{fast}}, PS, \phi) \quad \text{deg}
\]
Now finding the percentage spin that results in the maximum spin-induced throw for a range of cut angles:

\[
\phi A := (0\cdot \text{deg} \ 15\cdot \text{deg} \ 30\cdot \text{deg} \ 45\cdot \text{deg} \ 60\cdot \text{deg} \ 75\cdot \text{deg} \ 85\cdot \text{deg})^T
\]

\[v := v_{\text{slow}}\]

\[
i := 0 \quad \phi := \phi A_i \quad \theta_{\text{SIT}}(PS) := -\theta_{\text{throw}}(v, 0, \omega(v, PS), \phi) \quad \text{PSA}_i := \text{Maximize} (\theta_{\text{SIT}}, PS)
\]

\[
i := 1 \quad \phi := \phi A_i \quad \theta_{\text{SIT}}(PS) := -\theta_{\text{throw}}(v, 0, \omega(v, PS), \phi) \quad \text{PSA}_i := \text{Maximize} (\theta_{\text{SIT}}, PS)
\]

\[
i := 2 \quad \phi := \phi A_i \quad \theta_{\text{SIT}}(PS) := -\theta_{\text{throw}}(v, 0, \omega(v, PS), \phi) \quad \text{PSA}_i := \text{Maximize} (\theta_{\text{SIT}}, PS)
\]

\[
i := 3 \quad \phi := \phi A_i \quad \theta_{\text{SIT}}(PS) := -\theta_{\text{throw}}(v, 0, \omega(v, PS), \phi) \quad \text{PSA}_i := \text{Maximize} (\theta_{\text{SIT}}, PS)
\]

\[
i := 4 \quad \phi := \phi A_i \quad \theta_{\text{SIT}}(PS) := -\theta_{\text{throw}}(v, 0, \omega(v, PS), \phi) \quad \text{PSA}_i := \text{Maximize} (\theta_{\text{SIT}}, PS)
\]

\[
i := 5 \quad \phi := \phi A_i \quad \theta_{\text{SIT}}(PS) := -\theta_{\text{throw}}(v, 0, \omega(v, PS), \phi) \quad \text{PSA}_i := \text{Maximize} (\theta_{\text{SIT}}, PS)
\]

\[
i := 6 \quad \phi := \phi A_i \quad \theta_{\text{SIT}}(PS) := -\theta_{\text{throw}}(v, 0, \omega(v, PS), \phi) \quad \text{PSA}_i := \text{Maximize} (\theta_{\text{SIT}}, PS)
\]

\[\text{PSA}_{\text{slow}} := \text{PSA}\]

\[v := v_{\text{fast}}\]

\[
i := 0 \quad \phi := \phi A_i \quad \theta_{\text{SIT}}(PS) := -\theta_{\text{throw}}(v, 0, \omega(v, PS), \phi) \quad \text{PSA}_i := \text{Maximize} (\theta_{\text{SIT}}, PS)
\]

\[
i := 1 \quad \phi := \phi A_i \quad \theta_{\text{SIT}}(PS) := -\theta_{\text{throw}}(v, 0, \omega(v, PS), \phi) \quad \text{PSA}_i := \text{Maximize} (\theta_{\text{SIT}}, PS)
\]

\[
i := 2 \quad \phi := \phi A_i \quad \theta_{\text{SIT}}(PS) := -\theta_{\text{throw}}(v, 0, \omega(v, PS), \phi) \quad \text{PSA}_i := \text{Maximize} (\theta_{\text{SIT}}, PS)
\]

\[
i := 3 \quad \phi := \phi A_i \quad \theta_{\text{SIT}}(PS) := -\theta_{\text{throw}}(v, 0, \omega(v, PS), \phi) \quad \text{PSA}_i := \text{Maximize} (\theta_{\text{SIT}}, PS)
\]

\[
i := 4 \quad \phi := \phi A_i \quad \theta_{\text{SIT}}(PS) := -\theta_{\text{throw}}(v, 0, \omega(v, PS), \phi) \quad \text{PSA}_i := \text{Maximize} (\theta_{\text{SIT}}, PS)
\]

\[
i := 5 \quad \phi := \phi A_i \quad \theta_{\text{SIT}}(PS) := -\theta_{\text{throw}}(v, 0, \omega(v, PS), \phi) \quad \text{PSA}_i := \text{Maximize} (\theta_{\text{SIT}}, PS)
\]

\[
i := 6 \quad \phi := \phi A_i \quad \theta_{\text{SIT}}(PS) := -\theta_{\text{throw}}(v, 0, \omega(v, PS), \phi) \quad \text{PSA}_i := \text{Maximize} (\theta_{\text{SIT}}, PS)
\]

\[\text{PSA}_{\text{fast}} := \text{PSA}\]
Here is how the percentage spin (PSA) required for maximum spin-induced throw (SIT) varies with cut angle ($\phi_A$) for both slow and fast shots:

And here's how much throw you can get at each of those angles:

$$\theta_{\text{SIT}}(v, \text{PS}, \phi) := -\theta_{\text{throw}}(v, 0, \omega(v, \text{PS}), \phi)$$

At slow speed, with a straight shot only about 50% of maximum sidespin is required to get maximum throw. For large cut angles, almost 100% of maximum sidespin is required for maximum throw, and more throw is possible.