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
by David G. Alciatore, PhD, PE ("Dr. Dave")

originally posted: 6/16/2021 last revision: 6/16/2021

From TP A.14, throw is calculated with the following, where speeds are in units of m/s:

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

$$v_{rel}(v, \omega_x, \omega_z, \phi) := \sqrt{(v \cdot \sin(\phi) - R \cdot \omega_z)^2 + (R \cdot \omega_x \cdot \cos(\phi))^2}$$

$$\theta_{throw}(v, \omega_x, \omega_z, \phi) := \operatorname{atan}\left[\frac{\min\left(\frac{\mu(v_{rel}(v, \omega_x, \omega_z, \phi)) \cdot v \cdot \cos(\phi)}{v_{rel}(v, \omega_x, \omega_z, \phi)}, \frac{1}{7}\right) \cdot (v \cdot \sin(\phi) - R \cdot \omega_z)}{v \cdot \cos(\phi)}\right]$$

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

$$v_{slow} := \frac{1 \cdot mph}{\frac{m}{s}} = 0.447 \qquad v_{medium} := \frac{3 \cdot mph}{\frac{m}{s}} = 1.341 \qquad v_{fast} := \frac{7 \cdot mph}{\frac{m}{s}} = 3.129$$

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

$$\omega(v, PS) := \frac{5}{4} \cdot \frac{v}{R} \cdot PS$$

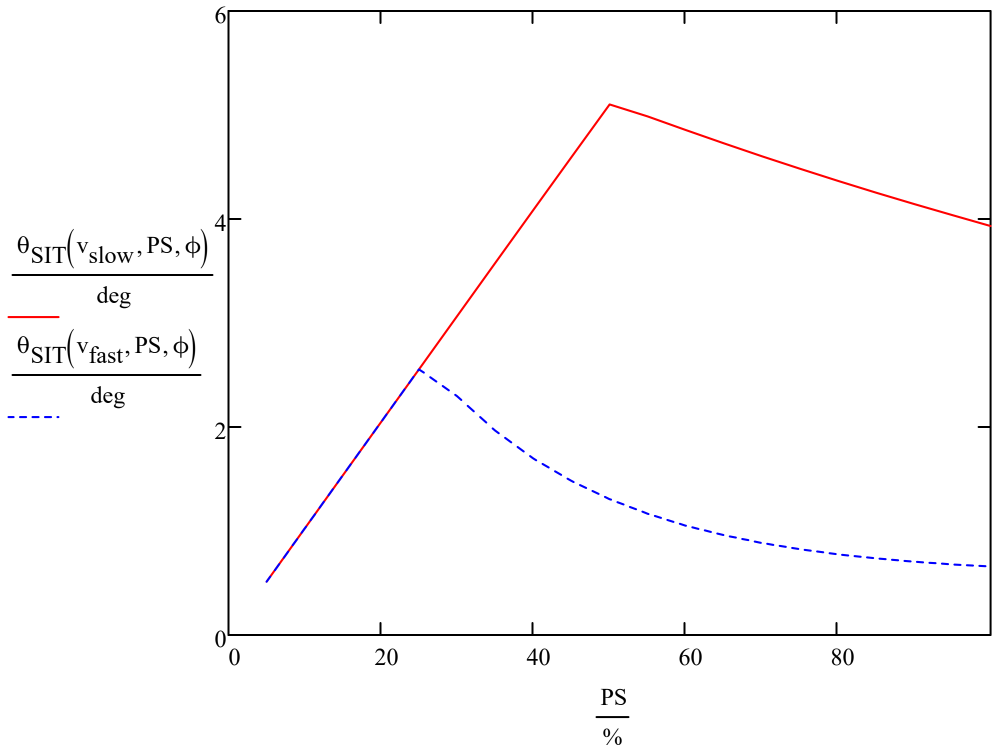
For a slow stun shot, where spin-induced throw (SIT) is maximum, SIT for a given percentage spin (PS) is:

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

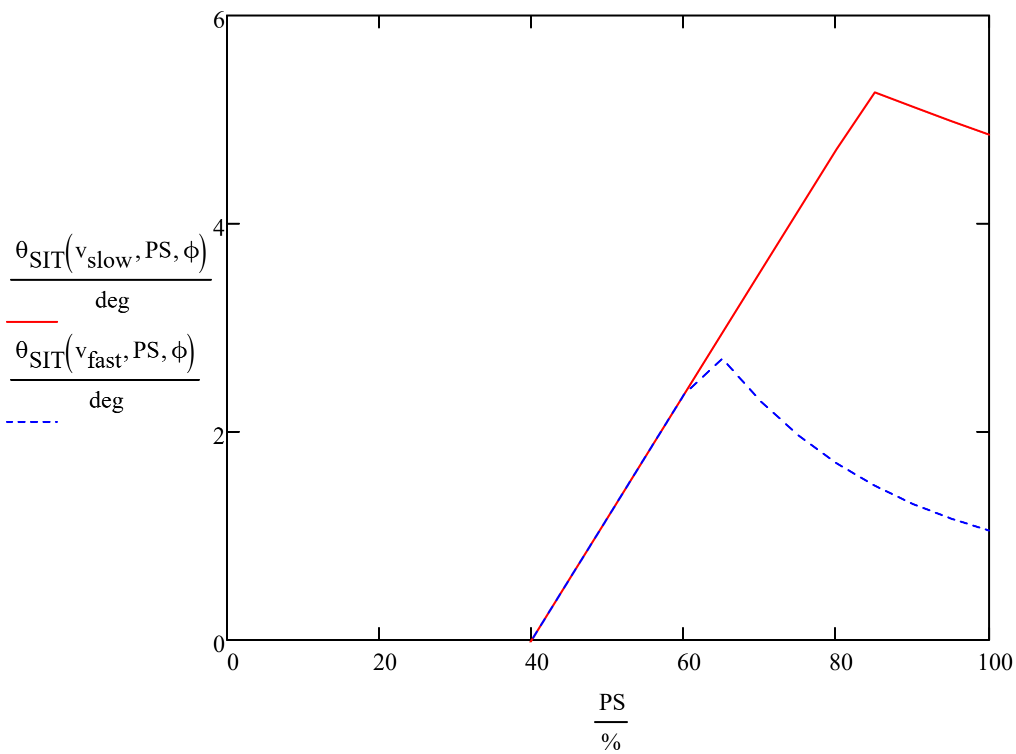
Here is how spin-induced throw (SIT) varies with percentage spin (PS) for slow and fast shots:

$$PS := 0, .05 .. 1$$

straight shot: $\phi := 0$



1/2-ball hit: $\phi := 30 \cdot deg$



Now finding the percentage spin that results in the maximum spin-induced throw for a range of cut angles:

$$\phi A := (0\cdot deg\ \ 15\cdot deg\ \ 30\cdot deg\ \ 45\cdot deg\ \ 60\cdot deg\ \ 75\cdot deg\ \ 85\cdot deg)^T$$

$PS := 0.95$

initial guess

$v := v_{slow}$

$i := 0 \quad \phi := \phi A_i \quad \theta_{SIT}(PS) := -\theta_{throw}(v, 0, \omega(v, PS), \phi) \quad PSA_i := \text{Maximize}(\theta_{SIT}, PS)$

$i := 1 \quad \phi := \phi A_i \quad \theta_{SIT}(PS) := -\theta_{throw}(v, 0, \omega(v, PS), \phi) \quad PSA_i := \text{Maximize}(\theta_{SIT}, PS)$

$i := 2 \quad \phi := \phi A_i \quad \theta_{SIT}(PS) := -\theta_{throw}(v, 0, \omega(v, PS), \phi) \quad PSA_i := \text{Maximize}(\theta_{SIT}, PS)$

$i := 3 \quad \phi := \phi A_i \quad \theta_{SIT}(PS) := -\theta_{throw}(v, 0, \omega(v, PS), \phi) \quad PSA_i := \text{Maximize}(\theta_{SIT}, PS)$

$i := 4 \quad \phi := \phi A_i \quad \theta_{SIT}(PS) := -\theta_{throw}(v, 0, \omega(v, PS), \phi) \quad PSA_i := \text{Maximize}(\theta_{SIT}, PS)$

$i := 5 \quad \phi := \phi A_i \quad \theta_{SIT}(PS) := -\theta_{throw}(v, 0, \omega(v, PS), \phi) \quad PSA_i := \text{Maximize}(\theta_{SIT}, PS)$

$i := 6 \quad \phi := \phi A_i \quad \theta_{SIT}(PS) := -\theta_{throw}(v, 0, \omega(v, PS), \phi) \quad PSA_i := \text{Maximize}(\theta_{SIT}, PS)$

$PSA_{slow} := PSA$

$v := v_{fast}$

$i := 0 \quad \phi := \phi A_i \quad \theta_{SIT}(PS) := -\theta_{throw}(v, 0, \omega(v, PS), \phi) \quad PSA_i := \text{Maximize}(\theta_{SIT}, PS)$

$i := 1 \quad \phi := \phi A_i \quad \theta_{SIT}(PS) := -\theta_{throw}(v, 0, \omega(v, PS), \phi) \quad PSA_i := \text{Maximize}(\theta_{SIT}, PS)$

$i := 2 \quad \phi := \phi A_i \quad \theta_{SIT}(PS) := -\theta_{throw}(v, 0, \omega(v, PS), \phi) \quad PSA_i := \text{Maximize}(\theta_{SIT}, PS)$

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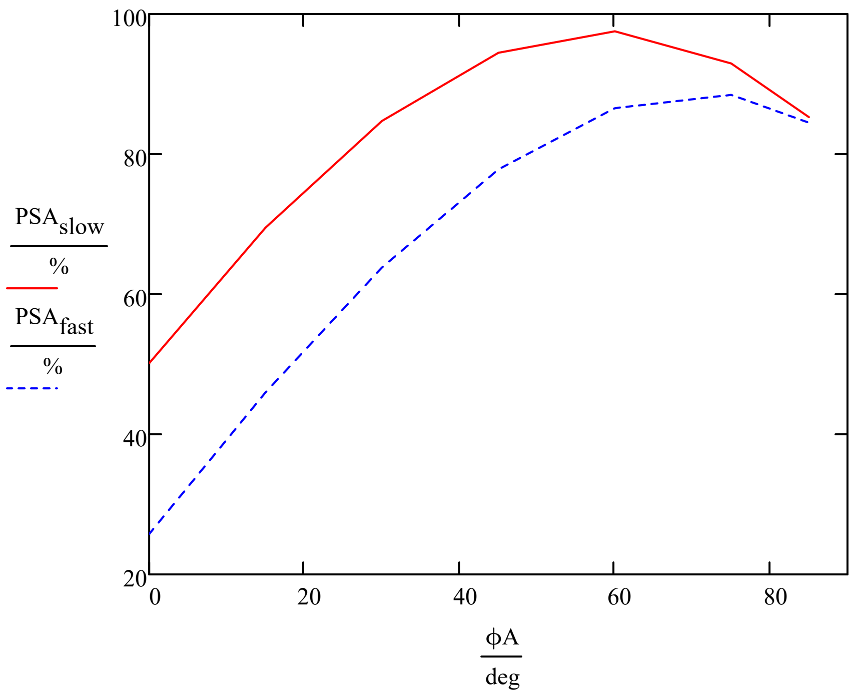
$i := 6 \quad \phi := \phi A_i \quad \theta_{SIT}(PS) := -\theta_{throw}(v, 0, \omega(v, PS), \phi) \quad PSA_i := \text{Maximize}(\theta_{SIT}, PS)$

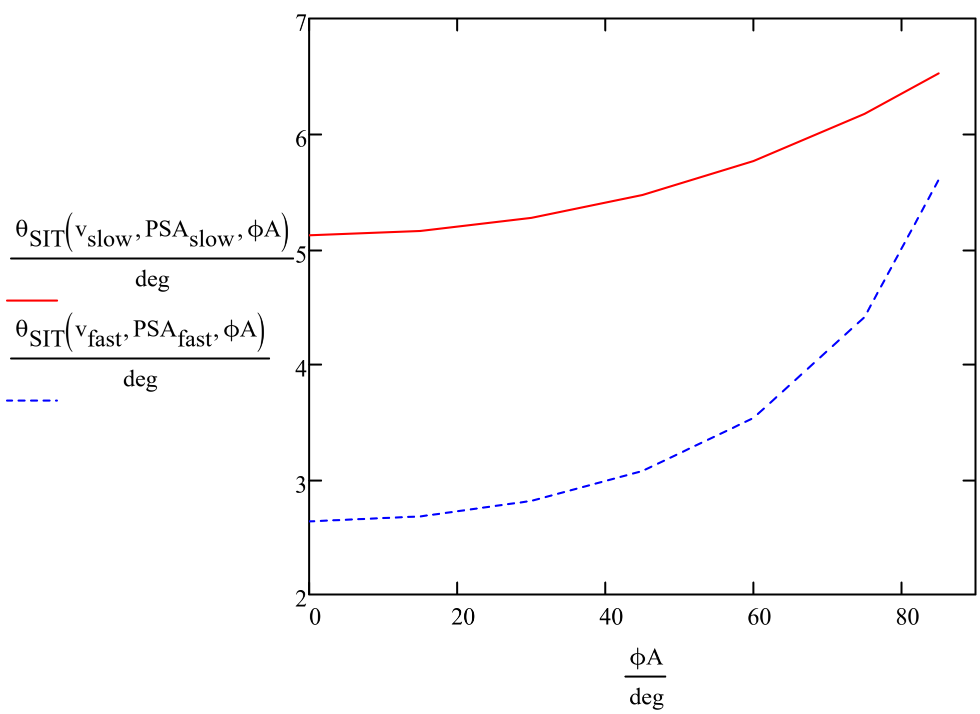
$PSA_{fast} := PSA$

Here is how the percentage spin (PSA) required for maximum spin-induced throw (SIT) varies with cut angle (ϕA) for both slow and fast shots:



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

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



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.