Dr. Dave's shooting dimensions:

- forearm length: \( l := 14 \text{ in} \)
- length of cue between grip and bridge at set position: \( c := 45 \text{ in} \)
- bridge length: \( b := 12 \text{ in} \)

From the geometry in the diagram above:

\[ d \cdot \cos(\phi) = c - l \cdot \sin(\theta) \tag{1} \]
\[ d \cdot \sin(\phi) = l - l \cdot \cos(\theta) \tag{2} \]

Adding the squares of these two equations gives the distance (d) between grip and bridge during the stroke:

\[ d(\theta) := \sqrt{c^2 + 2 \cdot l^2 - 2 \cdot c \cdot l \cdot \sin(\theta) - 2 \cdot l^2 \cdot \cos(\theta)} \]
Dividing Equation 2 by Equation 1 gives the cue elevation angle ($\phi$) during the stroke:

$$\phi(\theta) := \tan \left( \frac{l \cdot (1 - \cos(\theta))}{c - l \cdot \sin(\theta)} \right)$$

The coordinates of the tip $(x, y)$ during the stroke are given by:

$$x(\theta) := (c + b - d(\theta)) \cdot \cos(\phi(\theta))$$

$$y(\theta) := -(c + b - d(\theta)) \cdot \sin(\phi(\theta))$$

The minimum forearm angle ($\theta_{min}$) possible at the end of the backstroke, with the tip at the bridge $(x=0)$ is:

$$\theta := -45 \cdot \text{deg}$$

$$\theta_{min} := \text{root}(x(\theta), \theta) = -56.369 \cdot \text{deg}$$

Assuming the forward stroke is the same length as the backstroke results in the same angle forward:

$$\theta_{max} := -\theta_{min}$$

$$\theta := -80 \cdot \text{deg}, -79 \cdot \text{deg}, -80 \cdot \text{deg}$$

Cue ball geometry (added to the tip trajectory plots below for scale):

$$t := 0 \cdot \text{deg}, 1 \cdot \text{deg}, \ldots, 360 \cdot \text{deg}$$

$$R := \frac{2.25}{2} \cdot \text{in}$$

$$x_{CB}(t) := (b + R) + R \cdot \cos(t)$$

$$y_{CB}(t) := R \cdot \sin(t)$$

Plot of the cue tip trajectory during the entire stroke:

$$\theta := \theta_{min}, \theta_{min} + 1 \cdot \text{deg} \ldots \theta_{max}$$

\[y(\theta) \text{ (in)}\]

\[y_{CB}(t) \text{ (in)}\]
Close-up of the cue tip trajectory close to the CB contact point:

\[
y(\theta) \quad (\text{in})
\]

\[
y_{CB}(t) \quad (\text{in})
\]

Total tip height variance (\(\Delta y\)) over a given distance (\(\Delta x\)) around the tip contact point:

\[
\Delta x := 4 \cdot \text{in} \\
x_{\text{start}} := b - \frac{\Delta x}{2} = 10 \text{ in} \\
x_{\text{end}} := b + \frac{\Delta x}{2} = 14 \text{ in}
\]

\[
\theta := 0 \\
\theta_{\text{start}} := \text{root} \left( x(\theta) - x_{\text{start}}, \theta \right) = -8.212 \text{ deg} \\
x(\theta_{\text{start}}) = 10 \text{ in}
\]

\[
\theta := 0 \\
\theta_{\text{end}} := -\theta_{\text{start}} \\
x(\theta_{\text{end}}) = 13.999 \text{ in}
\]

\[
\Delta y := y(\theta_{\text{start}}) - y(\theta_{\text{end}}) = 0.016 \text{ in} \\
\Delta y = 0.411 \text{ mm}
\]

Obviously, from the plots and numbers above, a pure pendulum stroke results in the tip moving very straight into and through the CB position, with an accurate tip contact point.