TP 4.4
Relationship between the amount of throw and cut angle

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\[ v'_n = e \cdot v \cdot \cos(\theta) \]

Assuming that all speed in the normal direction is delivered from the cue ball to the object ball, from linear impulse \( F' \) and momentum:

\[ F' = m \cdot v \cdot \cos(\theta) = \frac{m \cdot v'_n}{e} \]
From linear impulse and momentum in the tangent direction:

\[ m \cdot v'_t = \mu \cdot F' = \frac{\mu \cdot m \cdot v'_n}{e} \]

so

\[ v'_t = \frac{\mu \cdot v'_n}{e} \]

Therefore, the throw angle is given by:

\[ \theta_t = \tan \left( \frac{v'_t}{v'_n} \right) = \tan \left( \frac{\mu}{e} \right) \]

\( \mu \) and \( e \) both vary with speed and cut angle. The throw angle does not vary with speed significantly. The throw angle increases with cut angle. Here are typical values for a large cut angle shot:

\[ e := 0.92 \quad \mu := 0.06 \]

\[ \tan \left( \frac{\mu}{e} \right) = 3.731 \text{ deg} \]

**NOTE** - The analysis above is a very simplified model. For a more thorough analysis that takes speed and spin effects into consideration, see TP A.14. The results in TP A.14 agree fairly closely with experimental data for various cases.