technical proof

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# TP 4.3
# English-induced throw effects

supporting:
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**http://billiards.colostate.edu**
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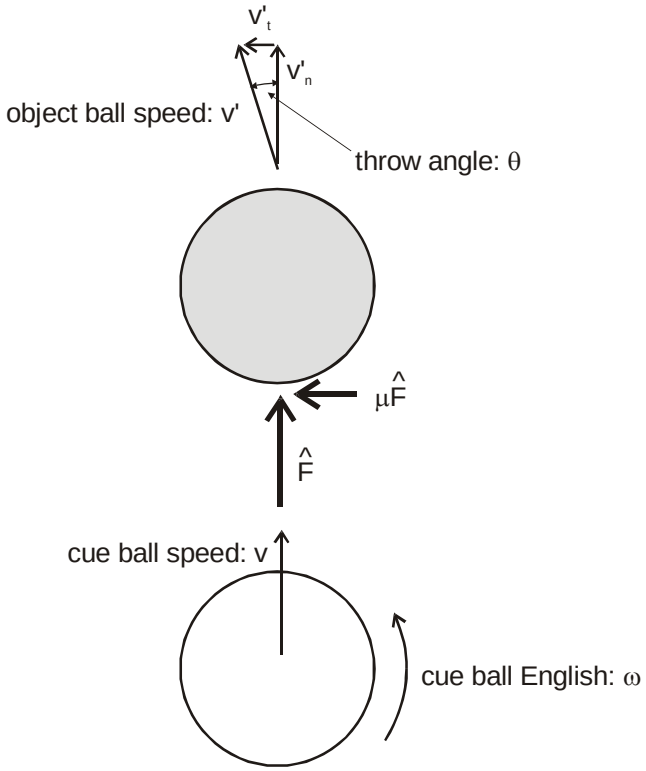


The normal impulse (F') is related to the final object ball speed in the normal direction ($v'_n$):

$$F' = m \cdot v'_n$$

From linear impulse and momentum in the tangential direction:

$$m \cdot v'_t = \mu \cdot F' = \mu \cdot m \cdot v'_n$$

So the final object ball speed in the tangential direction is given by:

$$v'_t = \mu \cdot v'_n$$

Therefore, the throw angle is given by:

$$\theta = \operatorname{atan}\left(\frac{v'_t}{v'_n}\right) = \operatorname{atan}(\mu)$$

$\mu$ varies with speed and the amount of English. The maximum throw angle occurs at slow speeds. Here are typical values for a slow, head-on collision:

$$\mu := 0.06$$

$$\operatorname{atan}(\mu) = 3.434\,\text{deg}$$

**NOTE** - the analysis presented here is a simplified view of spin-induced throw. To see a more complete analysis that also considers cut angle, vertical plane spin, and speed effects, see **TP A.14**.