David Alciatore ("Dr. Dave") **ILLUSTRATED PRINCIPLES**

"Throw – Part I: introduction"

***Note**: Supporting narrated video (NV) demonstrations, high-speed video (HSV) clips, and technical proofs (TP) can be accessed and viewed online at www.engr.colostate.edu/pool. The reference numbers used in the article help you locate the resources on the website. If you have a slow or inconvenient Internet connection, you might want to view the resources from a CD-ROM. See the website for details.*

This is the first of a series of articles I plan to write concerning "throw" effects. If you don't yet know about "throw" and the effects of speed, cut angle, and English, you are probably missing some shots that you might think you should make, and you are probably not able to make some shots you might see others make. First, let's start out with some terminology and definitions. **Throw** is the change in object ball (OB) direction due to sliding friction forces between the cue ball (CB) and OB during impact. The sliding friction force results from relative motion between the CB and OB caused by English or cut angle. Diagram 1 illustrates **spin-induced throw** (**SIT**) caused by English. In this case, the right English causes sliding friction during impact that pushes the OB to the left. Left English would have the opposite effect ... it would throw the OB to the right.

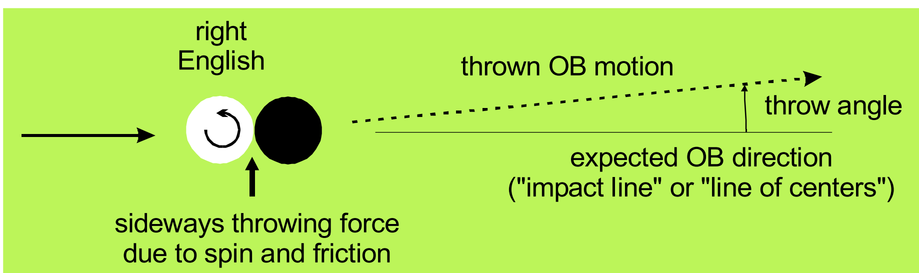


Diagram 1 Spin-induced throw (SIT)

Another source of throw is the natural sliding motion between the CB and OB created by a cut angle. This type of throw is illustrated in Diagram 2 and is labeled **collision-induced throw** (**CIT**) or cut-induced throw. CIT throws the OB in the direction of the CB motion. For example, in Diagram 2, where the OB is cut to the right, the CB throws the OB to the left in the direction the CB travels after impact. Diagrams 1 and 2 also illustrate some other important terminology. The **impact line** (AKA **line of centers**) is the line of action going through the centers of the CB and OB at contact. This is the direction one would normally expect the OB to travel after impact, if there were no throw. In fact, with new and polished balls, throw can be very small and the OB will follow the impact line very closely. The amount of throw can be described by **throw angle**, which is the angle between the thrown OB direction and the expected impact-line direction.

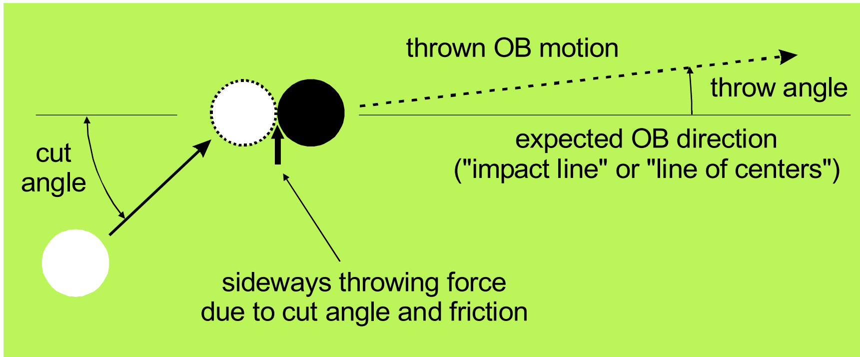
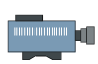


Diagram 2 Collision-induced throw (CIT)

When a shot has both English (Diagram 1) and a cut angle (Diagram 2), additional terms are used to characterize the English. The term **inside English** is used if the English is applied on the OB side of (i.e., "inside") the cut. For example, in Diagram 2, the OB is being cut to the right; so right English would be referred to as inside English. In this case, the CB is struck on the right side of the CB, which is on the OB side of the aiming line. Left English, in this case, would be referred to as **outside English** because the CB would be struck on the side of the aiming line away from ("outside") the OB. It turns out that with just the right amount of outside English, throw can be eliminated completely. In this case, the English can be referred to as **"gearing" outside English** because the CB "rolls" on the OB during impact instead of sliding (e.g., see HSV A.8 and HSV A.62), as if the two balls were gears meshing together. I really like this analogy because I am a "gear-head" mechanical engineer. With no relative sideways motion between the CB and OB during impact, there is no sliding friction or throw. With "gearing" outside English, the OB heads exactly in the impact-line (line-of-centers) direction after impact. We will look at the effects of outside English more in a future article.


high-speed video

HSV A.8 – Outside English cut shot
HSV A.62 – Cut shot with outside English and slow speed

Another term used in describing throw effects is **cling**, which refers to excessive friction between the CB and OB during a cut shot caused by a chalk smudge, dirt, and/or roughness on the CB and/or OB. When there is cling, the OB gets thrown much more than normal, so don't forget to clean (and even polish) those balls periodically. We already have enough reasons (or excuses) to miss a shot without having to also worry about clingy balls.

Often, throw is undesirable and can cause you to miss a shot. However, there are some cases where throw can be your friend. Diagram 3 illustrates one such example. The obstacle ball (the stripe) blocks the path the CB would need to take for a simple cut shot of the OB (the solid). Instead, the CB must be aimed to miss the obstacle ball, and right English must be used to throw the OB to the left towards the pocket (see NV 4.15). The shot must be hit softly (but with enough English) because the amount of throw can be much larger at slower speeds. This shot is not that difficult, and it can be invaluable in a game if you need a little extra space for a shot. When balls are frozen (i.e., touching), throw can be a significant factor because it can be much larger than normal. NV 7.5 and NV 7.6 show dramatic examples of both CIT and SIT as applied to frozen ball cases.


normal video

NV 7.5 – Frozen ball throw
NV 7.6 – Frozen cue-ball throw

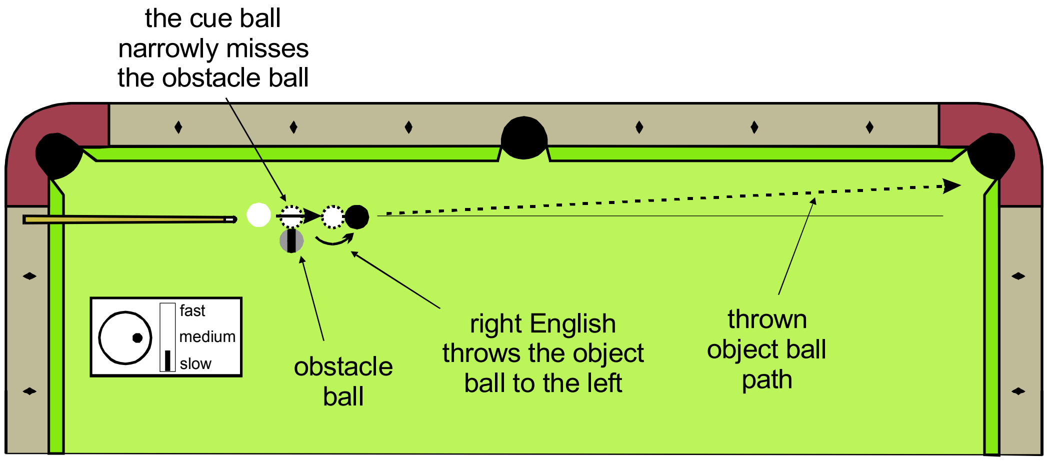


Diagram 3 Using SIT to pocket a shot

normal video

NV 4.15 – Using throw to make a partially blocked shot

Diagram 4 shows an example where if you don't know about throw (or if you don't already correct for it subconsciously), you'll probably miss the shot. In this case, CIT causes the OB to be thrown in the direction of the CB motion. This throw must be accounted for when shooting cut shots, especially longer shots where the margin of error is smaller. You must over-cut shots a little to compensate for the throw. In the diagram, the shot is lined up so the impact line through the ghost-ball target and the OB points to the right of the pocket to compensate for the throw to the left. This compensation is particularly important with longer shots that are hit softly. The lower speed increases throw (there will be more about this in future articles) and the longer shot distance results in larger throw distance, as illustrated in the diagram. For a given throw angle, the throw error increases with distance.

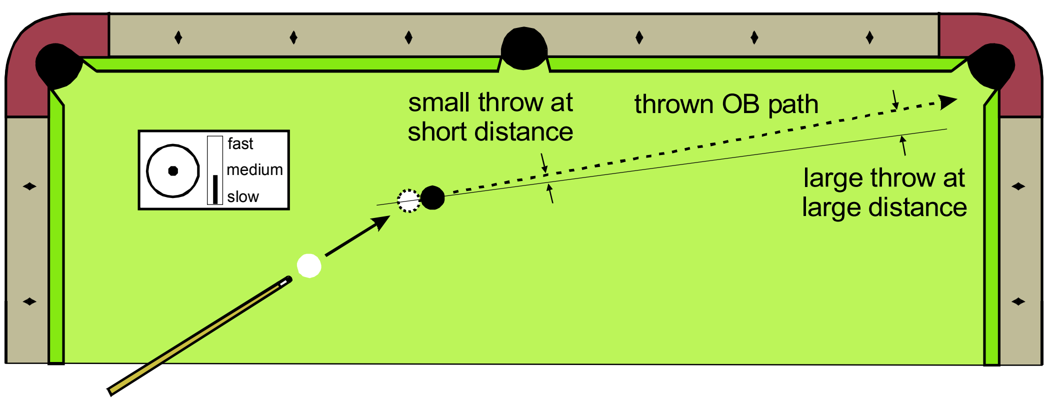


Diagram 4 Adjusting for CIT

normal video

NV 4.16 – Over-cutting a cut shot to compensate for throw

Well, that's enough for now. Over the next few months we'll look at some of the details concerning throw. We'll look at the effects of cut angle, speed, and spin. This will help you build intuition for how much to adjust for different situations at the table. A complete physics and math-based analysis can be found in TP A.14. If you like that kind of thing, you can check out the analysis and results online. If you don't like math and physics, just wait for my next few articles where I'll present some of the results in a more understandable way with some examples. I'll see you guys next month.


technical proof

TP A.14 – The effects of cut angle, speed, and spin on object ball throw

Good luck with your game,
Dr. Dave

PS:

- If you want to refer back to any of my previous articles and resources, you can access them online at *www.engr.colostate.edu/pool*.

Dr. Dave is a mechanical engineering professor at Colorado State University in Fort Collins, CO. He is also author of the book: "The Illustrated Principles of Pool and Billiards."