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

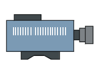
"Draw Shot Physics - Part III: spin ratio"

***Note**: Supporting narrated video (NV) demonstrations, high-speed video (HSV) clips, and technical proofs (TP), and all of my past articles, can be accessed and viewed online at **billiards.colostate.edu**. 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 or DVD. Details can be found online at: **dr-dave-billiards.com**.*

This is the third article in a series on draw shot physics. In the previous two months, we looked at the basics, listed a set of conclusions from a physics analysis (**TP B.8**), and looked at some practical examples where the conclusions are useful. With a straight-on (0° cut angle) draw shot, the draw distance is determined solely by the amount of spin the cue ball (CB) has when it hits the object ball (OB). Last month, we looked at how the CB's spin changes due to "drag" on the way to the OB. Clear demonstrations of this can be viewed in **HSV 3.1** and **NV B.10.** For a draw shots with a cut angle (i.e., not straight in), both the speed and spin on the CB are important factors. With some shots, it is important to have a lot of CB spin but not too much forward speed to get the best result (e.g., position for the next shot). When the CB has lots of spin and less speed, it is said to have a high spin-to-speed ratio, which is the focus of this month's article.


technical proof

TP B.8 – Draw shot physics


high-speed video

HSV 3.1 – Stop-shot showing loss of bottom spin over distance


normal video

NV B.10 – Drag spin loss and English persistence

I recently extended the analysis in TP B.8 to look at both CB spin and spin-to-speed ratio. The gory details can be found in **TP B.9**, if you're interested in that sort of thing. I know most of you probably aren't interested in the math and physics, but I hope most of you will be interested in some of the results. **Diagram 1** is a graph that illustrates the general trends. The horizontal scale indicates how far the cue tip is offset from the center of the CB. The extreme left side corresponds to no offset (0%); and the extreme right side corresponds to maximum tip offset (100%) at the miscue limit. The vertical scale indicates the amount of spin and spin-to-speed ratio the CB has when it hits the OB, both of which are reduced by cloth "drag" along the way to the OB. Generally, to get more spin at contact with the OB, you must hit the CB harder and lower. This is the case with the red curve in the diagram, which corresponds to shots where the CB is not very far from the OB. As you increase tip offset (i.e., as you move to the right in the diagram), the amount of spin at the OB increases (i.e., the curve keeps going up) until you approach the miscue limit, where the curve levels off (see the right side of the red curve). The green curve shows that for shots where the OB is farther away, the maximum CB spin at OB contact occurs at about 80% tip offset. As you increase the tip offset beyond this (closer to the miscue limit), the amount of spin the CB has when it hits the OB is actually less. This was described and illustrated in detail last month, but to summarize: hitting the CB farther from center gives the CB more initial spin but less initial forward speed. With less forward speed, the drag action of the cloth has more time to slow the CB's spin, and the CB ends up with less spin as it arrives at the OB.

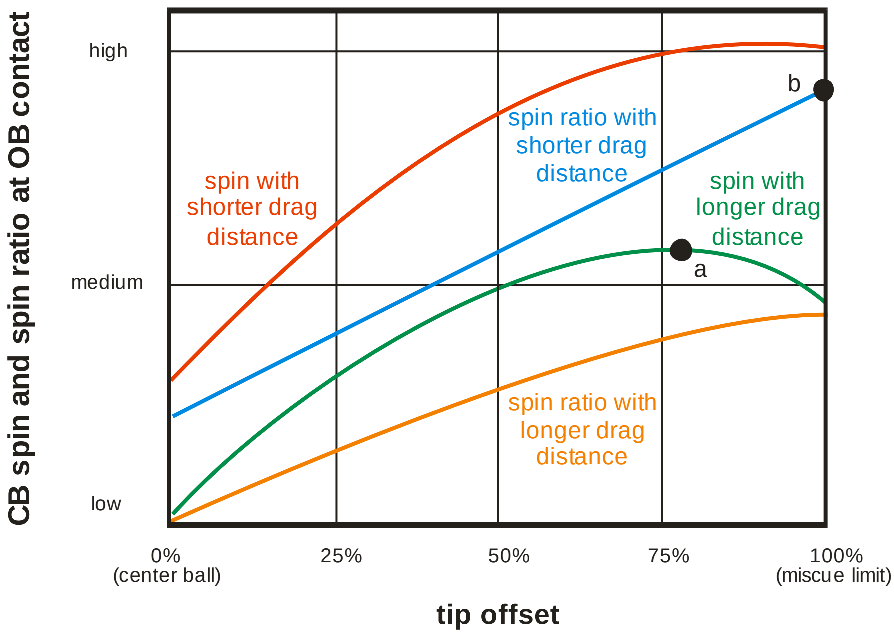


Diagram 1 Spin and spin ratio vs. tip offset

technical proof

TP B.9 – Draw shot spin vs. spin ratio

The blue and orange curves in Diagram 1 show how the spin-to-speed ratio of the CB (when it hits the OB) varies with tip offset. It turns out that the this ratio always increases with increasing tip offset; so for shots where the spin ratio is important (an example will be shown below), it does help to hit the CB as low as possible, close to the miscue limit. Points "a" and "b" in the diagram suggest good advice for the two pool shots illustrated in **Diagram 2**. Shot "a" is a **power draw shot**, where the CB is far from the OB and you want to draw the CB straight back a long distance to get position for the 2-ball shot. The location of the 3-ball and the straightness of the shot demand power draw in this situation. This is not an easy shot, but sometimes a power draw is the best or only option. Point "a" in Diagram 1 implies that the best strategy for this type of shot is to hit the CB firm with the tip contact point at about 80% of the miscue limit (see last month's article for illustrations). As pointed out above, hitting the CB any lower would result in less draw for a given cue speed on this shot and create a greater risk for miscue. Shot "b" is what I call a **quick-draw shot**. Here, the goal is to have the CB draw back away from the tangent line direction as soon as possible to get the CB to head straight up table for decent position on the 5-ball shot. With the final CB position shown, the 5-ball shot is easy, and it leads to automatic position for the follow-up 6-ball shot. With this type of shot, where there is a cut angle, the more speed the CB has, the longer it will persist along the tangent line before the draw "takes." For shot "b," we need to have ample CB spin for good draw action, but not too much CB speed. In other words, we need a high spin-to-speed ratio. With too great a speed, the CB would head into the side rail more directly and the CB would then rebound across table to the wrong side of the 5-ball. Point "b" in Diagram 1 implies a high-spin-ratio quick draw is achieved by hitting the CB as low as possible (with the largest possible tip offset at the miscue limit), using less cue speed. **NV B.47**, **NV B.25**, and **NV B.26** show several good game situation examples where more spin and less speed (for a higher spin-to-speed ratio) is the right play. I filmed these videos last year with fellow BD columnist Tom Ross. Check them out.

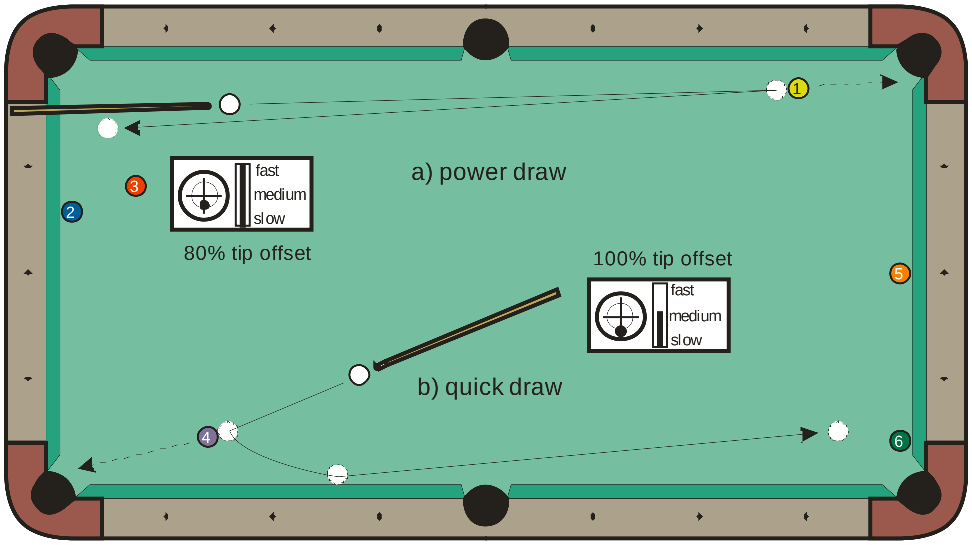


Diagram 2 Power draw vs. quick draw


normal video

NV B.25 – Using draw and English to beat a scratch in a side pocket
NV B.26 – Draw shots near a rail
NV B.47 – Draw shot off a rail requiring slower speed for position

Diagram 3 illustrates more examples of how CB speed and spin affect the path of the CB. Demonstrations of these effects can also be viewed in **HSV B.23** and **NV B.45.** The black arrow in the diagram shows the stun shot (AKA "stop shot at an angle") path. Here, the CB is struck slightly below center at medium speed resulting in stun (no top or bottom spin) at the 3-ball. In this case, the CB heads straight down the tangent line of the shot. The orange curve shows the quick-draw path, where the maximum tip offset is used to create a high spin-to-speed ratio. Here medium speed is used to limit motion down the tangent line in order to get the CB up table with as little sideways drift as possible. The purple curve shows what would happen if more speed were used with the same tip offset. The CB persists along the tangent line longer and doesn't draw as quickly. The red and blue curves show a similar effect, but this time with less CB bottom spin. All of this illustrates the tremendous amount of CB control we have with typical draw shots. Unfortunately, it also shows how easily it is to miss the intended path because the range of possible paths is so wide. If pool were easy, it wouldn't be as fun … right?

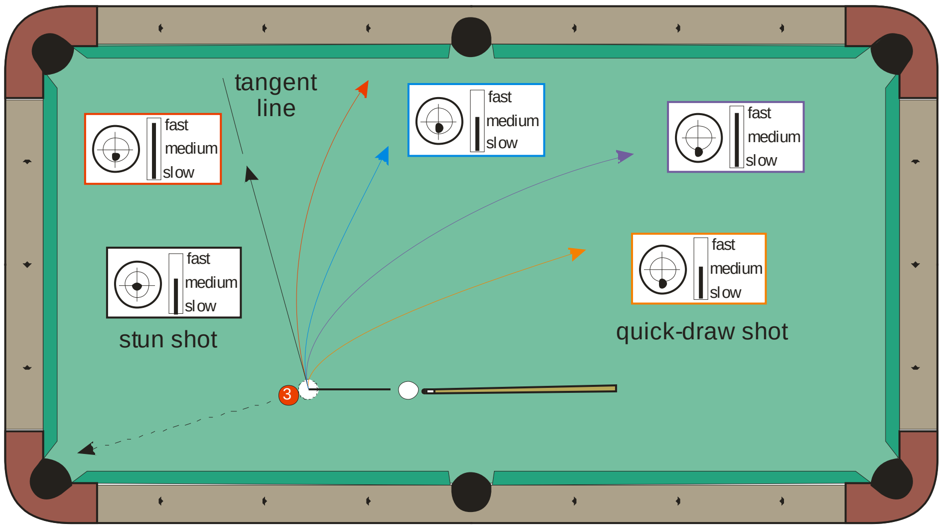
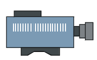


Diagram 3 Draw shot speed and spin effects


high-speed video

HSV B.23 – cue ball path speed, spin, and cue elevation effects


normal video

NV B.45 – Cue ball path speed effects

Well, I hope you enjoying and benefitting from my series of articles dealing with draw shot physics. Next month, I will conclude the series by looking at the effects of cue elevation.

Good luck with your game,
Dr. Dave

PS:

- If you want to refer to any of my previous articles and resources, you can access them online at ***billiards.colostate.edu***.
- I know other authors and I tend to use lots of terminology (e.g., squirt, throw, stun, impact line, etc.), and I know not all readers are totally familiar with these terms. If you ever come across a word or phrase you don't fully understand, please refer to the online glossary on my website.

Dr. Dave is a mechanical engineering professor at Colorado State University in Fort Collins, CO. He is also author of the book, DVD, and CD-ROM: "The Illustrated Principles of Pool and Billiards," and the DVD: "High-speed Video Magic."