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

"Draw Shot Primer – *Part II: aiming*"

***Note**: Supporting narrated video (NV) demonstrations, high-speed video (HSV) clips, and technical proofs (TP) can be accessed and viewed online at **billiards.colostate.edu**. The reference numbers used in the article (e.g., **TP A.20**) help you locate the resources on the website. If you have a slow or inconvenient Internet connection, you might want to view the resources offline using a CD-ROM. See the website for details.*

This is the second article in a series dealing with draw shot principles. Last month, we explored some of the basic physics of draw shots. This month, we'll look at how some of those results can be used to analyze and compare various draw shot aiming systems.

Diagrams 1 and 2 repeat some of the results from last month's article. The graph in **Diagram 1** shows how much the cue ball deflects away from its original direction for typical draw shots of various ball-hit fractions. **Diagram 2** illustrates the three points shown in the graph that correspond to the cue ball angle changes for 1/4-ball, 1/2-ball, and 3/4-ball hits. The cue ball's final path is deflected away from its original direction (the aiming line) by 58° for the 1/4 ball hit, 90° for the 1/2-ball hit, and 128° for a 3/4-ball hit. As you can see, the deflected angle varies significantly as the ball-hit fraction (cut angle) changes. But, if you're like me, you might be wondering if there is a useful aiming system to help you reliably predict the final direction for the cue ball for any cut angle. When you see how nearly straight the curve is in **Diagram 1**, you can't help but think that there must be a system that would work fairly well over a very wide range. Luckily, there are such systems.

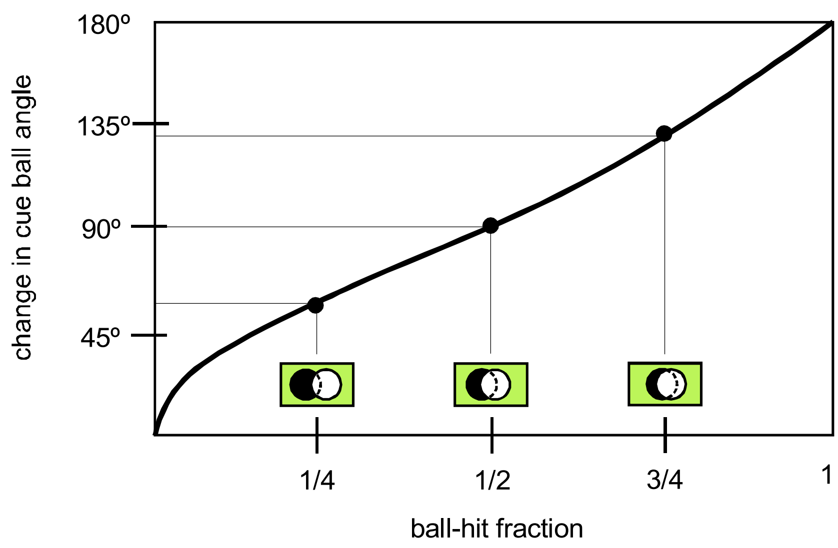

Diagram 1 Deflected cue ball angle vs. ball-hit fraction for an average draw shot

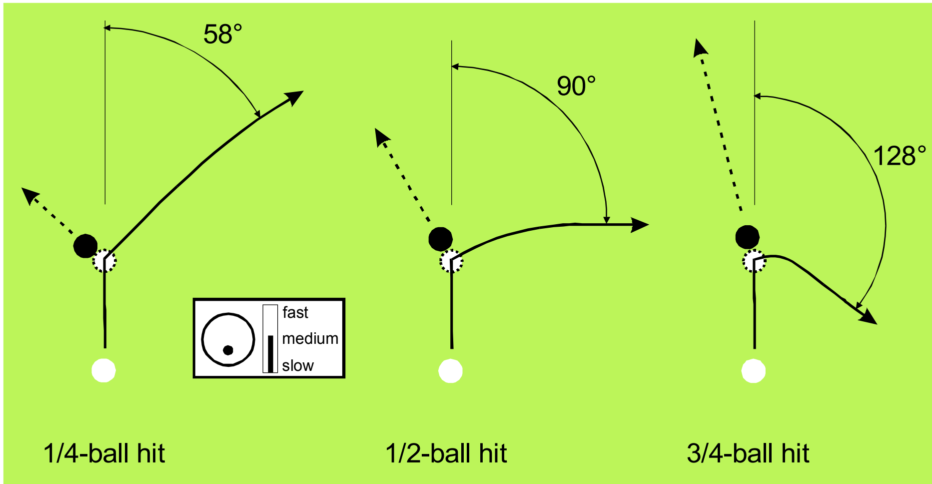

Diagram 2 Shots corresponding to the points in Diagram 1

One fairly well known (or at least old) system for predicting the final cue ball direction for a draw shot is the *bisector-point system*. It is illustrated in **Diagram 3**. In words, the angle bisector between the desired final cue ball direction and the original line of centers between the cue ball (CB) and object ball (OB) defines the aim point for the shot (point P in the diagram). A "bisector" is a line that divides an angle in half. With point P as the aim point, the final cue ball direction will be as shown in the diagram, after the draw action takes hold. Note that the final cue ball path is parallel to (i.e., at the same angle as) the predicted direction. Also note that the aim point P on the object ball is different from the contact point between the ghost ball (GB) and object ball.

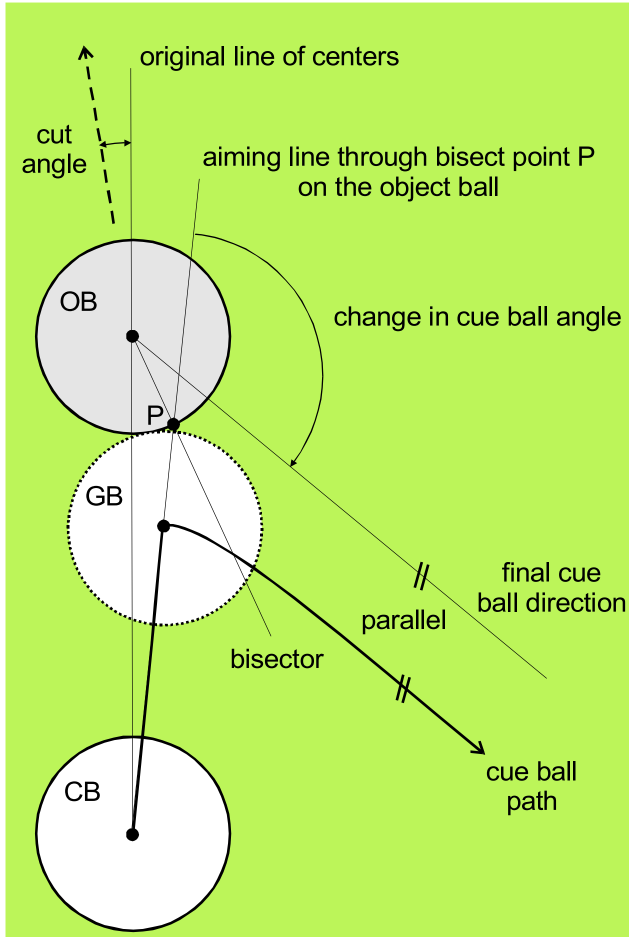

Diagram 3 Bisector-point system

In Bob Jewett's October, 1995 BD article, he suggested an alternative method for implementing the bisector-point system, where you divide the angle between the original line and desired final cue ball direction by four. The necessary cut angle will be 1/4 of the total angle. I will refer to this method as the *double-bisect system*. It is illustrated in the left side of **Diagram 4**. It turns out that these two systems don't agree exactly, but they give similar results over a wide range of shots (see **TP A.21**). The double-bisect system disagrees with the bisector-point system more for larger cut angles and for larger distances between the cue ball and object ball (see **TP A.21**). And as we'll see below, neither system is perfect for all cut angles. They work best for small cut angles (see **TP A.20**). Despite the disagreement between the systems, they both still have their merits. Because the bisector-point method is based on knowing the desired cue ball draw direction, it is most useful for planning carom shots, where the final cue ball direction is the most important concern. The double-bisect system is more useful for predicting cue ball direction for a given cut shot. Here, you need to send the object ball to a target (at a given cut angle), but you also need to predict the resulting cue ball motion to detect a possible scratch, avoid traffic created by surrounding balls, break-out clusters, or just plan accurate position for the next shot. I will look at more details and show examples of how to apply the systems next month.

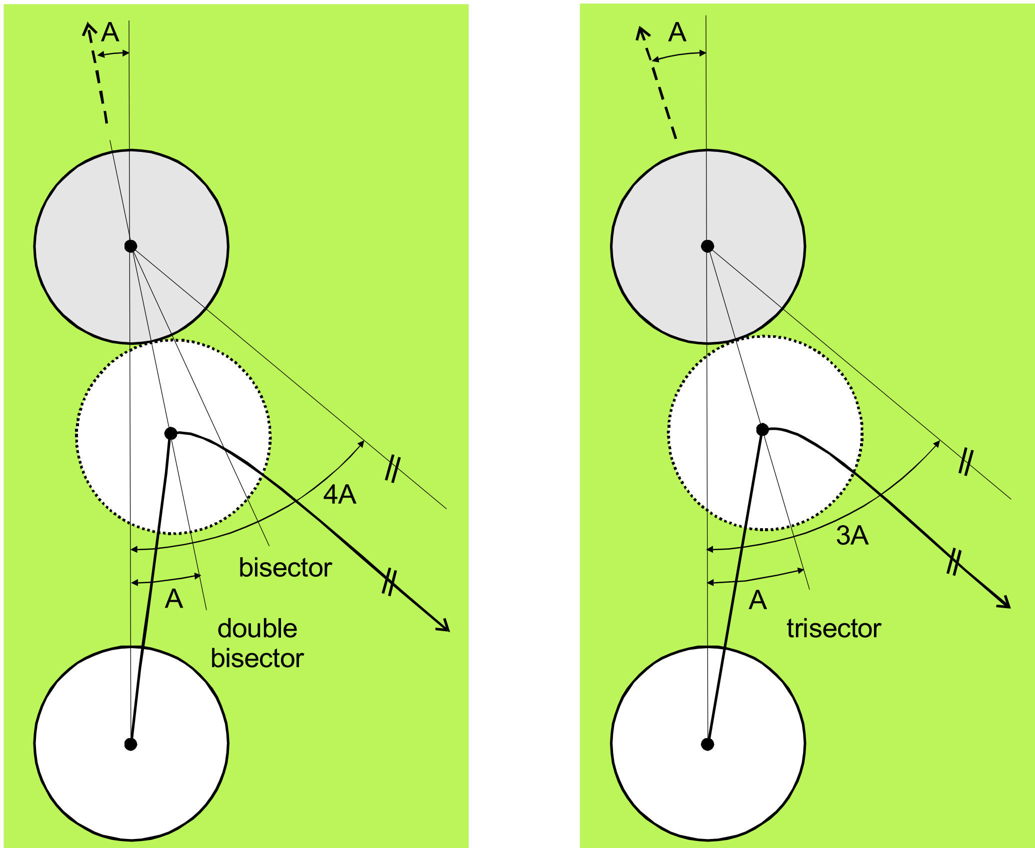

Diagram 4 Double-bisect and trisect systems


technical proof

TP A.20 – The effect of spin, speed, and cut angle on draw shots
TP A.21 – Comparison of bisector-point and double-bisect draw systems

The right side of **Diagram 4** illustrates a system I call the *trisect system*. It is very similar to the double-bisect system; but instead of dividing the shot angle into four pieces, it is only divided into three. To apply the system, you first observe the cut angle for the shot. As summarized in **Principle 29**, the cue ball's final direction will be three-times that angle away from the initial line from the cue ball to the object ball (see the right side of **Diagram 4**). As I'll show next month, as with the peace sign implementation of the 30° rule (see **NV 3.8** and my past articles dealing with the 30° rule), you can use your hand to help measure the cut angle and visualize the final cue ball direction. I'm a hands-on, visual, kind of guy, so I love using my fingers, hands, and cue stick as aiming aids at the pool table. Again, I'll explain and illustrate this in more detail next month.

Principle 29 Trisect draw aiming system

For a typical amount of draw, the angle between the final cue ball direction and the initial line between the cue ball and object ball is three times the cut angle.


normal video

NV 3.8 – Using your hand to visualize the 30° rule

As can be seen in **Diagram 5** (from **TP A.20**), the trisect system is more accurate than the double-bisect system over a large range of ball-hit fractions. The double-bisect system is a little more accurate for large ball-hit fractions (small cut angles), and both systems work poorly for small ball-hit fractions (large cut angles), especially the double-bisect system. In general, the trisect system provides a much better match to the exact curve. Also, the trisect system agrees perfectly with the 90° angle predicted for a 1/2-ball hit (see last month's article and **TP A.20**). It is important to remember from last month that the exact curve shown in **Diagram 5** applies only to draw shots with a "typical" amount of draw. You might remember from last month that a "typical" amount of draw is the amount of draw required to change the cue ball's direction by 90° for a 1/2-ball hit. For draw shots with a lot more or less action than "typical," the cue ball angle will deviate from the exact curve shown, and the trisect system may not apply as well.

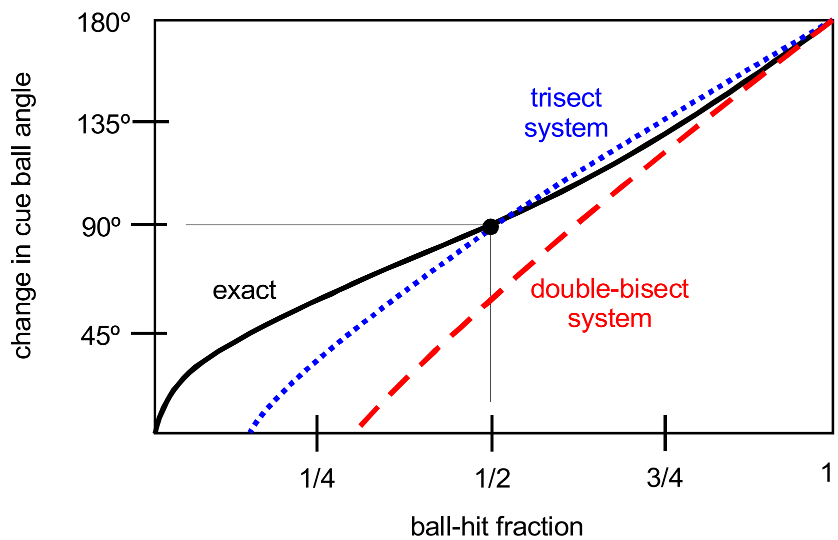

Diagram 5 Comparison of the double- bisect and trisect systems

Well, now that we've covered the basics of draw shot physics and how some of these results can be used to analyze and compare draw shot aiming systems, its time to look at how all of this can be useful in your game. Unfortunately, we're out of space for this month, so it will have to wait until next time. In the next three months, we'll look at: examples of how to put the trisect system to good use, general recommendations for good draw technique, and how the amount of draw can be characterized by "numbers of tips." I hope you will look forward to reading these articles as much as I look forward to writing them.

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 ***billiards.colostate.edu***.

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."