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

"Draw Shot Physics - Part IV: cue elevation effects"

*__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 fourth article in a series on draw shot physics. In the previous three months, we looked at the basics, listed a set of conclusions from some physics studies, looked at some practical examples where the conclusions are useful, and related "quick draw" to spin-to-speed ratio. All of my past articles are available at **billiards.colostate.edu**. This month, we will conclude the series by looking at the effects of cue elevation.

Diagram 1 illustrates an important concept related to cue elevation. Diagram 1a shows a level cue with a fairly small tip offset from center. Diagram 1b shows an elevated cue with the tip contact point at the same height above the table (and below the ball's center). Even though the tip is contacting the cue ball (CB) at the same point in both diagrams, the tip offset is much larger with the elevated cue. Tip offset is defined as the perpendicular distance between the line of action of the cue and the center of the CB. The **tip offset**, not the vertical height below the center, is what determines the amount of spin you can impart to the CB. For a given tip offset, the only thing you can do to create more draw distance is to have more cue speed at impact with the CB (see my April '09 article for more info).

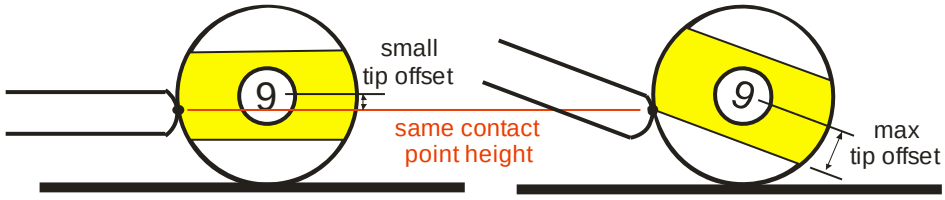

Diagram 1 Effect of cue elevation on tip offset

Some people think that with an elevated cue, the CB will be airborne during most of the shot, and therefore won't be losing any spin on the way to the object ball (OB). The airborne part is true, especially for fast speed shots, because the cue elevation drives the CB into the table causing the ball to hop and bounce on the way to the OB. It is also true that the CB doesn't lose significant spin while it is airborne (because there is no friction between the CB and the cloth). However, the CB loses significant spin during the hops, including the first hop when the CB is driven down into the table. The more you elevate the cue, the less spin the CB will have when it gets to the OB, for a given tip offset and cue speed. Other potential problems with adding too much elevation include:

1. It can be more difficult to visually align the cue with the desired aiming line of the shot.

2. If you don't hit exactly on the centerline of the CB (either intentional or not), the CB will swerve and go off line more (see **NV 4.14** and **HSV B.10**).

3. With more speed, the CB will hop over a longer distance and possibly hit the OB while still bouncing; and if the CB hits the OB while airborne, the cut angle will be changed (see **HSV B.37**) and you might miss the shot.


normal video

NV 4.14 – English swerve due to an elevated cue


high-speed video

HSV B.10 – MOFUDAT stroke drill follow and draw effects
HSV B.37 – Jump shot over-cut effect and examples

Another effect people sometimes site when claiming they can get more draw with more cue elevation is: the CB is being trapped between the tip and table, allowing the tip to deliver more spin. This might be true with highly elevated masse shots; however, as shown in **HSV B.44**, with modest cue elevations, the CB leaves the tip well before the CB bounces off the table.


high-speed video

HSV B.44 – Cloth compression and cue ball trajectory for draw shots of various elevations

Before continuing, I want to make it clear that slight cue elevation is required on most pool shots because the back of the cue extends over the rails, and the tip will therefore be lower than the butt (see **TP A.3**). And with draw shots, a little more elevation is required, since the tip will be even lower on the CB than with a center-ball hit. And if somebody has large hands with "plump" fingers and a short bridge length, the cue will also need to be elevated a little more to get the tip low enough. But this article isn't concerned with the amount of elevation required to provide clearance. Here, the focus is on whether or not there is a benefit to using additional elevation.


technical proof

TP A.3 – Minimum cue elevation required for a head-spot-to-foot-spot center-ball-hit shot

I recently did an analysis (**TP B.10**) to explore the theoretical effects of cue elevation on the speed and spin of the CB. Here are some of the conclusions from the analysis:

1. **Elevating the cue reduces the amount of CB spin at OB contact**, resulting in less draw distance (see my April '09 article for more info). The loss in spin is small for near-level cue elevations, but increases with more elevation (for a given cue speed and tip offset).

2. **Modest cue elevations (about 0-15 degrees) reduce the spin-to-speed ratio of the CB at OB contact**, resulting in "slower" draw (see my June '09 article for more info).

3. **As you increase cue elevation above about 20 degrees, the spin-to-forward-speed ratio increases, allowing for "quicker" draw** (see my June '09 article and Diagram 2 below for examples and more info). An extreme example is a highly-elevated masse draw shot, where you create lots of backspin with very little forward speed.

Now, sometimes cue elevation is required to shoot over an interfering ball, or to avoid a double hit when there is only a small gap between the CB and OB. And as noted in conclusion 3 above, with larger cue elevations, better "quick draw" action can result. However, **for maximum draw distance, a level cue (or as close to level as possible) appears to be best**.

technical proof

TP B.10 – Draw shot cue elevation effects

Diagram 2 illustrates two quick-draw examples where cue elevation helps provide a larger spin-to-speed ratio to help make the shots possible. The shot in Diagram 2a is a 9-ball example where a run-out is unlikely due to the 6-ball on the side-pocket point. The 5-ball is also difficult to pocket with the current CB position. Instead, a safety is played, where the CB is drawn back behind the 7-ball and 8-ball blockers. The elevation allows for the necessary amount of draw with limited forward speed so the 5-ball just makes it to (or close to) the end rail. Your opponent would likely not hit the 5-ball from the tough position created; and with ball in hand, you can easily pocket the 5-ball-9-ball combo for the win, without having to deal with the troublesome 6-ball. This is a shot from a multi-DVD project Tom Ross and I are currently working on called "The Video Encyclopedia of Pool Shots." The shot in Diagram 2b is an 8-ball quick-draw example. The CB must be drawn back as soon as possible with as little sideways shift as possible. With all of the striped balls surrounding the 8-ball, we wouldn't want to end up on the bottom-rail side of the 8-ball. We also wouldn't want to bump the 8-ball too much because it would be difficult to predict exactly where the CB and 8-ball might end up. The best shot here is to elevate to give the CB enough spin, but not too much forward speed, to draw back quick enough to clear (or bump slightly) the 8-ball. This creates an easy and reliable out. As in the previous example, this shot would not be possible without fairly high cue elevation.

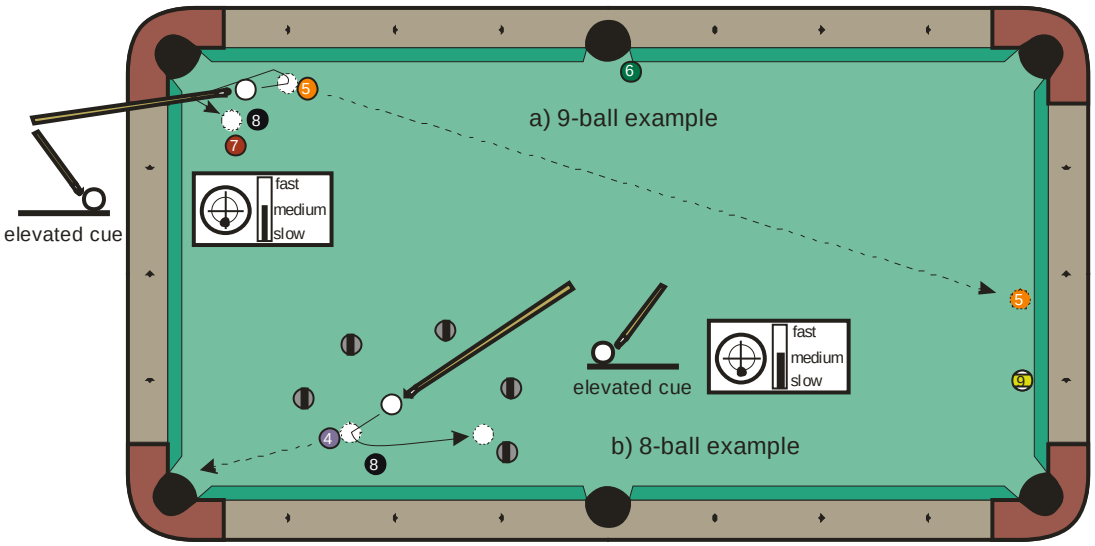

Diagram 2 Quick draw examples

I have often heard people claim that added cue elevation helps them get more draw distance (for example: "I can get more snap on the ball when I jack up."). First of all, for shots where there is a small gap between the CB and OB, elevating the cue is the best way to get good draw without risking a double hit. Beyond this, here are some other possible reasons why people might think elevation helps:

1. If you elevate the cue and use the same tip contact point on the CB, you will get more draw because the effective tip offset is larger (see Diagram 1).

2. With more cue elevation, the draw can be "quicker" (see Diagram 2 and my June '09 article). People might think this is "more draw." The draw wouldn't be as quick with a near-level cue cut shot, but the draw distance can be longer with a near-level-cue straight-in shot, with the same tip offset and cue speed.

3. Some people might be able to generate more cue speed with a little added cue elevation. Maybe they can drop their elbow and use their shoulder muscles to help create power, while maintaining tip contact-point accuracy. Or maybe the added elevation just feels and/or looks better, possibly allowing for more comfort and power. More cue speed (for the same tip offset) will always give you more draw.

Anytime you practice or do experiments with draw shots, it is important to verify that you are hitting the CB where you think you are. The best way to do this is to use a marked ball (for example, a Jim Rempe CB or an Elephant Practice ball) or a striped ball, and note the location of the chalk mark on the ball after each shot. Just make sure you align the markings on the ball with the line of action of the cue (for example, see the 9-ball stripe in Diagram 1b). People are often surprised by how high the actual tip contact point is on the ball despite how low they might think they are aiming. Sometimes, people just don't aim low enough on the CB. Sometimes people drop their elbow during the stroke, before tip contact. This brings the tip up, and you get less draw. If you tighten your grip during the stroke, the tip will drop and you might scoop the CB in the air. Always look at the mark on the CB after the shot ... the chalk mark never lies!

Well, I hope you have enjoyed and benefitted from my series of articles dealing with draw shot physics. Next month, I plan to start a series dealing with how to detect and prevent various types of fouls.

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."