BY David Alciatore Ph.D.

DRAWING CONCLUSIONS

Examining cue elevation might lead to unexpected results.

[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 help you locate the resources on the Web site. You might want to view the resources on a CD-ROM or DVD. Details can be found 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. 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 amount of 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 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, which is needed for more draw distance. 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).

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 high-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 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 CB centerline, the CB will swerve and go off line (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. If the CB hits the OB while airborne, the cut angle will be changed, and you might miss.

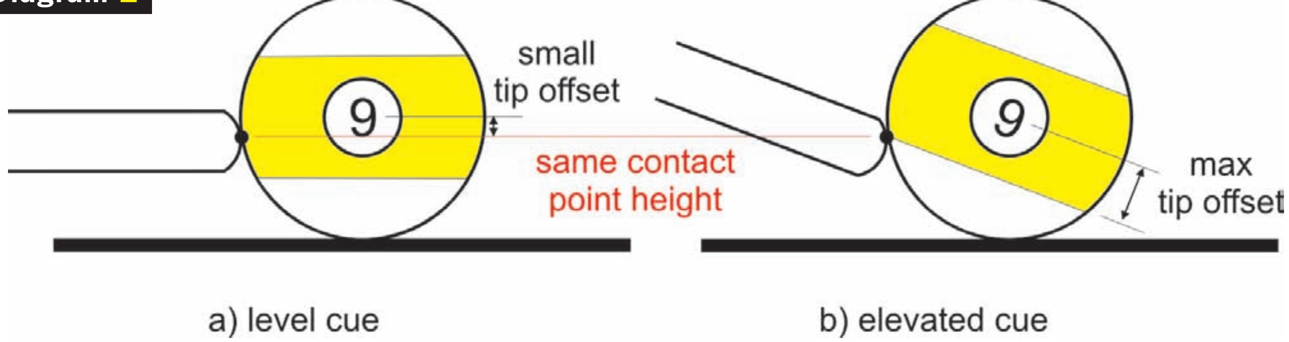
Another effect people sometimes cite when claiming more cue elevation means more draw is that the CB will be trapped between the tip and table, allowing the tip to deliver more spin. This might be true with highly elevated masse shots; however (as shown in HSV B.44), with modest cue elevations, the CB leaves the tip well before the CB bounces off the table.

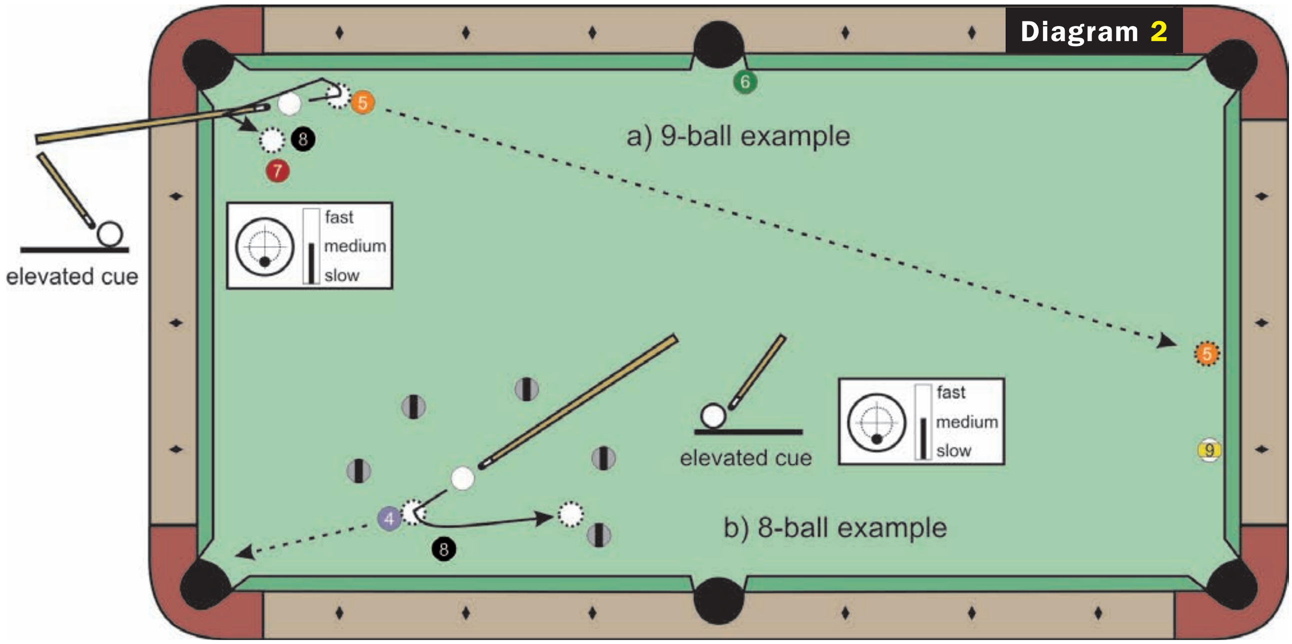
Before continuing, I want to make it clear that a slightly elevated cue is required for most shots. Because the back of the cue extends over the rails, the tip will be lower than the butt. With draw shots, additional elevation is required, since the tip will be even lower on the CB than with a center-ball hit. But we aren't concerned with the amount of elevation required for clearance. Here, the focus is on whether or not there is benefit to adding additional elevation.

I recently worked up a physics analysis (TP B.10) to study the effects thoroughly 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. 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.

Diagram 1





3. As you increase cue elevation above about 20 degrees, the spin-to-forward-speed ratio increases, allowing for "quicker" draw (see **Diagram 2**). An extreme example is a highly-elevated masse draw shot, where you create a lot of backspin with very little forward speed.

Now, sometimes cue elevation is required to clear over an obstacle ball, or to prevent a double hit when there is 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.

Diagram 2 illustrates two quick-draw examples where cue elevation helps provide a larger spin-to-speed ratio. The shot in Diagram 1a is a 9-ball example where a runout is unlikely due to the 6 ball on the point of the side pocket. 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 two 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, and with ball in hand, you can easily pocket the 5-9 combo, without having to deal with the troublesome 6 ball.

The shot in Diagram 2b is a quick-draw example in a game of 8-ball. The CB must be drawn back quickly and 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 is difficult to predict exactly where the CB and 8 ball would end up. The best bet here is to elevate your cue to give the CB enough spin — but not too much forward speed — to draw back quickly and clear (or slightly bump) the 8 ball. This creates an easy and reliable out. Neither of these shots would be possible without fairly high cue elevation.

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 a good amount of 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" (shown in Diagram 2). People might think this is "more draw." While the draw wouldn't be as quick with a near-level-cue cut shot, 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 hit the CB at the intended spot. 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 look at the chalk mark on the ball after each shot. Make sure you align the markings on the ball with the line of action of the cue (see the 9 ball in Diagram 1b). People are often surprised by how high the actual contact point is on the ball, despite how low they might think they are aiming. 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.

David Alciatore is a mechanical engineering professor at Colorado State University in Fort Collins, Colo. 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."