Supporting narrated video (NV) demonstrations, high-speed video (HSV) clips, 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 articles 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 follow-up series dealing with **throw**, which is a change in object ball (OB) direction due to sideways forces between the cue ball (CB) and OB during a collision (see **NV B.86** for more info and demonstrations). Over the last few months, I presented the results of experiments performed to characterize the effects of different surface treatments on the amount frozen and non-frozen pool balls throw (see **NV D.16** and **NV D.17**). The experiments also looked at what causes cling (AKA "skid" or "kick"), which is an excessive amount of throw, more than what you would normally expect. The previous articles and experiments dealt with cut shots, where there is an angle between the CB aiming line and the OB target direction. Cling can also affect straight follow shots. That's the topic for this month.

Diagram 1 shows a useful principle related to straight follow shots (per the physics in **TP A.16**). In general, the distance the OB travels forward CB travels forward (if it were free to move until stopping naturally, without hitting a ball, cushion or pocket) is 7 to 8 times the distance the CB travels forward. This number can vary quite a bit with different cloth and ball conditions, but it is a good general "rule of thumb." Recently, I did an experiment on my table to experimentally check the number. It's not that difficult. Do it yourself the next time you're at a table. Just place the CB and OB in the same place every time, as shown in Diagram 1. Then hit the shot over a range of speeds to send the OB over a range of distances between the starting point and the far rail. Measure and record the CB and OB distances after each shot, either with a tape measure or by counting diamonds (and fractions of diamonds). Then calculate the OB-distance-to-CB-distance ratio for each set of numbers. For example, if the CB travels 2 inches and the OB travels 16 inches, the ratio would be 8 (16 / 2). This would be a useful benchmark to know for your equipment. On my table, the average value was about 8.5, which is a little larger than normal. In other words, my CB isn't traveling quite as far as typical, based on how far the OB is travelling. Since the ratio was high, I decided to do an additional experiment. I wiped the CB with Silicone spray to simulate slicker and cleaner conditions. Then the factor went down to about 7.5, which makes sense since a slick CB will lose less spin in the hit and have less rolling resistance on the cloth.

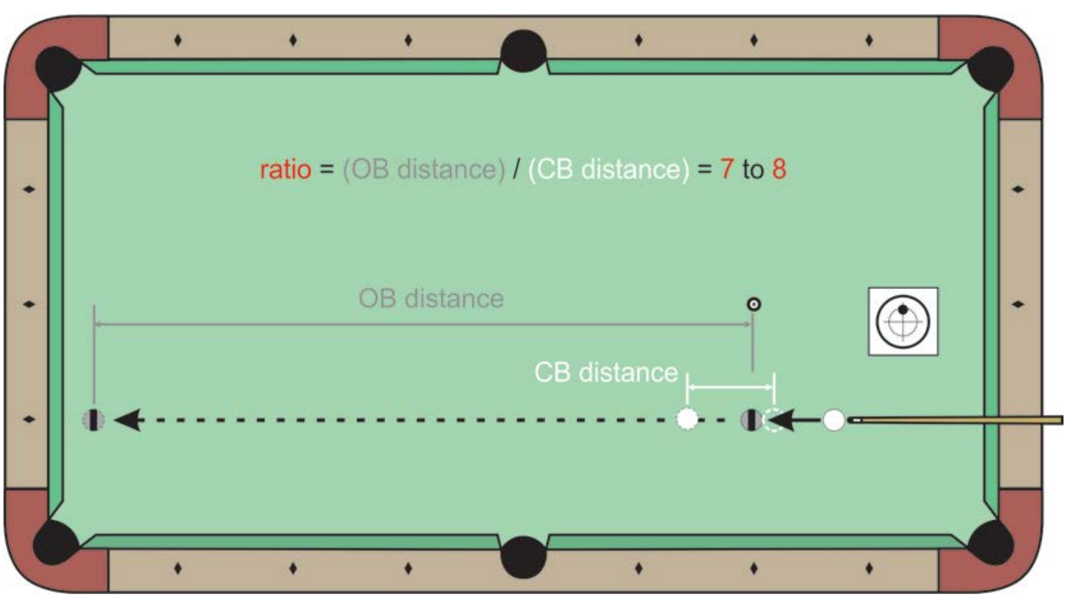


Diagram 1 Follow distance

The follow distance and ratio apply only when the hit between the CB and OB is "good." If a chalk smudge happens to appear at the CB-OB contact point during the collision, all bets are off. Cling will occur and the CB won't follow nearly as much as you would expect with a clean hit. **HSV B.46** illustrates this effect, clearly demonstrating how the CB hops, loses a significant amount of topspin and post-impact follow, and transfers a small amount of backspin to the OB when there is cling. Maybe this has happened to you during game situations, where the hit sounds a bit different and the shot doesn't quite play out as you expect. It's certainly happened to me.

It turns out that there are certain situations where follow-shot cling is more likely to occur than others. The worst-case scenario is when the fresh chalk mark from the tip hitting the CB happens to end up exactly at the contact point with the OB. When this happens, cling is pretty much guaranteed to occur. To better understand this, first look at **Diagram 2**. It shows the tip height that causes the CB to roll immediately as it leaves the tip. This immediate-roll height is at 40% of the ball's radius (0.4R), which is a touch below the miscue limit (at 0.5R). An example of where you would want to hit the CB at the immediate-roll height (or higher, which is risky) is a fast-speed follow shot (AKA a "force follow" shot). You want the CB to have full roll when it arrives at the object ball (OB) to generate good follow action. If you were to hit lower than the 0.4R height, the CB probably wouldn't have full roll when it reaches the OB.

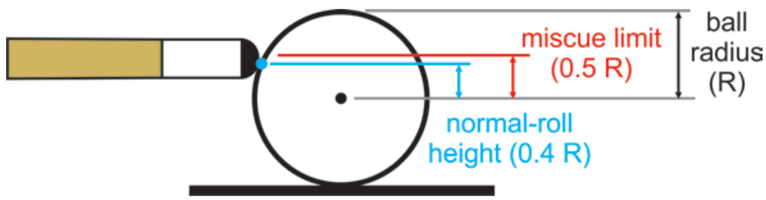


Diagram 2 Immediate-roll tip height

As shown in **Diagram 3**, if the immediate-roll tip height is used, there will be a certain distance (d) where the tip contact point will arrive exactly at the CB-OB contact point, resulting in cling and poor follow. **TP B.16** presents the analysis used to figure out this potentially-unfortunate distance, and the results are summarized in **Table 1**. It turns out that there is more than one answer. If the distance between the balls is about 1.4 balls, the chalk smudge will take the shortest-distance path to the OB contact point, as shown in Diagram 3. If the CB were farther away, say at a distance of 4.5 balls, the chalk mark would make an extra revolution as the ball rolls, and still end up at the OB contact point. There is an easy method you can use at the table to figure out these "bad" distances (without complicated math). If you have an Aramith red-measles ball, use that; otherwise use a solid or stripe as the CB. First freeze the CB to the OB with a red dot (or the center of the number circle) in contact with the OB. Then roll the CB straight back until the mark is approximately at the immediate-roll tip height. To create other distances, just roll the CB back additional revolutions farther. Then chalk up the tip and hit the ball on the mark. You should get cling a large percentage of the time, assuming you had the mark close to the correct height and the tip hit the ball on the mark without sidespin. You can check the chalk mark on the CB after a shot to see how close you got to hitting the mark. I tried out this procedure at the 1.4-ball distance, being very careful, and I got cling pretty much on every attempt.

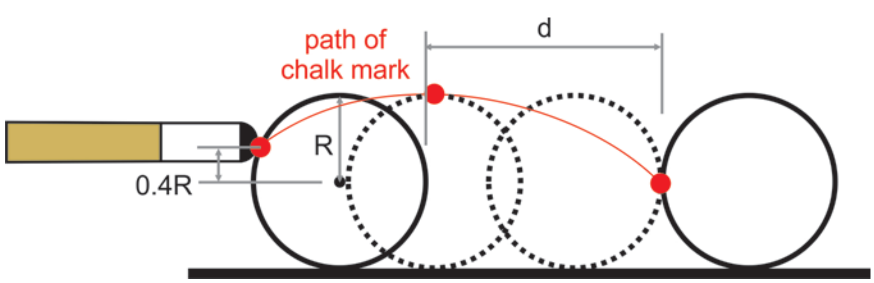


Diagram 3 Follow cling ball separation distance

Table 1 Follow cling ball separation distance results

distance between the CB and OB for follow cling	
inches	**number of balls**
3.1	1.4
10.1	4.5
17.2	7.6

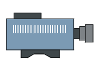
So how is all of all of this information useful? Well, if you want to prevent cling and get the amount of follow you expect on a straight shot, it is good to know or be able to visualize the distances in Table 1. If the CB happens to be at one of these distances from the OB, hit the CB a little lower than the immediate-roll height shown in Diagram 2. This will cause the CB to slide a bit before developing full roll, which will delay the spot from arriving at the OB contact point, preventing cling. If the distance between the CB and OB is anything other than the distances in Table 1, then an immediate-roll shot is a good choice because the chalk smudge will automatically be at some point other than the CB-OB contact point, and again the shot will be cling-free.

I hope you are enjoying my throw follow-up series. If you want to learn more about throw, lots of information and video demonstrations can be found on the throw resources page in the FAQ section at ***billiards.colostate.edu***.

Good luck with your game,
Dr. Dave


normal video

NV B.86 –Cut-induced throw (CIT) and spin-induced throw (SIT), from VEPS IV
NV D.16 – Pool ball cut-induced throw and cling/skid/kick experiment
NV D.17 – Does a pool and billiards frozen combination throw more than a small-gap stun shot?


high-speed video

HSV B.46 – CB and OB hop and spin transfer during follow shots


technical proof

TP A.16 – Final ball speeds, distances, and directions for natural roll shots
TP B.16 – CB-OB distance for follow cling

PS:

- I know other authors and I tend to use lots of terminology, 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 author of "The Illustrated Principles of Pool and Billiards" book and DVD, and co-author of the "Video Encyclopedia of Pool Shots (VEPS)," "Video Encyclopedia of Pool Practice (VEPP)," and "Billiard University (BU)" instructional DVD series.