“Throw Follow-up: Part II: More Results” **ILLUSTRATED PRINCIPLES**
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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 second article in a follow-up series dealing with throw, which is the change in object ball (OB) direction due to sideways forces between the cue ball (CB) and OB during impact (see **NV B.86** for more info and demonstrations). Last month, I presented the results of an experiment performed to characterize the effects of different surface treatments on the amount pool balls throw. The experiment also looked at what causes cling (AKA “skid” or “kick”), which is an excessive amount of throw. With last month’s tests, the surface treatments were applied in a particular order to the same set of balls. But would the results be the same if things were done in a different order? For example, would cleaning with alcohol alone have the same effect as cleaning with alcohol after previously cleaning with Acetone, which is what was done last month? This question is answered in the new experiment. Also, all of the results presented last month were for a ½-ball hit 30° cut angle. In the experiment this month, we will see how throw and cling change with a larger cut angle.

Diagram 1 shows the test shot used in the experiment. The 1 ball is frozen to the 2 ball, and there is a spare CB frozen to the 1 ball. Unlike last month, where the cut angle was 30°, here the angle is 45°. The purpose for the spare ball at the ghost-ball position is to help ensure a consistent and square hit on the 1 ball and minimize any effects of unintentional sidespin on the CB. It also allows easy simulation of the effects of different conditions on the CB-to-OB contact point. The CB is hit squarely into the frozen ball with no sidespin to create an accurate and consistent 45° cut. With a straight hit along the line of the balls, the 2-ball would not be thrown at all and would head straight up table along the “line of centers” direction. However, with a cut angle, the 2 ball gets pushed off line at an angle as shown in the diagram. The frozen combination simulates a normal, non-frozen stun shot, where throw is largest.

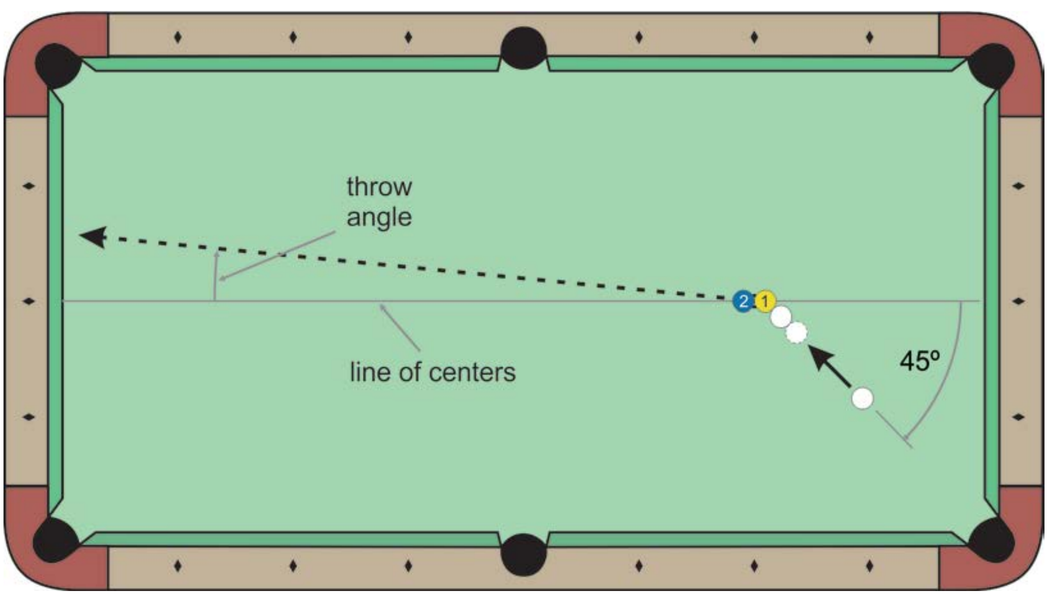

Diagram 1 Test shot for throw experiments

Diagram 2 shows the results of the first test that determined how throw angle varies with shot speed for a 45° cut. As with the 30° cut last month, throw is smaller at faster speeds. In this case, the throw at slower speeds (close to 7°) is more than twice that at faster speeds (about 3°). That's one reason top players often use more speed rather than less where there is a choice (and where the speed won't decrease the effective size of the pocket much). With faster speed, the OB goes closer to the intuitive and easy-to-visualize line-of-centers direction. Also notice in the graph how throw appears to approach a limit at slower speeds where friction is greatest. All of the tests from both last month and this month can be viewed in online video **NV D.16**.

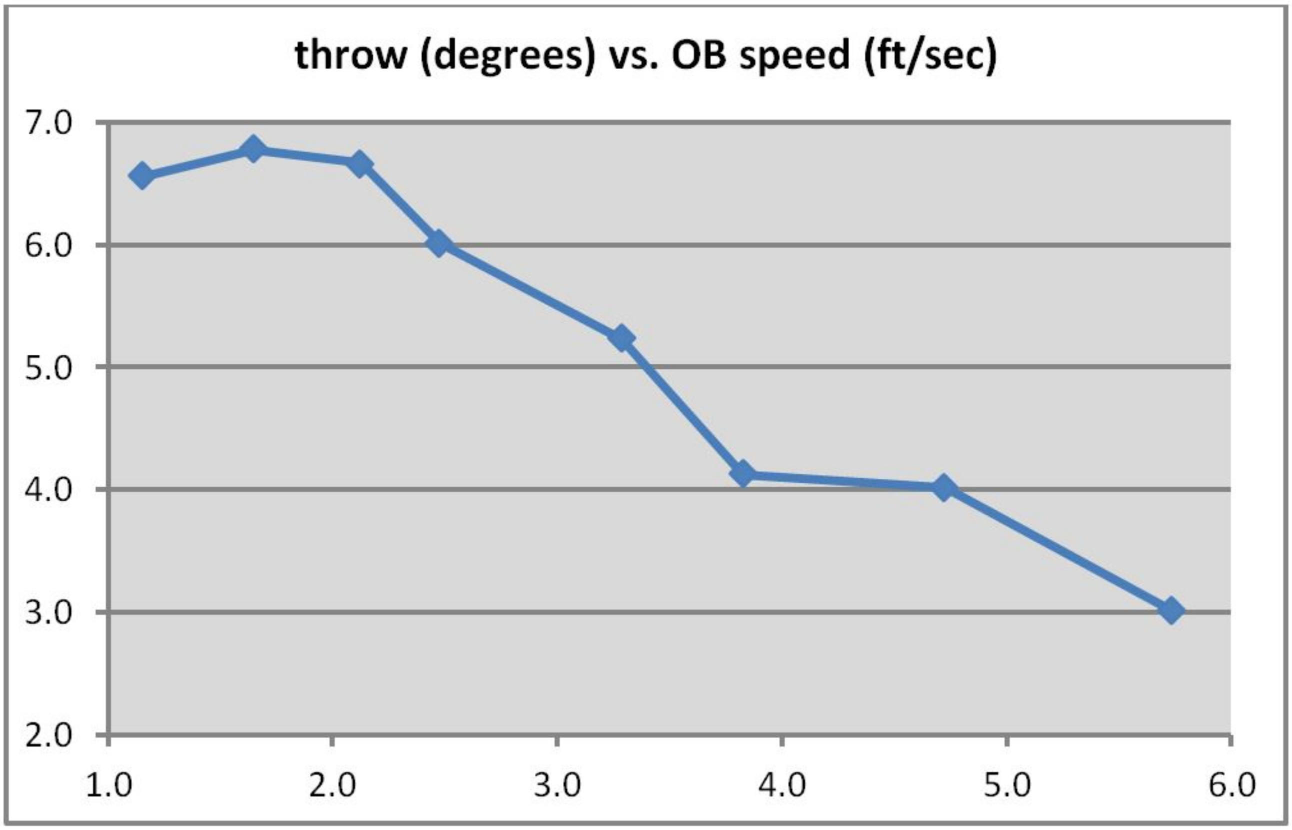

Diagram 2 How throw varies with shot speed

The next set of tests explored how throw varies with selected ball-surface conditions. **Table 1** summarizes the results, starting with unmodified used balls. The first treatment tested was rubbing alcohol, to see the independent effects of alcohol. Remember, last month the balls were cleaned with alcohol after they had already been cleaned with Acetone. Notice how the amount of throw increased dramatically (from 4.9° to 11°). That was the case last month also, but now we know it is due to the alcohol and not a previous treatment. Notice how the throw decreased again (down to 3.6°) with the Aramith ball cleaner, below what is typical with used and unclean balls (4.9°).

Table 1 **Results of surface condition experiments**

test	throw		
	inch	cm	degrees
used	5 3/8	13.7	**4.9**
alcohol	12 3/8	31.4	**11.0**
Aramith	3 7/8	9.8	**3.6**
chalk/chalk	13	33.0	**11.6**
spit/chalk	12 7/8	32.7	**11.5**

With a 45° cut, there is potential for a much larger increase in throw than with 30° cuts because it takes more friction force to gear the balls together during impact. Therefore, the effects of cling can be much more noticeable at the table with larger cuts (since the resulting throw is much more than normal). In the next set of tests (see the "chalk/chalk" row in the table), I applied chalk to both contact points of the three frozen balls to create cling (excessive throw). The throw increased from 3.6° to 11.6°, more than a factor-of-3 increase! This would definitely be noticeable (and even shocking) at the table if it occurred during a normal shot (which could happen, especially with a slow stun shot, if a chalk smudge happened to appear at the ball contact point).

In the test just described, chalk was added to the contact point between the spare CB and the 1 ball to see if this has any effect on the results. If you watch the online video, you will see that spare frozen CB picks up some spin as the first OB acquires spin during collision as the two OBs attempt to gear together. To see if this is a significant effect or not, I then repeated the tests after cleaning the chalk off the contact point between the spare ball and first OB. I went even further by wetting the CB-OB contact point with saliva before each shot to reduce friction even more. If you watch the video, you will see that the frozen CB picked up no spin at all as the OBs attempted to gear during the collision. At first, I thought the amount of throw would be very different, but as shown in the last row of the table, it didn't change much. This sort of justifies the frozen combo test as a simulation of a normal non-frozen stun shot, because it shows that there is no significant effect on throw when the CB is in contact with the first OB during the collision, even if there is chalk at the contact point.

Much more throw is possible at larger cut angles. With the 30° cuts last month, the largest throw was about 7°. With the 45° cuts, the largest was over 11°. At larger cut angles, it takes more friction force to gear the balls together, so added friction can have a greater effect.

Again, online video **NV D.16** shows and describes the results of all of the experiments performed. Check it out when you get a chance. It is a lot more interesting to actually see an effect rather than just read about it. Even better, try some of the experiments on your own. They aren't that difficult, and they don't take much time.

Based on the results of the experiments (from both last month and this month), here is some important advice:

- Keep pool balls clean.
- Wipe chalk marks off the cue ball when you have ball in hand, and between games.
- Clean chalk smudges off OBs whenever you spot any.
- Dirty and chalk-smudged conditions can result in excessive throw.

- Use standard pool-ball cleaners. Other cleaning products and waxes can create radically different throw properties.

I hope you are enjoying my throw follow-up article 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

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.