

Seeking Truth of Beliefs

by BOB JEWETT



ARE YOU A billiard experimenter? In a sense, every time you play, you're testing theories. "If I play with reverse, I can kill the cue ball on the rail." "With a firm hit, this bank shot will shorten enough to make."

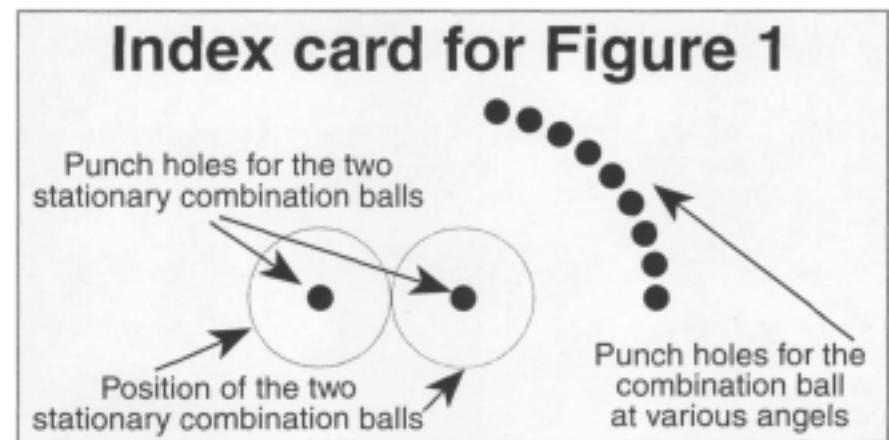
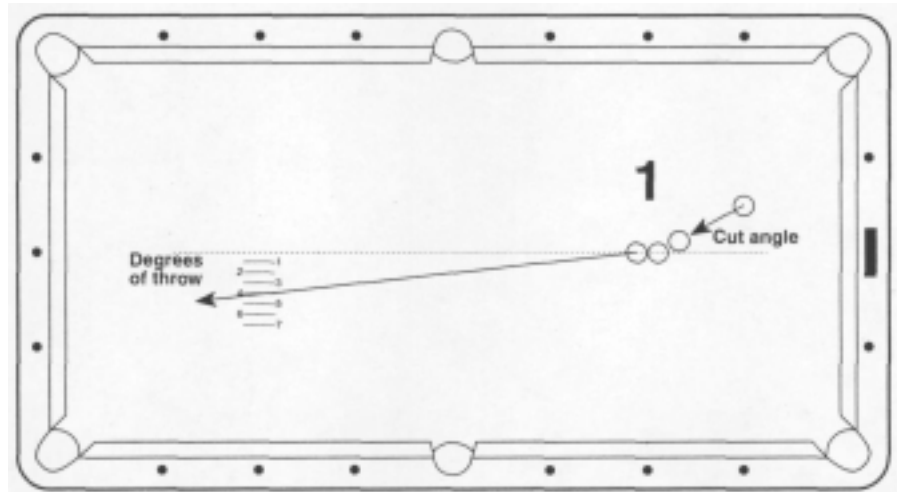
"This shot goes if I just roll it softly." On each shot, you have some theory that you put to the test.

There are past and present "pool physicists" who have undertaken some fairly serious studies of rotating spheres on green cloth. Below are some of their results and some suggestions for how to do your own experiments.

In 1941, Prof. Arthur Moore of the University of Michigan was investigating Willie Hoppe's stroke. His interest had been sparked by a multi-flash photo spread in *Life Magazine* of the carom legend's shots. (Some of these are in Hoppe's book, *Billiards As It Should Be Played*.) As a preliminary study, Prof. Moore measured how efficiently the cue stick hits the ball. To do this, he had to measure the speed of the stick before and after the hit, and the speed of the cue ball. This would tell him how much of the stick's energy was transferred to the ball. Both ball and stick were suspended on thin wires like a swing from the ceiling, then the stick was pulled back a measured distance to a backstop and released. By measuring the swings of the ball and stick, and applying some simple physics, the speeds could be calculated.

Moore's somewhat surprising result was that the ball swung up higher than the stick started. Its speed was 30% above the speed of the stick for the whole range of speeds used. A roughly 50% increase is expected for a tip that wastes no energy during contact, so Moore's measurements showed a collision with 81% efficiency.

In a very readable book, *The Physics of Ball Sports*, by C. B. Daish, some related results are given. Using fast strobe lights, like those used to photograph Hoppe's stroke, the duration of the hit on golf and tennis balls were measured while the



speed of the shot was varied. The remarkable result is that the time of contact decreases on faster shots.

The most thorough experimental treatment of pool available in print is Jack Koehler's *Science of Pocket Billiards*. His experiments have demonstrated facets of how balls and sticks work that most players would never guess. If you want to try your own experiments, this is a great book to start from. My only complaint is that it gives almost no theoretical background for the subjects studied.

Just this year, a group at the University of Wisconsin began some experiments. In their first trial, they measured the force on the tip during a break shot by using an

electronic strain gauge. The peak force was about 450 pounds for a cue ball velocity of 26 feet per second. Further experiments are planned using a video system that can shoot 1000 frames each second.

A very interesting experimental apparatus has been built, again Michigan. The Clawson Cue Company has constructed "Iron Willie," a machine that can shoot shots with precisely set speed, English, and elevation. Published results are sparse so far, but it appears Willie is being used mostly to study the mysteries of squirt. I hope to report more on this soon.

I'm sure you're eager to try some of your own experiments by now. What do you need to start? First is a hypothesis (or be-

lief) to put to the test. "There is more throw on soft combination shots than more forceful combination shots," is one.

Next you need a way to test this: Set up combination shots and measure how much throw there is for different kinds of shots.

Now you may start worrying about the details of the experiment. Does the table roll off? How fast is "soft?" How can you accurately measure the angle of throw? Will spin on the cue ball change things? Will the angle of approach of the cue ball change things? What if the two combination balls aren't frozen? These represent too many variables. Get rid of some, at least for the first experiment; you can always incorporate more and different factors in later experiments.

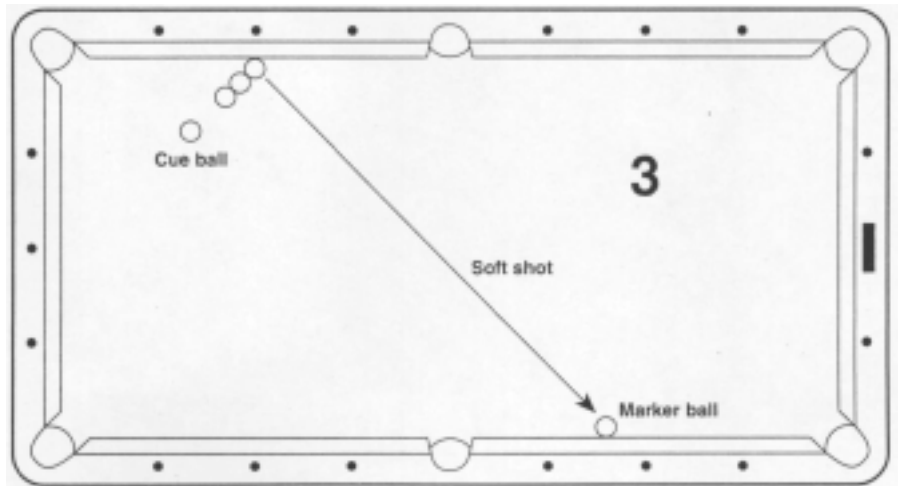
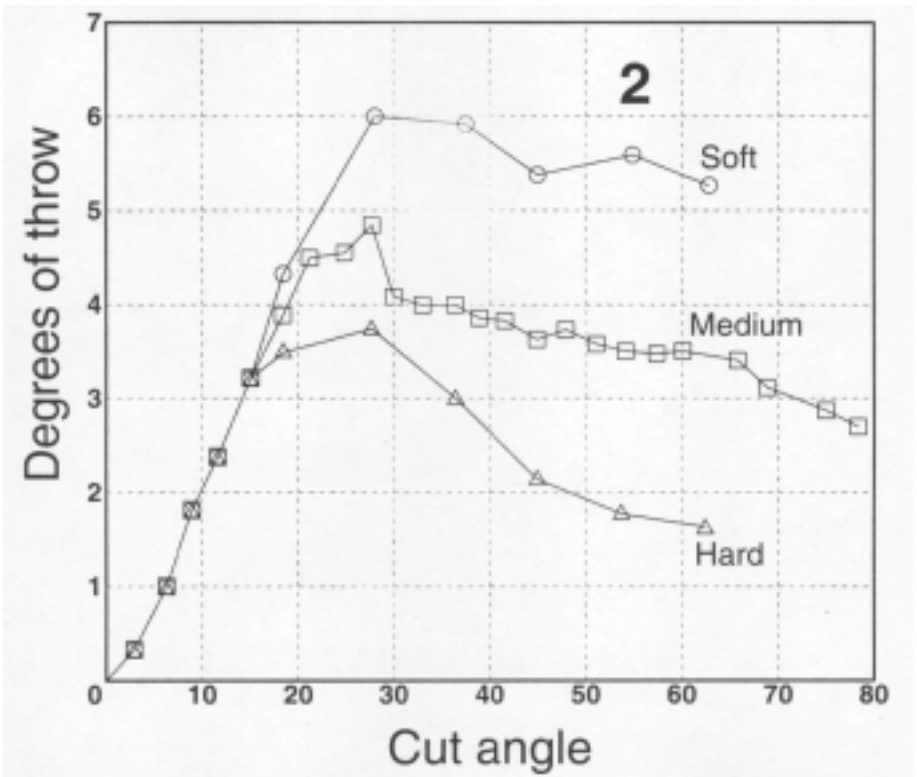
Try this: Place the combo balls on the foot string aimed straight up the table and frozen together. Place a third object ball slightly separated and at an angle as shown in Figure 1. Shoot the cue ball into the proxy cue ball. Call it a soft shot if the ball just reaches the far rail, medium if it goes another table length, and hard for another table length.

To get consistent results, you will need to be able to place the balls in the same positions repeatedly. Get a large index card (3 by 5 inches is barely large enough) and a hole punch. Punch two holes for the frozen combo balls, and a semi-circle of holes, each whole 10 for the third object ball so it can contact the combo at various angles. Tape the card to the table, roll the balls into the holes, and start your measurements. I find the use of a card like this much more precise than tapping the balls into position, and it is easier to set up the angles on paper.

When I did all of this, I got the results plotted in Figure 2. The amount of throw is on the vertical axis, and the cut angle is on the horizontal axis. For example, the maximum throw measured was six degrees (A degree of throw is about half a ball diameter in four diamonds of travel.) which happened for a 30-degree angle (half ball hit) and a soft shot.

The results are not completely as expected. Note that up to a 20-degree hit angle, there is little change in throw for hard versus soft shots. As the angle continues to increase, the soft shot keeps a fairly constant five to six degrees of throw, but the throw on the hard shot gradually drops down to a degree and a half.

The results suggest a further experiment. The three curves are nearly the same straight line for cuts from zero to 20 degrees. In theory, if the combination balls are separated by a certain distance, the cut



should exactly cancel the throw at all speeds and for cut angles that aren't too large. Try the experiment for several separations from an eighth-inch to an inch.

Here's another experiment that will test a common belief about banks. Prepare a card that will place three object balls in a straight line and separated from each other slightly. Place the three as shown in Figure 3. Shoot the cue ball softly straight into the combo bank just hard enough to bounce the front ball a foot or two off the second rail. Place a "marker" ball where the ball hits on the second rail. With prac-

tice, you should be able to hit the marker almost perfectly full. (It helps to have an assistant to adjust and replace the marker.)

Once you have the angle for a soft bank down, predict where the ball will hit for a much harder shot, then try the experiment. I think you'll be surprised; I was.

If you try these experiments — even the one already completed — I'd like to hear your results. Please send them to me in care of this magazine or by E-mail to jewett@hpl.hp.com.

Bob Jewett is an engineer at Hewlett-Packard and the 1974 ACU-1 men's billiard champion.