

BY Bob Jewett



# MEASURED FORCE

Practicing shots on the outer limits of speed control.

**THINGS THAT** vary can be sorted into two main types: those that vary in steps and those that vary continuously, or without perceptible steps between all possible examples. The first kind of variation includes species of birds, gears in a manual transmission, the named colors in a rainbow (remember Roy G. Biv), and the number of balls pocketed in a ran. In the continuous category are your car's MPG efficiency, how long lunch takes, the actual colors in a rainbow, and the speed of the cue ball.

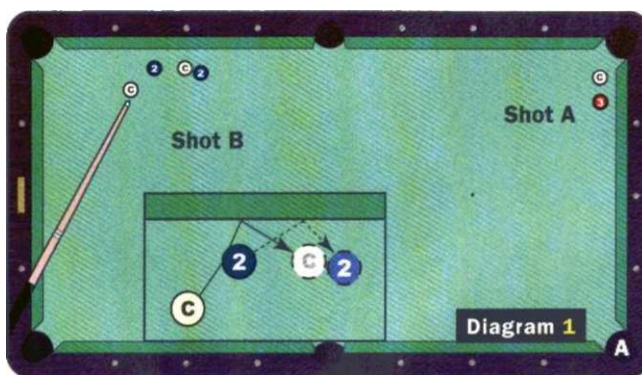
Humans like to put things into categories, even if they don't fit very well. If you look at the colors in a rainbow carefully enough, you will see that there are more colors than you could ever count — and not just the red, orange, yellow, etc. that people commonly name. At pool you see this in the division of shots into draw, stop and follow, and the pigeon-holing of cut shots into fractions of a ball such as a quarter, half, three-quarters and full. The reality is that there are infinite variations within and/or between the categories. The practicality is that the human mind tends to group like things into a manageable number of piles.

So, let's categorize shot speed. Several such arbitrary lists have been created, usually without rhyme or reason. Here is a shot speed system with some reason.

First, consider the full range of speeds used in games. At the high end is the break shot which is about 20 MPH for good players of usual ability. At the low end are soft safeties — shots in which you are either taking a foul (in games such as straight pool or one-pocket) or you are playing a safety on a ball very close to a cushion. Beginners often practice breaking but rarely practice the soft shots, and consequently they are frequently stumped by any shot below 1

MPH. Their comfortable speeds are medium, fast, and break speed.

The physics behind shot speed has a few interesting wrinkles. First, the practical quantity in a shot is how many diamonds it will travel on the cloth. It turns out that this is directly proportional to the energy in the ball (E) and



consequently proportional to the square of the velocity (V) of the ball. This follows directly from the equation for kinetic energy:

$$E = \frac{1}{2}mv^2$$

We will measure kinetic energy in diamonds traveled on a typical table rather than in the technical correct unit of joules.

A second aspect is that when a ball hits a cushion it loses roughly a fixed fraction of its energy. The fraction seems to change a little for hard shots versus soft shots, but a good average value is 2/3. Yes, the ball retains only a third of its energy in each full-on rail collision. This fact becomes very important in multi-rail shots.

For shots that don't hit any cushions, you can just measure the travel with the diamonds on the table to get their energies, while for longer shots you need to include the losses at the rails. As an example, if you shoot straight up and down the table at near break speed, you may be able to hit the far cushion three times with the cue ball traveling a total of five lengths of

the table. Using the one-third rail-loss factor, it's possible to deduce that if you had a table of unlimited length, that shot would have traveled 1,000 diamonds, where a diamond is 12.5 inches.

In making our list of categories, we need to cover the whole range of shot energies with a reasonable number of categories, and we need to distinguish between shots that seem fundamentally different. If we want to include safety shots with less than a diamond of energy, the steps better not be uniform or we would need 1,000 steps to get to the top end. Instead, let's use something like the scale used for earthquakes such that each magnitude step in the scale represents a constant ratio of energy larger than the next-lower magnitude. Since

a rail-contact causes reduction in energy by a factor of 3, it seems like a reasonable energy ratio to use, and it turns out that it simplifies the speed levels.

After a little math — contact me directly if you are really interested in the details — here is a table of shot speed categories. Note that the energy is listed as a distance.

| CATEGORY NUMBER | DISTANCE, THEORETICAL | DISTANCE, ACTUAL SPEED, | SHOT MPH |
|-----------------|-----------------------|-------------------------|----------|
| 1               | 1/3 inch              | same                    | 0.1      |
| 2               | 1 inch                | same                    | 0.17     |
| 3               | 3 inches              | same                    | 0.32     |
| 4               | 1 diamond             | same                    | 0.55     |
| 5               | 3 diamonds            | same                    | 1        |
| 6               | 9 diamonds            | 1 length+               | 1.7      |
| 7               | 31 diamonds           | 2 lengths               | 3.2      |
| 8               | 100 diamonds          | 3 lengths               | 5.5      |
| 9               | 310 diamonds          | 4 lengths               | 10       |
| 10              | 1000 diamonds         | 5 lengths               | 17       |

You may be puzzled by category 10 where a 1,000-diamond shot only goes 5 lengths (or about 40 diamonds). Let's go through the shot. Suppose you start on the head string and shoot straight up

and down the table. The ball arrives at the foot rail having lost 6 diamonds of its original 1,000 diamonds of energy — remember that distance and energy are equivalent for ball travel. The 994 is cut by a factor of three in the first rail contact leaving 331 (in round numbers). The ball arrives at the second cushion with 8 diamonds less than that due to the travel back, leaving 323. Coming off the second rail it has 108. Continuing the arithmetic, off the third rail it has 33, and off the fourth rail just 8 diamonds of energy, which barely gets the ball to the fifth rail.

How many of these categories are you comfortable using in actual play? Most players seem to struggle with any shot outside of just 6, 7 and 8. Some beginners never shoot as softly as 6, having learned that the farther the ball travels, the better chance it has to find a pocket.

As a drill for the high-speed end of the scale, try shooting the cue ball straight up and down the table five lengths to leave it within one diamond of the far rail and within a diamond of the center of the table, it may be that your table has cushions that take away even more

than two-thirds of the energy on each bounce, in which case five lengths may not be possible except with a bouncing cue ball that flies from cushion-nose to cushion-nose. Don't go to that technique; instead back off to four lengths. For completeness, try all of the speeds 6 through 10.


**Diagram 1** shows two low-speed drills to help you with the low end. In shot A, the cue ball is close to the object ball, and the goal is to make the ball in pocket A taking as many shots as possible — no rail is required on each shot, but you must hit the object ball. Taking 10 shots is good for a beginner. Once you have mastered soft shots, 40 should be your goal. There is a simple cheat that allows you to take a few hundred shots if you have the patience, but don't use that cheat if you discover it.

In shot B, the object ball starts close to the cushion with the cue ball a little farther out. Pretend you are playing 8-ball. You have no real shot, and all your opponent's balls are up-table by Shot A. Play the cue ball to contact the ball, then the cushion and then freeze to the object ball. Count the freeze as good if you

leave the cue ball within a chalk's-width of the object ball. For a real safety, the idea is to leave no jump shot. See how many times you can do this in a row taking the cue ball in hand each time but leaving the object ball as is.

As another soft-shot drill, try this one that I got from Tom Riccobene, an instructor in New Mexico. Place all the object balls along the headstring spaced apart evenly. The cue ball is not involved in the shots. Knock the first ball as short a distance as you can up the table. The second ball has to go further than the first, and so on. See if you can shoot all 15 balls with constantly increasing distances. An alternative to this drill is to shoot each ball to try to freeze it to each successive diamond (or pocket) around the table — there are conveniently 15 such spots around the table outside the kitchen. Set your own tolerance on "freezing," such as a ball diameter or a hand span.

Of course, real shots often require far more speed precision than this arbitrary division into categories, but I think that spending a little practice using these steps will help your speed control.




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