

Bob Jewett



Drawing Draw

Part 2 of charting the cue ball's path.

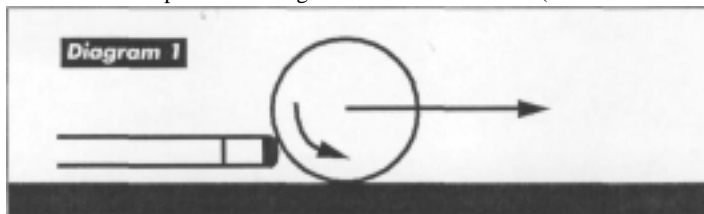
Last month I described a graphic technique for understanding how draw and follow interact with the forward speeds of the cue ball and object balls, and how speed is converted to spin and vice versa. The basic idea is shown in **Diagram 1**, where the cue ball is struck with draw. If there is no object ball in the cue ball's path, the speed and spin arrows evolve as shown, with the spin (draw) arrow, getting shorter and finally turning into follow as the speed arrow decreases from the initial value due to the drag from the draw. An important point is that the spin arrow changes five units for each two units that the speed changes. Another is that the two arrows move at a constant rate towards each other. That constant rate is determined by how slippery the cloth is.

While this analysis is both interesting and useful, the real action starts when the cue ball hits an object ball at an angle. At that instant, the speed of the cue ball, which was in line with the draw or follow arrow, is knocked to a different line with a different speed. In **Diagram 2** the cue ball that we loaded up with draw is seen from above as it hits an object ball for a half-ball hit. The initial speed and spin are equal, and in opposite directions. Remember that we called this amount of draw "perfect," as there was just as much draw as a smoothly rolling ball

What does the speed of the cue ball become? To find it, draw a rectangle as shown in the diagram. One corner is at the center of the cue ball, and one side is along the line joining the centers of the cue ball and object ball. The final detail that completely sets the rectangle is that the speed arrow of the cue ball is a diagonal of the rectangle. Believe it or not, there is only one rectangle that satisfies these three

requirements.

The new speed arrow of the cue ball is exactly the side CA, and the speed arrow of the object ball is side CB. This is a strange situation for the cue ball. The speed and the spin are no longer in the same direction (or



Spin (draw)

Speed

- 1
- 2

Spin (follow)

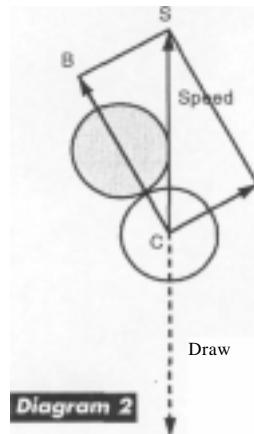


Diagram 2

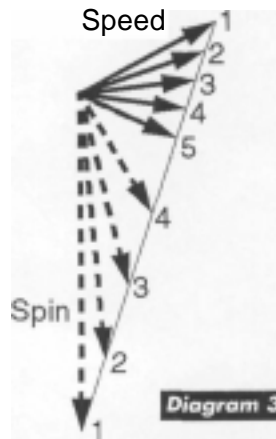


Diagram 3

along the same line) — what happens to each, and where does the cue ball go?

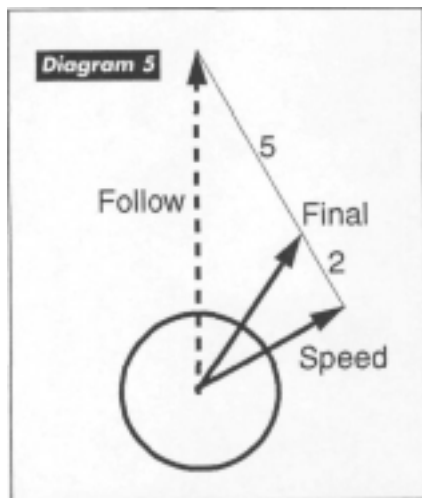
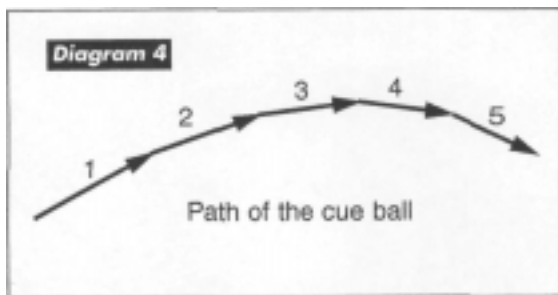
The two arrows still move according to the rule given earlier. They move towards each other (along a straight line) with the spin arrow changing 2 1/2 times as fast as the speed arrow. This is shown in **Diagram 3**, where the successive arrows are shown for five different times in sequence. At 5th-time sequence, the arrows are the same length and in the same direction, so the change stops at that point.

What sort of path does the cue ball follow during this time? It is easy to get a close approximation of the path by joining the speed arrows head-to-tail in order. **Diagram 4** shows what this looks like; the path shown is roughly a curve. If we used twice as many times, with the times more closely spaced, the ten arrows would form an even smoother curve. Technically, the ideal curve is a parabola, which is also the path a ball follows when thrown. At the end of the curving part of the path, the cue ball will continue to roll along the direction of Arrow 5, since by then the speed and spin have reached their happy common equilibrium.

This draw shot repays time spent in practice. Notice that the final path of the cue ball is a little past the perpendicular to the initial path. (The calculated angle is about five degrees.) Previous columns, including Dr. George Onoda's column in May 1989, suggest that it is hard to pull the cue ball back behind the perpendicular. How does the shot work for you? (It's no fair if you cheat by hitting more than half the object ball.) If the perpendicular is your limit, what are some reasons you might not be getting the angle predicted for "perfect" draw?

Usually the final direction of the cue ball is far more important than the exact curve it takes before it settles into that path. A simple case is shown in **Diagram 5**. This is the same shot as in **Diagram 2**, but with follow rather than draw. The speed is the same, but the spin is in the opposite direction. The final direction can be found by joining the speed and follow arrows, and then finding the point along that line that divides it in the ratio of 2.5.

The angle between the initial and final paths in this case is a very important one to know; it is the natural angle for a half-ball



hit. Position play that involves anything close to half-ball (a 30-degree cut) and a rolling cue ball will produce a deflection angle very close to this (about 34 degrees).

The geometry of the rectangle and the arrows can be used to develop various systems for cue-ball control. For example, you can show that if you play a follow shot with a small cut

angle to the left, the cue ball will be deflected to the right by 2 1/2 times the angle. In a previous column, I suggested 3 as the ratio. See what happens for you with real balls on real cloth.

Where does this factor of 2:5 come from? Roughly stated, it says how much more effective the simple movement of the mass of the ball is than the movement you get from the spin rubbing on the cloth. Physicists call this the "moment of inertia." The usual assumption is that the ball is uniform, but this is not always the case. Some cue balls have heavier centers, and the effectiveness of spin on such balls is smaller; they would be more lively if they were hollow with a heavy shell. Think about it this way: if you had a bicycle tire made out of lead, it would be hard to stop its spin by

grabbing the rim, but if all the lead were in the hub, the spin would be much easier to stop with that long lever arm from the spokes. How large is the effect for cue balls? It seems to be no larger than the effect of the cue ball's being small and light from wear.

In theory, this graphic system for figuring out where the cue ball will go can give you precise results. Since it depends on knowing how much spin the cue ball has, the easiest case is when the cue ball is rolling smoothly on the cloth. Fortunately, playing with a smoothly rolling cue ball is the easiest way to play position, next object ball willing. This system may also be useful for letting you know which shape shots are impossible — the speed arrowhead can be pulled over only so much by the spin arrow. This system can even be applied to masse shots, and for a given stick elevation and offset, you can draw out the curved part of the path as in Diagram 4. That extension will have to wait for a future column.

Bob Jewett is an advanced-level Billiard Congress of America Certified Instructor and a partner in the San Francisco Billiard Academy, which offers classes at all levels from beginning players to advanced instructors.