Bob Jewett

TECHTALK

Physics and Pool?

Is science really helpful in cue sports?

Can your play really benefit from an understanding of the math and science behind the game? That's a question I hear all the time, and the answer is not so clear.

I think that during a match, too much cogitation is a bad thing. If you have a tough 7-ball shot that needs outside draw to spin four cushions to get on the badly-placed 8, it is the wrong time to be calculating deceleration rates based on coefficients of friction and relative surface motions. I'm a firm believer in the simple technique: "See the shot, shoot the shot." That may startle long-time readers of this column, but please note that I'm only referring to a playing situation.

During practice time, you need to be thinking about what you're doing and why the balls behave as they do. Well, it's not required; you can become a champion without ever really understanding what's happening on the table. It just takes a lot of talent and practice time. For most of us, learning how the balls work, and especially how each factor can change the outcome of shots, makes practice time more efficient. If you can put your experience into a coherent framework, and build that base, your game will become solid more quickly.

A second area where science can help is to knock down bogus ideas or give support to valid and useful ideas, and perhaps extend them. An example of the former is the old advice on how to make a ball that is frozen on the cushion: "Hit the ball and cushion at the same time." It is remarkable how many confused, poorly-read players still believe this "obvious" but wrong notion. It is simple enough to disprove, but because a champion or two has passed on this "wisdom," it is still in circulation.

An example of old advice that physics can illuminate is the "perfect draw" shot. Major Broadfoot, in his excellent 1896 book "Billiards," discusses the shot shown in Diagram 1. The problem is controlling the path of the cue ball, and specifically sending it along the line perpendicular to the cue ball's original path.

Broadfoot's solution is to play the shot with a half-ball contact (aim the center of the cue ball at the edge of the object ball) and use "best draw." Broadfoot goes on to say that if you don't get a perpendicular cue ball path, you must have hit the object ball

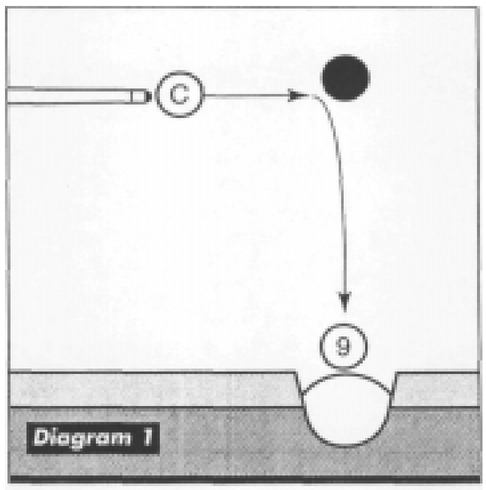

Diagram 1

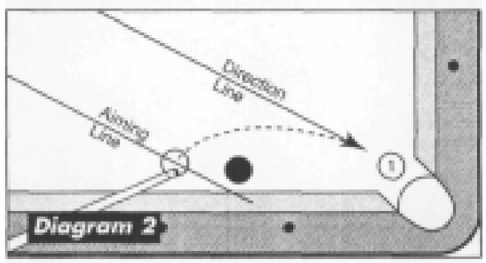

Diagram 2

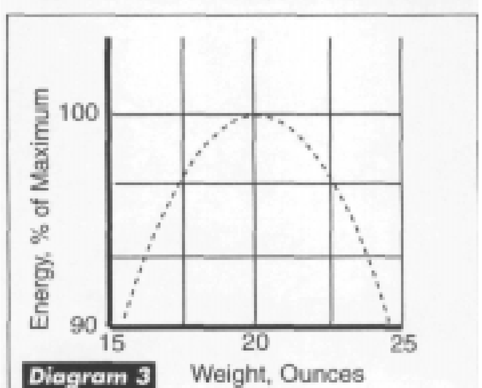

Diagram 3

with more or less than half ball. This basic idea has been covered several times in this magazine, first in Dr. George Onoda's May 1989 column, and more recently in my November 2000 article on half-ball shots.

A closer look at the physics of the shot explains how it works, and what can be modified. The final cue ball angle for any draw shot can be found by complicated equations or a simple graphical method given here in June 2001. It turns out that for a half-ball hit, "ideal" draw — that is, as much draw as a smoothly rolling ball has follow, so that the surface of the top of the ball is not moving at all — is not quite enough to pull the cue ball back to the perpendicular line. This means that if you do get the right path on the cue ball, either you hit the cue ball slightly fuller than half ball, or you managed to get "retrograde" draw on the cue ball.

When seated comfortably in your armchair, physics doesn't tell you the limits to shots. For example, without actually trying the draw shot above, you can't tell whether your tip, chalk, stroke, cloth, object ball, and cue ball can achieve Broadfoot's perfect draw. For that you have to go to the practice table and try a few shots. The practice is also necessary so that the next time the shot comes up, you will recognize it and be able to execute it.

Another shot where science provides at least a partial solution is the masse. Almost 200 years ago, a French scientist named Coriolis worked out the amazing result shown in Diagram 2. If you want the cue ball to curve into the final path shown, your stick needs to be pointing through the cue ball to a spot on the cloth on the "direction line" which is parallel to the final path. Coriolis also showed that the curved part of the path is a shape called a parabola, which is the same sort of path a ball follows in the air if wind resistance is not a factor. Unfortunately, Coriolis failed to provide a useful formula for how hard to hit the ball, just as a baseball coach won't tell you how hard to throw to get the ball to second base — you learn by doing. For more details on this way to aim masse shots, see Robert Byrne's book on "Advanced Technique."

Sometimes physics can provide general guidelines on how an experiment is likely to work out. People often wonder about the best weight for a break cue, where the main concern is how fast the cue ball is going. The actual experiment is very hard to do. If a person is swinging the stick, it is necessary to give him time to get used to the heft and balance of each different weight. Just because you break well with a 21-ounce stick doesn't mean it's best for you, but it could take you a month to get your timing down for a 17-ouncer. Basic physics does say that if you plot your break speed versus stick weight, the resulting curve should be quite smooth, like the plot in **Diagram 3.** On the vertical axis is the estimated energy in the cue ball compared to 100 percent at 20 ounces — the assumed best weight. The exact width of the curve needs to be determined by a sports kinesiologist (body motion scientist) but I expect no more than a few percent change in cue ball energy for a plus-or-minus two ounce change in stick weight.

This kind of smooth optimum is often seen in physical situations where there are two competing factors. In the case of a break stick, a light stick just can't get any speed into the ball — imagine breaking with just the shaft of your cue. On the other end, a very heavy stick is too hard to accelerate with just your arm — imagine tying a couple of bricks to the butt. Somewhere in the middle is the best weight, and the general nature of the problem says that you won't get 50 percent more power from a one-ounce change in stick weight.

Another area where knowledge of the physics of the game can help is in refereeing. Usually when judging which ball was hit first, you can detect a bad hit by the directions and speeds of the balls just after the shot. This is good, because it's often impossible to actually see the order of contact. Many players haven't caught on to this, and will call someone over to watch a hit when the legality of the hit will be clear from anywhere in the room. An example of this type of call is in **Diagram 4,** where the cue ball may hit the 7 or 9 first. The diagram shows the path of just the cue ball, something which you could certainly track from across the room. This alone is enough information for a physics-savvy referee to make a call. Can you tell which ball was hit first?

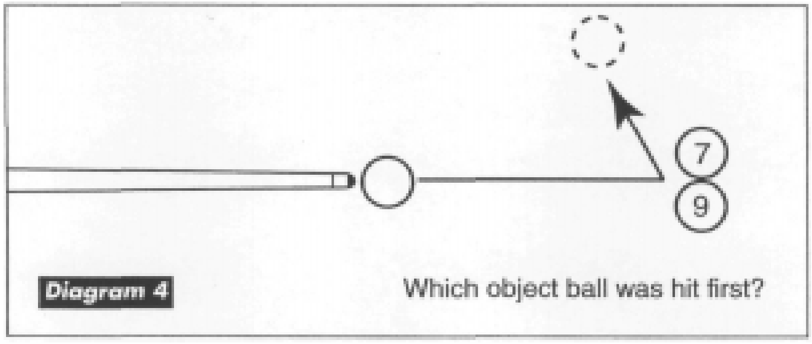

Diagram 4 Which object ball was hit first?

Another refereeing application is in double hits on close object balls. Balls do things for good physical reasons, and often players are confused about those reasons. In particular, if the cue ball hits a close object ball full, it will stop dead, just as when it hits a distant object ball full. I've had one player tell me that the subsequent high speed on the cue ball — it caught up with the object ball — was because he had "special stuff' on the ball, which decays rapidly as the ball moves off the tip, so it is not seen on longer-distance shots. Yeah, right.

A final application of physics in billiards is to the design of the equipment. Most recently, this has been seen in stick design where the underlying mechanisms of squirt (sometimes incorrectly called deflection) have been first revealed by high-speed camera, and then developed into a theory that can guide useful designs.

Do you need to know pool physics to play well? Goodness, no! Look at all the fine players who don't know tensor from tennis. It can help you learn more quickly, though, and for some people it's fun studying all on its own.