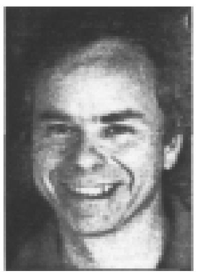
Pythagoras & Pool Perpendiculars

by BOB JEWETT



EVERY BOOK ABOUT pool that gets far enough into the subject to discuss combinations or position play says that the "kiss angle," or the angle between two colliding balls, is 90 degrees or a right angle. None of them tells you why. The explanation takes only a little physics plus your favorite theorem from high school geometry — the one by Pythagoras. Simple extensions of the analysis show how the kiss angle changes if throw or imperfect balls are included in the calculations.

Figure 1 diagrams a simple collision. The cue ball (or it might be an object ball) arrives along path C, sending the target ball along path A. The cue ball leaves along path B. For the time being, we will assume that there is no throw, so path A is along the line joining the centers of the two balls at the instant of the collision.

How do we know the angle between A and B is 90 degrees?

The solution is found by applying basic laws of physics: momentum and energy are neither created nor destroyed during the collision, although they are both transferred from one ball to another.

The momentum of an object is a tricky concept in physics because it has both a size and a direction. The amount of momentum increases with the speed and the weight of the object. The direction of momentum is simply the direction which the object is moving. In Figure 1, the lengths of the arrows represent the speeds of the balls, so the arrows show both the size and direction of the momentum of each ball.

All the momentum before the collision is carried by the cue ball. (The object ball has no momentum since it is standing still and has no speed.) This starting momentum is represented by arrow C. After the collision, some momentum has been transferred to the object ball (arrow A) and the cue ball has kept some (arrow B). The total momentum after the collision. A+ B, is the same amount of momentum as before the balls contacted each other, C, so A+B=C.

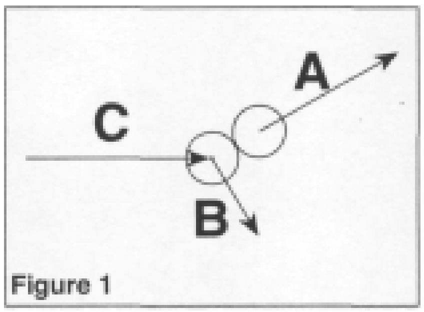


Figure 1

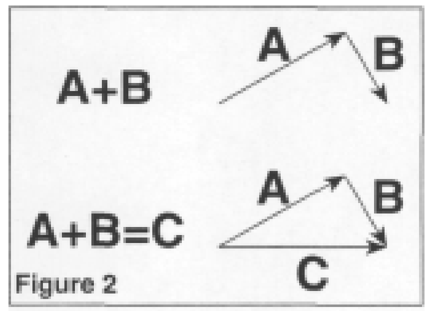


Figure 2

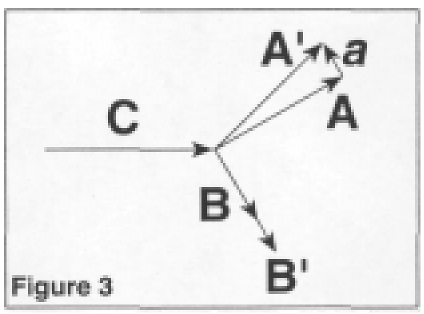


Figure 3

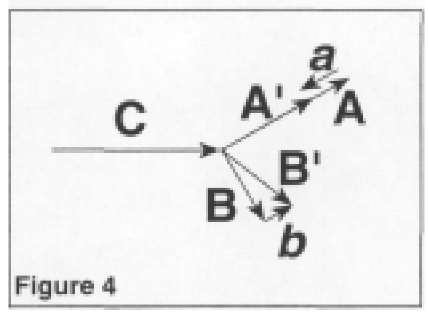


Figure 4

This equation doesn't take into account the directions involved. In physics, this is done by "vectors," which for our purposes means we need to add the A and B arrows graphically by putting them head to tail and keeping their original directions as shown in Figure 2. If you go in the A direction for the A length and then in the B direction for the B length, you get to the same spot as going in the C direction for the C length. You may want to check that if you go in the order B, A you still get to the same place.

The main point of the equation is that A, B and C form a triangle since the two paths from the left end of C go to the same point at the right end of C.

The amount of energy in a moving object increases with the weight of the object, just like momentum. Unlike momentum, energy increases as the square of the object's velocity. A physicist calculates an object's energy with the following equation: E = 'A x mass x velocity^2. So the initial energy is 'A x m x C^2. After the collision, the energy is shared by the two balls, ('A x m x A^2) + ('A x m x B^2). Since energy can be neither created or destroyed, that is the second law of thermodynamics, and assuming that no energy goes into heat or sound, the energy before and after the collision must be equal:

$$(\tfrac{1}{2} \times m \times A^2) + (\tfrac{1}{2} \times m \times B^2) = \tfrac{1}{2} \times m \times C^2$$

Using algebra, that equation can be reorganized as:

$$\tfrac{1}{2} \times m \times (A^2 + B^2) = \tfrac{1}{2} \times m \times C^2$$

Since 'A and m (the mass of one ball) are on both sides of the equal sign, algebra allows us to drop them from the equation altogether:

$$A^2 + B^2 = C^2$$

To summarize what we know so far, the

"velocity vectors" of the balls form a triangle . Due to conservation of energy, the three sides of the triangle have the relationship $A^2 + B^2 = C^2$. This is just the requirement of the Pythagorean Theorem, which states that any right triangle has $A^2 + B^2 = C^2$ if the 90-degree angle is between sides A and B. *QED,* as Mrs. Morgan use to say in geometry class.

Now that we have the basic result, it's time to examine some of the variations that can arise with use of English. Suppose there is some throw in the shot, for example if the cue ball has right (counter-clockwise) side-spin. There will be a small change, arrow a, to the A direction, as shown in Figure 3, which results in A'. It's important to note that the direction of a is perpendicular to A because that's the direction of the rubbing of the side-spin. In order to conserve momentum, B must change by an equal and opposite amount, resulting in B'.

For this outside English, the angle between A and B is widened by just the throw angle between A and A'. Furthermore, the cue ball speed is slightly increased, from B to B', which can be estimated as about 7% for maximum English and a cut shot of about 45 degrees.

Conversely, if left English were used, the angle between the cue and the object ball would close up some and the cue ball would leave the collision with slightly lower speed than before.

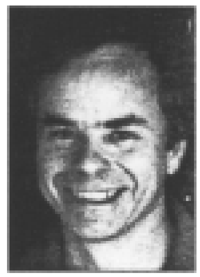
What happens if the balls are different weights? The problem becomes much more difficult to analyze, but the basic result is that for a heavy cue ball, the kiss angle is less than 90 degrees, while for a light cue ball it will be wider.

What happens if the balls are a little inelastic or "dead"? In that case, some energy of motion is lost during the collision as heat energy, not as much speed is transferred to the object ball, and A is shortened to A' as shown in Figure 4. Momentum is conserved even when energy is changing "type," so B must change by an equal and opposite amount to B' and the angle closes up to less than 90 degrees. This effect is very noticeable with ivory balls, which are not as springy as plastic.

This column has mostly dealt with the "why" rather than the "how" of the kiss angle. The cue ball path is so severely restricted by the physics of the collision that there is little room for adjustment if the object ball is to be driven to a precise target. Of course, after the collision, the cue ball can be maneuvered with draw and follow, but in that first instant Newton and Pythagoras are in control.

Friction: Friend *And* Foe

by BOB JEWETT



JULY, 1980. MIKE Sigel and Ronnie Allen. One pocket.

It was the sort of after-hours match everyone at the San Francisco Open had been hoping to see. Or at least everyone interested in clever tactics, precision safety play and a change from the smash-'em-shoot-by-the-numbers 9-ball tournament. It was a night made memorable by two pool legends, head to head in a tough, expensive contest of wit and moves and traps.

About two hours into the match, a third participant arrived: the fog. San Francisco Bay relieves hot, summer days by generating cool fog at night. The damp descended on the table, destroyed stroke, and especially aggravated Allen, who lamented, "It's tough. You know what the ball's supposed to do but it just won't do it."

Friction was the problem, as Allen well knew, and studying it a little may reduce your own frustration when friction attacks.

There are three types of friction found on pool tables: static, sliding and rolling. The first two are usually explained with a situation like a box on a table. (This is not much like a pool ball, but stick with me.) When you push on the side of the box, you have to get up to a certain force to start the box moving, but then a smaller force can keep it moving. The first is due to "static" friction and the second is due to "sliding" friction.

Physicists have found that how hard you need to push sideways is some fraction of the weight of the box. For example, with a 10-pound box, you might need 6 pounds of push to start the box moving and 2 pounds to maintain motion. If you double the weight of the box (20 pounds), you also double the required forces (12 and 4 pounds). The ratios of push to weight, in this case 0.6 and 0.2, are constant.

These ratios are called the "coefficients" of friction. They depend on the two materials rubbing against each other. Rubber on concrete has high coefficients which makes it necessary to push very hard to slide a rubber object across pavement. Rubber on ice has low coefficients and little force is needed to slide.

"Rolling" is a third kind of friction that is a little more obvious on a pool table. It describes how quickly a rolling balls slows down. A convenient way to think of rolling friction is that a ball slows down continuously as if it were rolling up a hill. The steeper a hill, the higher the percentage of its grade, the quicker a ball rolling up it will slow down. A moderately fast cloth acts like a 1% grade. Obviously the metaphor is not perfect, because a ball stops on a pool table, while a ball rolling up a hill will start rolling back down after stopping. But a hill's grade still provides a useful terminology for the speed of cloth.

There is an easy way to measure the speeds of cloth and thereby compare the speeds of tables. Shoot a lag shot that barely doesn't touch the head rail (the one you start from). Measure the time between the contact on the foot rail and when the ball stops moving. Timing needs to be accurate to a tenth of a second and the cue ball must not quite touch the head rail. The time will usually be between six and eight seconds. Multiply the time by itself and then by two. For example, if the time was seven seconds, the result would be 7 x 7 x 2 = 98. This is the speed of the cloth.

The speed of cloth is the reciprocal of, or one over, the slope. A table with a speed of 100 would slow a rolling ball as if it were going up 1 % grade slope, a 50-speed table would perform like a 2% slope.

To summarize, a faster cloth will produce a higher number. A slow cloth will produce a lower number and balls will roll as if they were going up a steeper incline.

I've seen tables as slow as 60; the cloth must have been a rug. The fastest table I've clocked was on an Accu-stats tape of a three-cushion match at Sang Lee's room in New York. The cloth was a very fine, thin weave, and the table was heated as required by international rules. The 10-second measured lag time gives a speed of 180. (The arithmetic is a little different for 10-foot tables, after you multiply the time by itself, then multiply by 1.8). The lesson there is that if you want the cloth to be fast, keep it thin, clean and dry.

Here's an experiment that shows that draw is the victim of friction. Get two striped balls of average cleanliness. Wash one of them and wax it with a hard wax. Using the undoctored ball as the cue ball, place the stripe equatorially, and shoot with draw and medium speed. Note how far up the table the draw lasts by noting when the rotation of the stripe turns over. Now try the same with the waxed ball. It's not unusual to get twice the original distance before the draw evaporates.

That night in San Francisco at the Sigel-Allen match, the damp had the opposite effect of wax; it increased the friction between ball and cloth, and the draw rubbed off very quickly. This seems backward, since lots of water makes things slippery. However, small amounts of moisture can actually increase friction. Have you ever licked your finger to turn a slippery page?

The last kind of friction is one that all players seek out — friction between the tip and cue ball — static friction. If the tip slides on the cue ball, it's a miscue, so the goal is to prevent any sliding at all. Chalk increases the friction. Again, this seems somewhat backwards since you also see people using chalk as a substitute for talc to make their bridge hand slippery.

Measuring the coefficient of static friction between the tip and ball turns out to be fairly easy. Just note how far from the center you can hit the cue ball without miscuing. As mentioned in Robert Byrne's series of articles on fundamentals, George Onoda has found this to be half the way from the center to the edge of the cue ball. With a little geometry it can be shown that the coefficient of static friction is 0.58 for a chalked tip on a cue ball.

If you can't hit as far from center as Onoda, here are some suggestions:

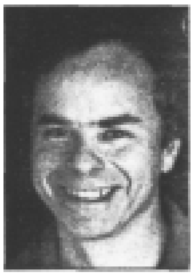
- Roughen your tip. I press coarse sandpaper into the tip.
- Chalk thoroughly but do not leave caking. The only way to make sure you have done a good job is to look at your tip.
- Get good chalk. Opinions and batches vary. Find what works for you.
- Clean the cue ball. Most dirt increases miscues.

This is necessarily a brief overview of a very complicated subject. To discuss this further, drop me a note in care of this magazine or send me E-mail, via the Internet to jewett@hpl.hp.com

TECH TALK

Seeking Truth of Beliefs

by BOB JEWETT



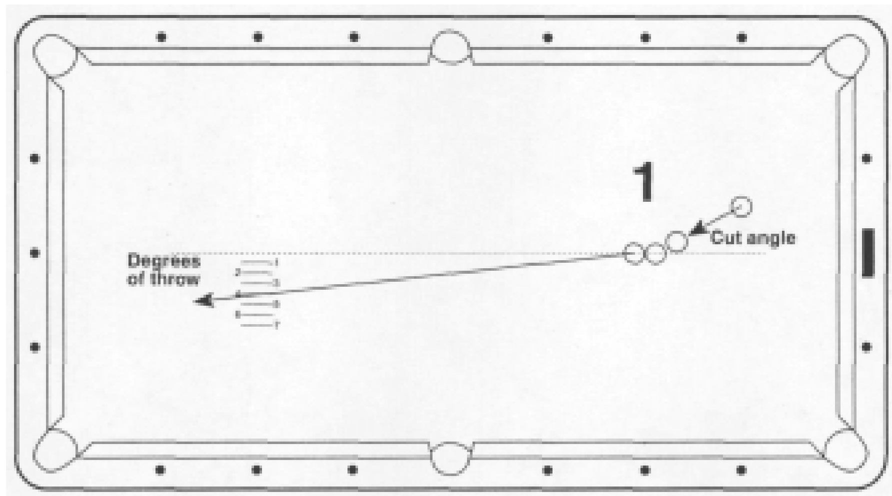
ARE YOU A billiard experimenter? In a sense, every time you play, you're testing theories. "If I play with reverse, I can kill the cue ball on the rail." "With a firm hit, this bank shot will shorten enough to make." "This shot goes if I just roll it softly." On each shot, you have some theory that you put to the test.

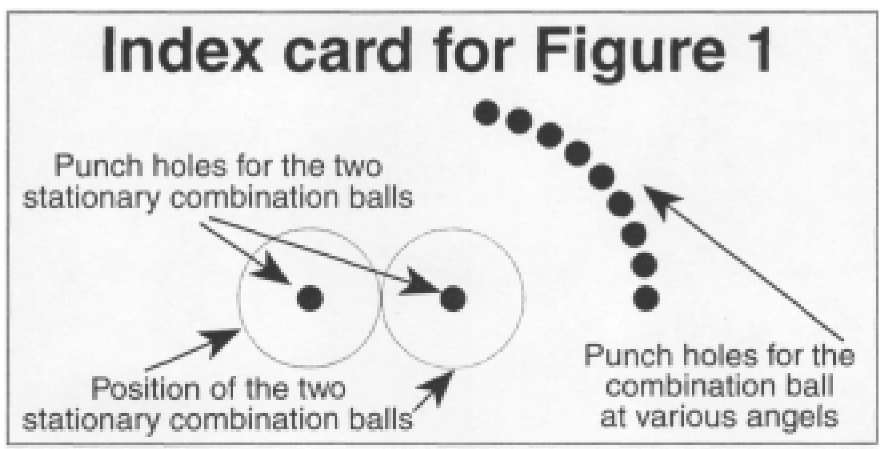
There are past and present "pool physicists" who have undertaken some fairly serious studies of rotating spheres on green cloth. Below are some of their results and some suggestions for how to do your own experiments.

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 belief) 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.

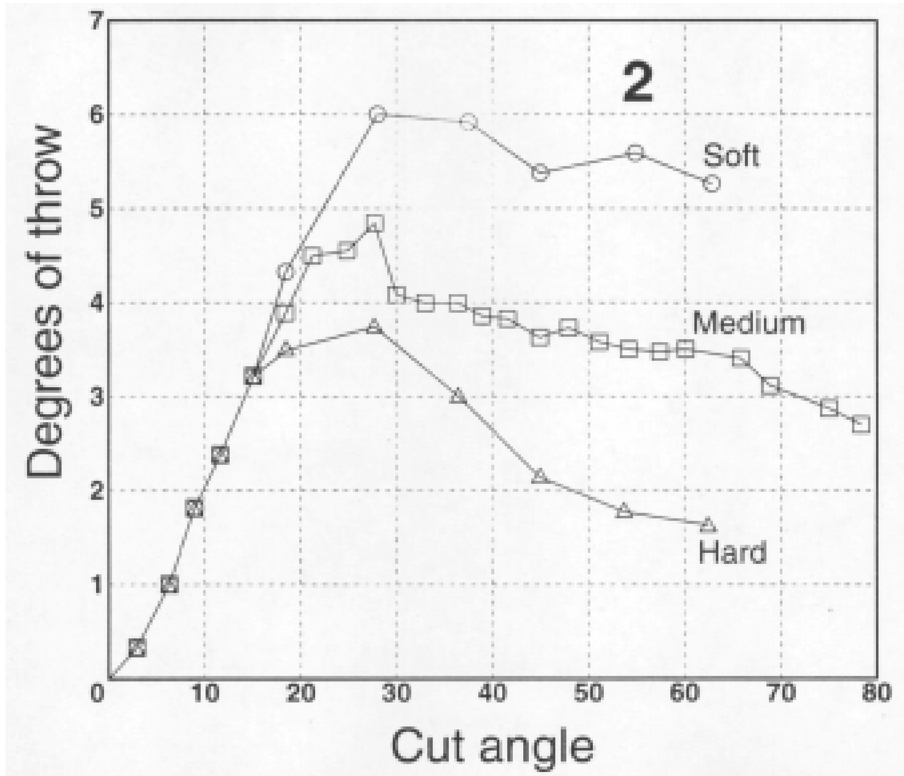
Try this: Place the combo balls on the foot string aimed straight up the table and frozen together. Place a third object ball slightly separated and at an angle as shown in Figure 1. Shoot the cue ball into the proxy cue ball. Call it a soft shot if the ball just reaches the far rail, medium if it goes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

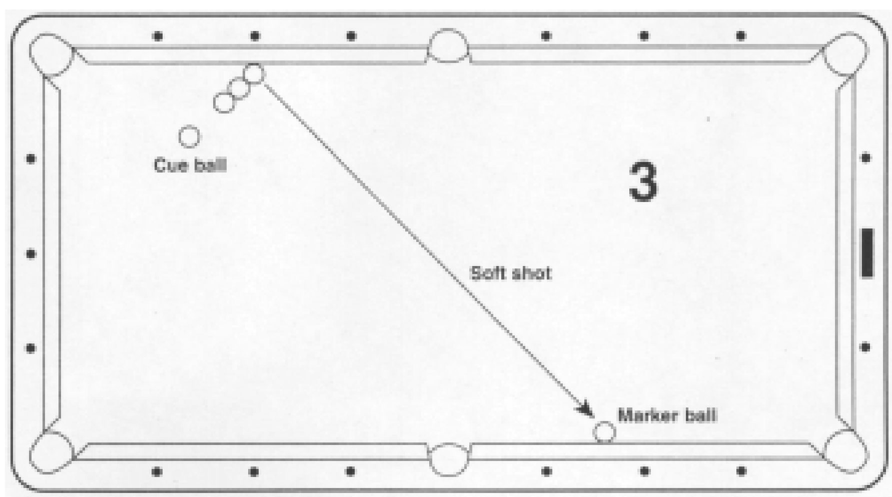
To get consistent results, you will need to be able to place the balls in the same positions repeatedly. Get a large index card (3 by 5 inches is barely large enough) and a hole punch. Punch two holes for the frozen combo balls, and a semi-circle of holes, each whole 10 for the third object ball so it 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 practice, 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; 1 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.

Virtual Pool

(Better than the real thing?)

by BOB JEWETT

WOULD YOU LIKE to have the stroke of Mike Massey for trick shots? To be able to play daily against someone who will run 50 at straight pool more often than not, and run over 100 yourself? To be able to predict exactly where the cue ball is going to end up on any shot? All this and more is possible with a new computer simulation game called Virtual Pool, available on CD-ROM.

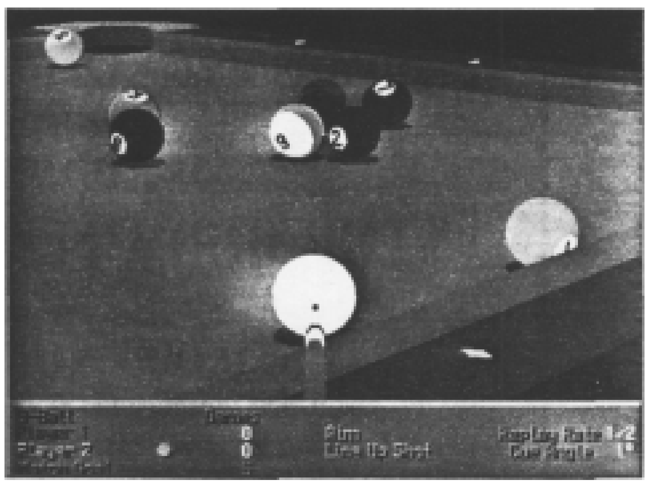
Your introduction to Virtual Pool begins with an animated video clip about the history of cue sports. Paintings and diagrams — the Billiard Archive and Mike Shamos are in the credits — illustrate the narrator's summary of billiard events from the elevation of lawn bowling to tables up to the current boom and recent players.

The basic control of play is much like other simulators on the market. You use the mouse to select the aiming angle and to place the tip for various amounts of English. To shoot, you press a key to let the program know you're ready, and then move the mouse back and then forward. The speed of motion determines the force of the shot. To avoid broken mice on hard shots, there is a "speed amplify" button which is especially useful on break shots.

There are lots of different things the simulator lets you do. You can practice alone, play against another player either on the same machine or over the phone or network, or play against a computer-generated foe. Of the latter, don't try your hand against Deadeye Dan until you have your aiming perfected; in our last match, he beat me 150-7 in straight pool.

Where Virtual Pool really shines is in the display graphics. The table is presented in a three-dimensional perspective. The player's point of view can easily be panned around the table to check angles and clearances, and can be zoomed in to check whether two balls are really touching. A single key returns you to an overhead shot to check the whole table. All of this works very quickly, so that the motion is smooth.

A very useful feature, and one that transforms the program from a mere game to a learning tool, is the shot prediction feature, called "tracking." With this turned on, the expected paths of all the balls are shown, and are updated as quickly as you change anything in the shot, such as the angle, speed or English. For example, at straight pool, you often need to break up clusters during a run. You can see exactly how much draw, follow and English will be needed to get the cue ball to break up a cluster. Even better, you will see where the balls in the cluster will end up, and you may conclude that there is no good way to go into the cluster along the path you had planned. This sort of prediction would not be of much use if the results weren't true to real life, and the programmers have done a very accurate job.



Another feature is a brief instructional clip taught by BCA Hall-of-Famer "Machine Gun" Lou Butera. He begins by saying that he'll run a rack of straight pool in 90 seconds, but only takes 66. A gallery of trick shots is also available. Lou shoots them in video clips and you can set them up and try them yourself in the simulator.

I have a few minor complaints. The "virtual" cloth is a little slow and slippery, perhaps just like many players will find on their new home tables. You are never required to raise the butt of the cue to avoid an obstacle, such as an object ball just on your side of the cue ball. If you crank up the speed, you can get more spin on the ball than Mike Massey; that's a fantasy for most of us. Also, Deadeye Dan kicks balls in better than any living human.

My major complaint about Virtual Pool is that although the game knows four different types of pool games, and you can do others in practice mode, snooker and carom billiards are not included. I understand that a snooker version is in the works; I hope that carom is not far behind.

The program comes with a startling guarantee. If your actual pool game does not improve after using Virtual Pool, you can get your money back. I won't be getting my money back, since I had a personal best at Internet Equal Offense after "virtually" running 150 a couple of times. (IEO is a pool competition held over a computer network, but played by real people on real tables.)

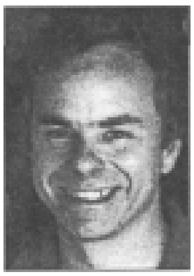
The hardware required is a PC, running Microsoft DOS or Windows 3.1, with at least a 386SX 40MHz or higher processor (I used a computer with a 60 MHz Pentium chip while evaluating the program), a SVGA card, a CD-ROM drive, at least four megabytes of RAM and two megabytes of free hard disk space. A sound card is needed if you want to listen to the music, sound effects or narration. The price is under $50, which in my mind makes this a must for any pool player who also has a PC.

Virtual Pool, is available for $49.95, from Interplay Productions, Inc., 17922 Fitch Ave., Irvine, CA 92714, (800) INTERPLAY. (A demo version of is available on the Internet; connect to the URL http://www.interplay.com/. A version for Macintosh platform is planned.)

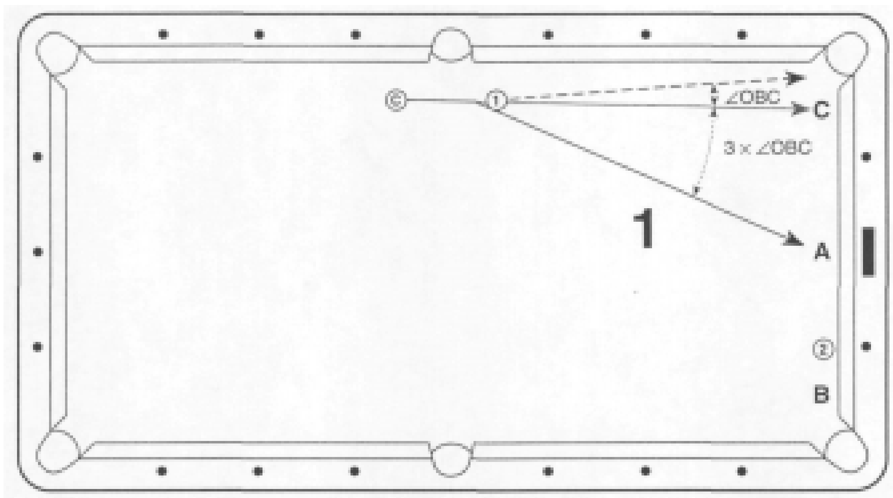
Bob Jewett (E-mail at jewett@netcom.com) is a former ACU-I billiards champion and currently trains BCA Certified Instructors in San Francisco.

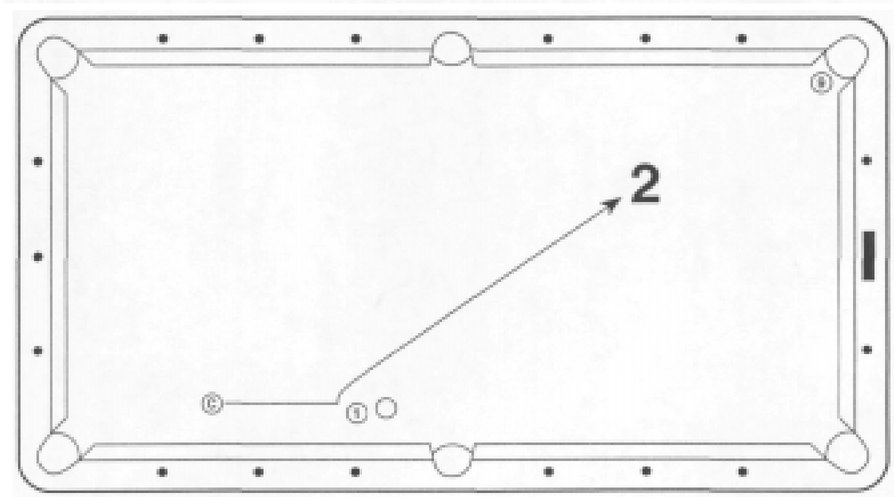
Follow and Draw Systems

by BOB JEWETT



WHEN YOU ARE learning pool, after you have control of the object ball direction, the next thing to master is the direction of the cue ball after contact. In a previous column, I called on the Pythagorean theorem to explain why the initial path of the cue ball is at a right angle to the path of the object ball. This column offers some systems for planning how follow and draw will bend the cue ball's path.





In Shot 1, the plan is to pocket the 1 ball and follow forward for the 2 ball. The problem is to determine whether the cue ball can be taken to the left side of the 2 for an easy shot (A) or if the much more difficult position on the "short side" at B is needed.

The system to use here we'll call the "triple-angle follow system." For nearly full shots like this, take the small angle of the object ball cut (/OBC), triple it, and the total is how far out the cue ball is deflected (3 x /OBC). In Shot 1, the initial cue ball path goes towards C on the end rail. This is half a diamond from the pocket. If the object ball is pocketed, the cue ball will go towards a point three times that distance to the right. For this simple shot, that would be towards point A, one-and-a-half diamonds to the right of the initial cue ball path.

You have to make sure of several things for this system to work well for you. The cut angle must be small. The cue ball must be rolling smoothly on the cloth, which will happen immediately if you hit about one tip above center. The cue ball and the object ball must be the same weight and fairly clean. As with any system, practice!

How accurate is this system? A lot depends on your pocketing accuracy. If you miss the center of the pocket by half a ball, the cue ball will land a ball and a half from the expected point. If the cue ball is heavy, like some tavern balls, it will drive through straighter, and you'll find a smaller number, maybe 2.5 or 2, must be used instead of 3 to get the direction precisely.

A second follow system isn't a system so much as a guide post. This is the half-ball follow angle, which has been discussed by Robert Byrne in his column and his *Advanced Techniques* book. In Shot 2, the best choice at the 9 ball is to play a carom, sending the cue ball off the 1 to the waiting 9.

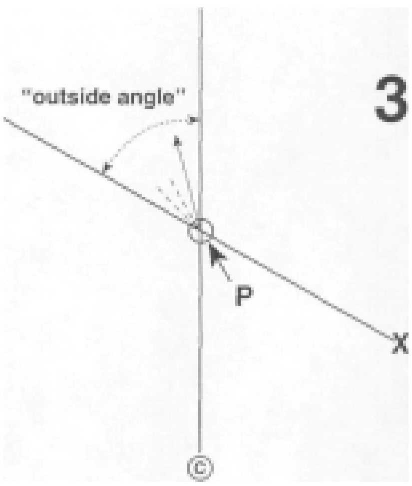
Use this technique: Aim for a half ball hit on the 1 ball, with the cue stick directed at the left edge of the 1. Hit the cue ball high and shoot only hard enough to be sure to get to the 9. The most common mistakes are shooting too hard and playing with draw or center.

For your practice, set the 1 a ball's width off the rail and place the cue ball one-and-a-half ball's width off, so you will be driving the cue ball parallel to the long rail. Move the 1 ball forward and back until the carom seems automatic. Note carefully the angle of deflection of the cue ball. In theory it will be close to 37 degrees, but this will change if the cue ball is not the same weight as the object ball.

The real importance of this shot comes from the stability of the deflection angle. While the object ball can be hit between three- and one-quarters full (about 15 to 45 degrees of cut), the cue ball path will change by only a few degrees. While there may not always be a 9 ball waiting for you at the half-ball follow angle, there will often be position or an easy safety.

Suppose the needed angle is not quite 37 degrees. To make the cue ball go straighter through, hit either more or less ball; how much requires judgment gained from practice. Try Shot 2 with the cue ball closer to the rail than for the ideal angle.

There are two ways to make the cue ball go wider. A little draw, or even center ball will bring the cue ball out some, but this is hard to control. It is easier to hit the cue ball harder so it slides some to the left before taking a path parallel to the soft shot. Try Shot 2 with the 1 ball a diamond farther down the table.



Knowledge of the half-ball follow angle is essential for position play. Practice this shot until the information is etched into your brain.

Minor adjustments in either direction can be achieved by adding side spin to the follow. Begin in the ideal position and see what left and right do.

There is a draw system that is a lot like the follow system; in fact, it is based on nearly identical physics. Suppose you have a situation like Shot 3. You want to draw the cue ball off the object ball towards point X. There are two equivalent aiming systems; see which is most accurate for you.

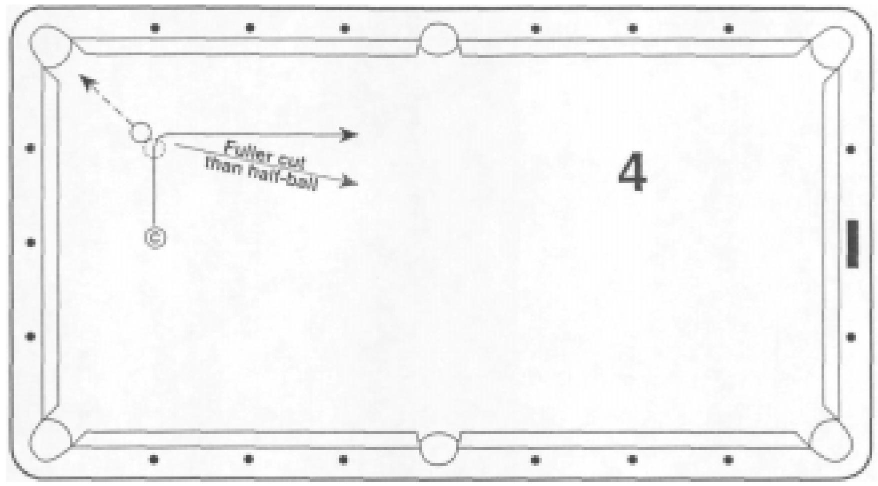
For the first system, take the "outside angle" between the two starting lines of the shot. Divide it in two, and in two again. Drive the object ball along the line closest to the path that goes straight-ahead, and the cue ball will draw back towards X.

The second way to aim is to shoot towards point P on the object ball, which is midway between the two major lines. Note that this is not where you will hit the object ball; the contact point will be the same as in the first method.

The second aiming system, also known as the "bisector point" system, is at least 80 years old; it is in *Daly's Billiard Book*, but is explained better in Willie Hoppe's *Billiards As It Should Be Played.*

This draw system requires very lively draw and is best if the cue ball is close to the object ball. The cut angle must not be too wide. If you can't pull the cue ball back as much as expected, you will need to adjust the system by shooting somewhat fuller.

There is a draw half-ball shot that is similar to the follow half-ball shot. In Diagram 4, a half-ball shot with draw pockets the object ball and bends the cue ball back as it goes up the table. For a typical amount of draw, the final path is at a right angle to the initial line of the cue stick. Of all the systems mentioned, this one is the most difficult to control, but it does provide a reference point.



For example, if you have a fuller-than-half-ball shot, you'll know you can bring the cue ball back behind the right-angle path.

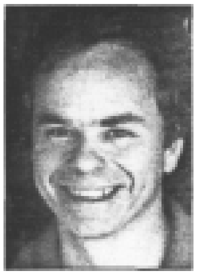
These systems all require either full follow or full draw. Of course, you can obtain any angle in between by using spin between these two extremes, but there is no good system for these gray areas. Learn to rely on your feel and use the systems to know where the boundaries are.

*Bob Jewett (E-mail at jewett@netcom.com) is a former ACU-I billiards champion and **currently** trains BCA Certified Instructors in San Francisco.*

TECH TALK

A Basic Skill Test

by BOB JEWETT



IN MY DECEMBER 1992 column I described a way to sharpen your skills called "progressive practice." Since then, a set of drills based on those ideas has been developed by my fellow instructors at the San Francisco Billiard Academy, Eric Harada and Joseph Mejia, and me. It is easy to use these drills to measure your present skill level and keep track of your improvement.

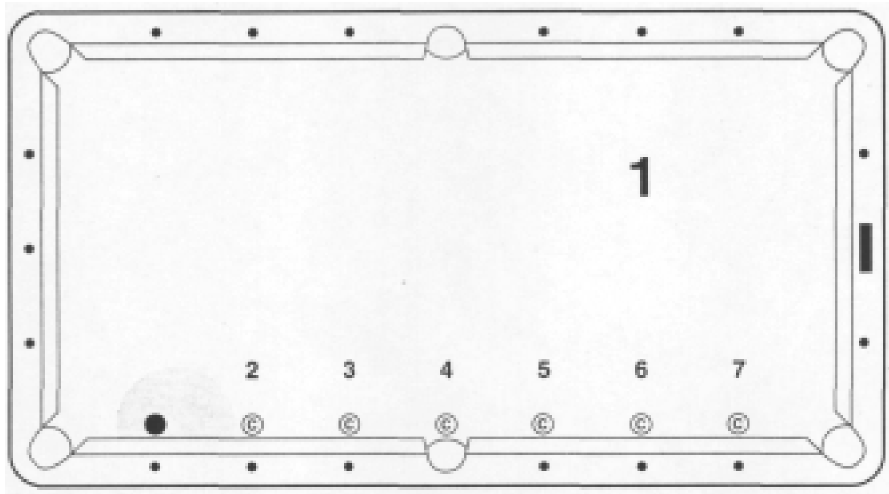
In Diagram 1, the goal is to pocket the object ball with a stop shot that leaves the cue ball within nine inches of the "phantom" cue ball (the cue ball at the instant it contacts the object ball). Start with the cue ball by the diamond marked 2; this will be an easy shot for most players. If you make the required shot, move the cue ball farther away, and try again. If you miss a shot, move the cue ball closer. So that you don't have to remember the last location of the cue ball, mark it with a coin on the rail.

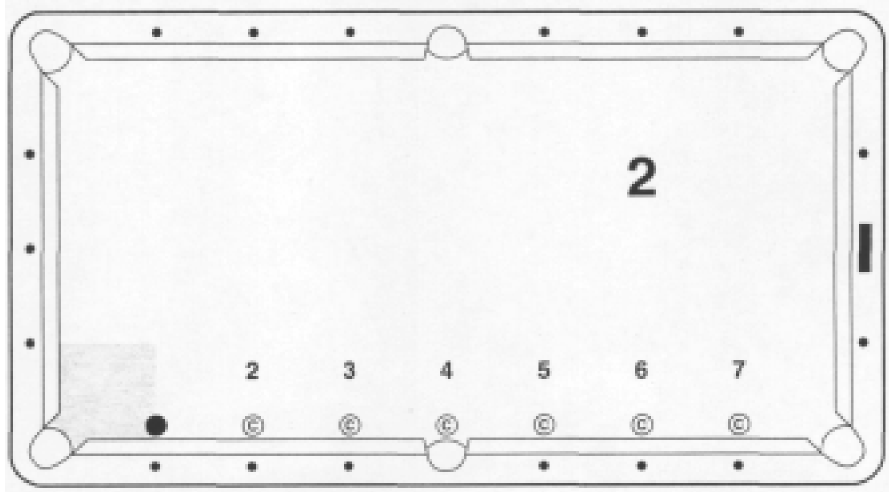
The goal is to work your way up to as high a number as possible. Remember to reduce the distance when you miss; that's the penalty for missing. When you are first trying the shot, you may want to move the cue ball one diamond at a time, but after one or two misses, use a half-diamond adjustment after each shot.

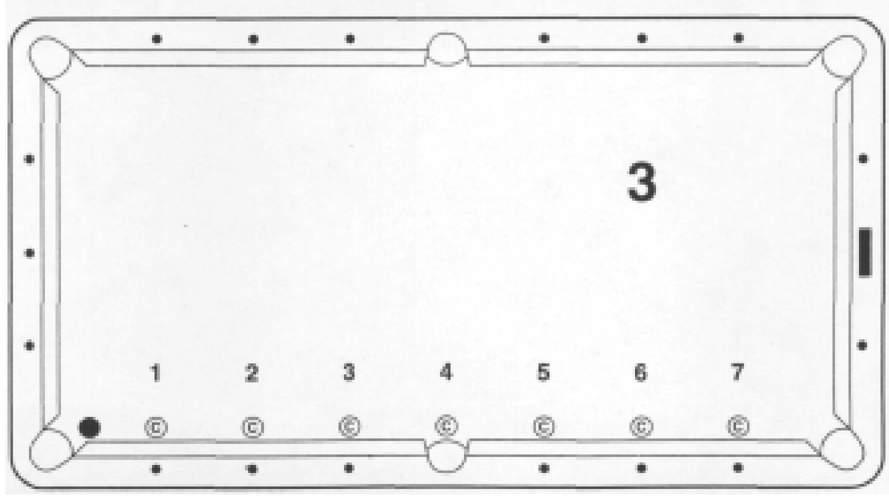
After you have shot 10 or 15 shots for the first diagram, note your distance, and go on to Diagram 2. This is a follow shot, with the goal of leaving the cue ball in the shaded area while pocketing the object ball. As before, if you meet the goals on a shot, move the coin and the cue ball back, but on this drill you also move the object ball back so that it remains one diamond from the cue ball. After a rack of shots, note your distance.

Diagram 3 is a draw shot. The object ball stays put again, and the cue ball is moved to change the difficulty. The goal, besides pocketing the object ball, is to draw the cue ball back at least as far as your starting point. For this drill, the coin on the rail is especially important since it gives you a target for your draw.

Diagram 4 is a cut shot. The object ball is always placed a diamond from the corner pocket and a ball off the rail. The cue







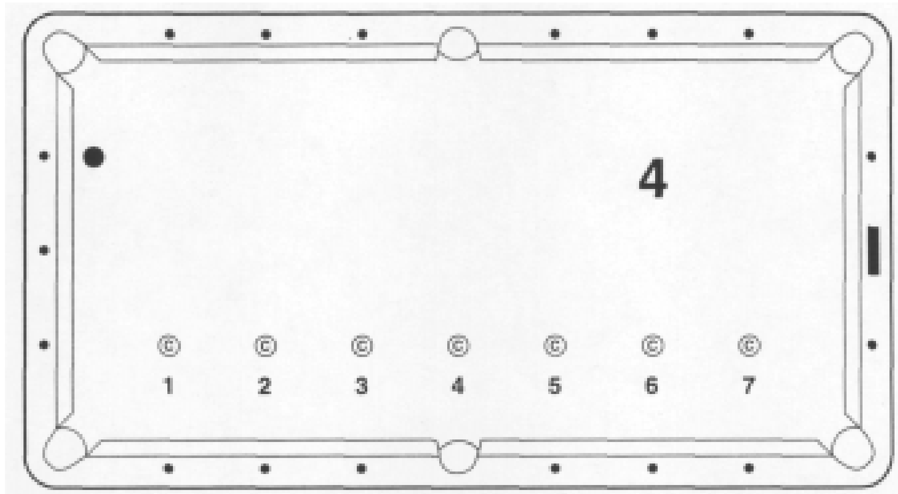
ball marches up the table always one diamond off the rail.

Once you have completed all four diagrams, add up the distances and multiply by two to find your total score. The factor of two comes from the fact that we have developed five increasingly difficult sets of drills, and this is the second set. If you include these shots as part of a regular practice routine, you can note your progress.

If you have a score of 40 or more, this set of drills is too easy for you. If you can't get over 15, you need an easier set. The point of these drills is to make the shots challenging but not impossible for your present level of play, whatever it is. With a score over 60, you may want to try turning pro; to score 60, you will be shooting most of your shots from the end rail.

Note whether your score on one diagram is considerably lower than the rest. If so, invest practice time there. For most players, scores are fairly even across the diagrams; if there is a low one, it is usually the draw shot.

Move the coin after each shot! Otherwise, you won't get a true indication of your average ability on the drill. If you want a more accurate measure, take smaller steps in each direction — a quarter-diamond rather than a half or full diamond.



It is OK to move the balls slightly in and out from the rail on the first three diagrams. The important factor is the length of the shot, and you are free to make the angle as auspicious as you want. The follow shot is impossible if you don't choose the right angle for the cue ball.

A full set of 20 progressive practice diagrams is included in the new BCA Instructor's Manual, which is available to any BCA member.

Bob Jewett (E-mail at jewett@netcom.com) is a former ACU-I billiards champion and currently trains BCA Certified Instructors in San Francisco.