

Bob Jewett



A Rub the Right Way

Make sure any actions involving throw result in a positive reaction.

Do you think you know how throw works? Here are some details that may surprise you.

Diagram 1 shows the forces involved when the cue ball comes up from the lower left and hits the object ball. There is a "push" force on the object ball from the cue ball that is along their line-of-centers. There is an equal and opposite force on the cue ball that is along their line-of-centers. Remember Newton's law, "For every action, there is an equal and opposite reaction."

In addition, there is also a force on the surface of the object ball from the motion of the cue ball across it. Let's assume that the cue ball has no spin at all when it arrives. Note that this force is along the tangent to the surface and perpendicular to the "push" force. Again, an equal and opposite friction force takes place on the surface of the cue ball.

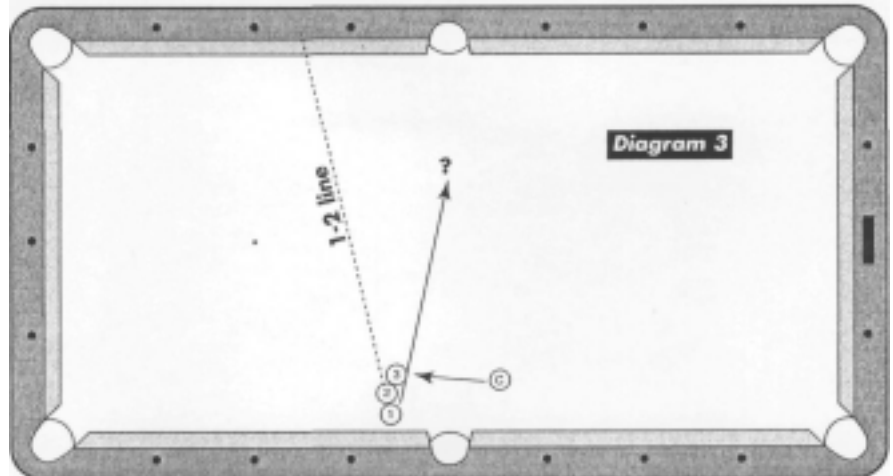
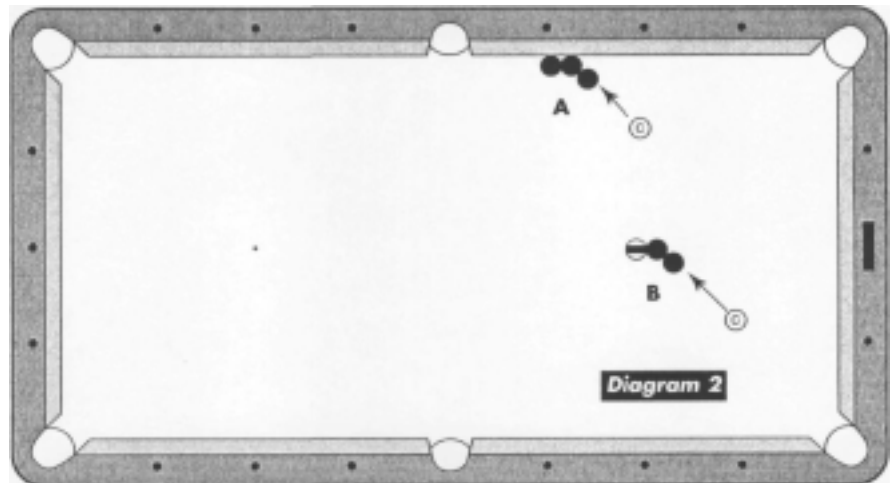
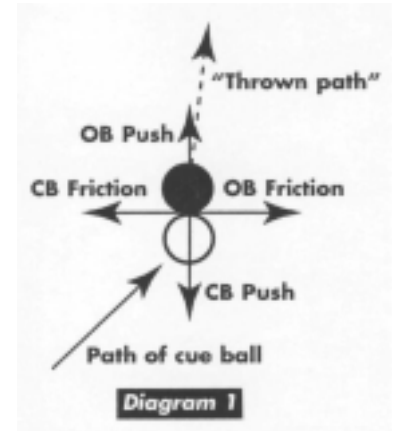
The two push forces are easy to understand: The balls don't want to be in the same place at the same time. The result is that the upward speed of the cue ball is transferred to the object ball, sending it straight up, while the remaining rightward speed on the cue ball will take it straight to the right.

The frictional forces are harder to understand. They are caused by two things happening simultaneously: the balls press together during the collision, and the surfaces are in motion relative to each other. In this case, the surface of the cue ball is moving to the right because the cue ball is moving (partly) to the right. Exactly what these sideways forces are going to do to the balls is not obvious. A more common situation for this kind of force is when the cue ball has draw or follow, and it is rubbing on the cloth. In this situation, the ball is pressed against the cloth by gravity, and the friction continues until the cue ball is rolling smoothly (no slipping) on the cloth. The ball-ball case is different in that the pressing together lasts only an instant, and the spin is, nearly always, only partly transferred.

There are two effects on the object ball from the sideways force. It will spin a little, just as a bicycle wheel will if you brush your hand along the tread. In the case shown, the spin will be counterclockwise. That's easy enough to figure out from the direction of the rubbing from the cue ball.

What's not understood is that the change in the path of the object ball — the throw — is directly linked to the spin transfer. If the object ball is thrown, it must also be spinning in direct proportion to the amount of throw. How much of each is partly determined by how sticky the balls are. More sticky, more spin and more throw.

In **Diagram 2A**, we see the classic demonstration of non-sticky balls not throwing. Shoot the combination normally and the "dead" ball will miss the far corner every time, but if you make the friction vanish by lubricating the contact point of the two balls on the cushion — spit will work — the shot is easy. Throw will drive the last ball slightly into the cushion, and the rebound will take it wide of the pocket.



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To study this further, move the balls to the middle of the table, as shown in **Diagram 2B**. It helps to have donut-shaped paper reinforcements to set the positions of the balls consistently. Set up the ball that the cue ball will contact to drive the middle ball into about half the stripe. Note that the stripe of the stripe ball is aligned straight up the table to let you see any spin on it.

Shoot the shot normally, and notice both how much the stripe rotates and how far off the centerline of the table the ball moves. Now try the spit. To see what happens for increased friction, apply some chalk to the contact point on the stripe. The spin on the stripe may be a little hard to see due to the rapid forward motion of the ball. You can get rid of this by having the stripe run directly into a fourth object ball placed an inch up the table. Be sure to wet the contact point on that ball so that it can't rub off the spin on the stripe. You should be able to get the stripe to spin slightly in place.

On your table, can you get the stripe to bank back to one of the near corner pockets? Notice that the throw and the transferred spin are in the same direction to make the bank. What speed gets the stripe over the farthest?

Another test of this idea will also show how much the transferred spin on the object

ball can affect bank angles. In **Diagram 3**, set up the 1-2-3 as shown. Paper reinforcements are a must for this setup. Place the 3 ball so that the 2 ball is driven about half full into the 1 ball. The object balls should be frozen to each other, but leave the 1 ball a couple of millimeters off the cushion.

Shoot the cue ball to hit about half of the 3 ball. The 2, 3 and cue ball should all clear out of the way to allow the 1 ball to bank somewhere close to the side pocket. You may get a kiss if the 2 ball is going into the 1 ball too full. If so, adjust the 3 ball for thinner contact. To see how speed affects this bank, try it both fast and slow. Mark carefully where the ball lands after it banks across the table. I use an object ball placed on the cushion where the other ball is expected to land. You should be able to land consistently within a few millimeters for a given speed.

Now to see how much spin is changing the angle, wet the contact point between the 2 and 3 balls, and try the shot again at different speeds. How much has the landing spot changed? If you compare this to the separation between the paths for the shot in **Diagram 2B** with and without lubrication, measured over a distance of four diamonds, the difference is how much the spin on the object ball changed the bank angle.

I think you will find at least two surprises when you try the above experiments, including a new perspective on bank shots.

If the cue ball has follow or draw on it when it hits the object ball, less side spin will be transferred, as part of the friction will be used up to put draw or follow on the object ball. Also, since the side spin works the same as draw or follow during spin transfer, if you shoot straight at a ball with draw, the object ball will actually jump into the air along a shallow angle that is the same as the throw angle. This angle is small enough that you probably can't notice it in normal play. Similarly, the cue ball is expected to jump up a little on all follow shots.

One time when this effect does become large enough to notice on follow and draw is for "vertical cling", when there is chalk at the contact point and much higher friction occurs between the balls. On straight — on follow shots, the object ball will jump up and then will fail to follow as far as expected. At the same time, the object ball will not go as far as expected, since it will have obtained a significant amount of draw, but this is harder to see. There is no way to make use of this in play; it is just another hazard of playing with dirty equipment.