THE PHYSICS AND GEOMETRY

OF

SHOOTING POOL

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Introduction

Good pool shooters have a plan for winning the game. The better strategy could be either to simply pocket the balls or to leave the opponent with a more difficult shot to make. Sometimes offense is the best defense. Either way, the best strategy depends on what the shooter knows. The shooter who knows how to control the cue ball for better position generally has an advantage over the shooter that only knows how to pocket balls.

Fundamental physics and geometry is knowledge that can improve the skill of the player. Knowing the physics of a masse, for instance, as to curve the cue ball for it to miss a ball in the way of pocketing another ball, can be an easy shot for one pool player and appear as an impossible one to another pool player.

Many pool players learn by doing, as to practice and play hours day after day. For guidance, there are books written by experts who have the credentials of having won tournament championships. Here, the physics and geometry is further provided for further insight. However, a mental approach is also significant. Further explained is how to line up for stroking with balance. The laws of physics and geometry then follow as a step-by-step guide from simply stroking straight to curving the cue ball in various ways for various effects.

Mental Fundamentals of Pool

Some fundamentals of pool are having a proper stance and bridge for properly lining up and stroking the cue stick. They are, however, somewhat secondary to those of the mind. Indeed, how we think regarding confidence and being relaxed to successfully execute a winning strategy is essential to success.

Fundamentals of the mind mainly pertain to our ability to concentrate on the execution of a winning strategy. It helps to focus by being relaxed and positive to the extent of not

becoming too lackadaisical or over confident. Know you can succeed if you line up correctly and stroke the cue stick as intended. Relaxing after making a difficult shot only to miss an easy one is self-defeating. Make the effort to concentrate on every shot. However, concentrating too much on the shot and not on fundamentals can also result in error.

If you doubt yourself on one-hand but become over confident on the other, then you are telling yourself mixed messages. Your mind, in turn, is more apt to send a wrong message to the body, such as for it to rise up too quickly out of its stance instead of staying down to properly execute the stroke. You might tend to concentrate too much on eyeing the object ball instead of other fundamentals that are important as well.

This advice is not for becoming a perfectionist. Enjoy playing even if you miss now and then, or often, but also weigh in mind the competitive spirit to win still involves ways to better execute and thereby ease frustration.

Think ahead in a relaxed manner. Relaxation is opposite to stress and pain. It is probably the best medicine in the world for whatever ails you. As for the game of pool, it is essential not to let your opponent bother you enough to interrupt your concentration. Relax as much as you can and do not let casual chatter get into your head. Block it out to concentrate on your plan of execution.

Think simple with a good plan of execution. By thinking simple, the game will become simple. Do not take an engine apart to find out only a bolt was loose. Look first for an easy remedy. Do not execute a difficult draw shot not needed for success if an easier shot is available for the same result. However, sometimes the more difficult is needed for easier shots to follow.

Plan ahead for the simplest and easiest way to run the balls off the table and/or leave your opponent in a more difficult situation. The more you know the more alternatives you have for accomplishment. Sometimes drawing the cue ball back is a better alternative for position and sometimes it is not the better alternative. It all depends on the situation and how well you master the fundamentals of properly executing the plan.

Simplicity and experience go hand and hand. A simple technique for discovering how many different ways the cue ball and object ball react is to purposely scatter the balls for easy shots. Try pocketing an object ball without the cue ball bumping into another ball for either of them ending up in a more difficult position for a table run. Start with easy shots to clear balls out of the way for more easy shots to follow. Try to

run the table in pocketing all fifteen balls without missing. If you miss, start over. Eventually you will acquire a feel for controlling the cue ball and how to plan ahead.

Practicing this way enables you to learn the outcome of stroking the cue ball in simple ways for better positioning. Most positioning is just a matter of shot selection and speed control. Select the easiest ball to pocket that enables you to position the cue ball for another easy shot. Concentrate on all shots. Concentration on easy shots enables the mind to better gage the necessary action for more difficult shots. For learning, stroke the cue ball to find out how it caroms off the object ball and railing. Sometimes tap it easy and sometimes follow through more smoothly. Try following through high and low on the cue ball at various distances and angles of impact. Try hitting the cue ball left and right of center in various ways for various effects. Eventually you will even learn how to curve the cue ball for easier shots. However, keep in mind that even the purpose of curving the cue ball is to simplify the game rather than to make is too complex to grasp.

Lining Up

Lining up correctly with a proper stance is critical to accuracy. Consider, for reference, the style of Joe Davis who retired as undefeated world champion of snooker from 1927 to 1946 (with no tournaments held during the years 1941 through 1945). He retired undefeated even though he became half blind his last five years. As for his stance, he wore a tie that hung straight down over his stick. He bent over with his right foot back to see straight ahead where the stick hit the cue ball, and then where the cue ball hit the object ball. (His level stroke allowed for more follow through on the cue ball when hitting it above center.) The stance allows for a straighter swing. If you line up straight with stroking the cue ball at its center, and the swing of the stick is straight, then your stroke is more apt to be successful.

Except for a masse or a swerve (curving the path of the cue ball), Joe Davis stroked level with the table whether he stroked high or low. Stroking high and following through enables more forward spin while stroking low can either stop or draw back the cue ball after it hits the object ball. (However, for drawing the cue ball back, a 45 degree downward stroke allows the stick to hit the cue ball below center without lifting it as much, thus allowing a more forceful stroke for more draw. Snooker balls are smaller. Joe Davis stroked level with the table to ensure he hit the cue ball low as intended.)

Miscuing can also be avoided by chalking the cue tip to undue its smooth surface, but too much chalk makes it more slippery instead.

The cue stick is usually held with the thumb and fingers of the back hand slightly back from where it would balance by weighing the same in opposite directions. The bridge of the other hand resting firmly on the table, through which the rear hand pushes the stick, consists of an eye-loop formed with the thumb and index finger for the stick to pass over the middle finger. An open V bridge of only the thumb and index finger more conveniently allows a higher level-stroke above the center of the cue ball.

For drawing the cue ball back, a smooth accelerated stroke can be achieved by beginning with a slow stroke and speeding up the swing with follow through. The speed-up can also be achieved by means of a flick of the risk forward near enough to the cue ball for more effective reverse spin depending on the distance between the cue ball and the object ball. At more distance, there is more table friction to counter the reverse spin. The reverse spin can even be reversed for forward roll instead.

For a difficult stroke off the rail that the cue ball is next to, stroking between the middle and index fingers planted on the rail, or through a V loop formed of the thumb and index finger, with the knuckles of the four fingers planted on the rail, is recommended. Stroking over another ball to hit the cue ball is also another difficulty aided by a V bridge of the fingers. More concentration is needed for more success of such difficult situations. As for a cue ball too distant to reach over the table and still maintain balance, a bridge stick is used. For balance while holding the bridge stick, it is achieved by adjusting the elbow as needed of the stroking arm.

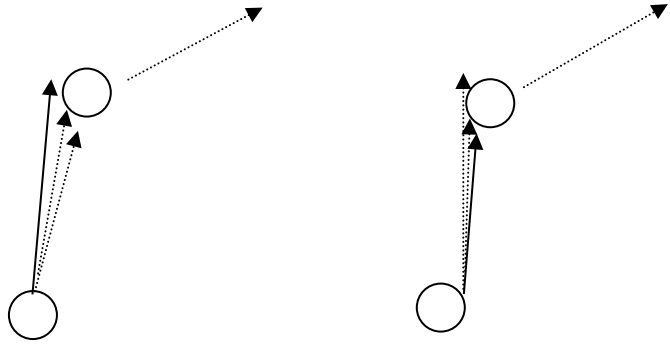
For most shots, success depends on stroking level and smooth to hit the cue ball center. Center contact is easier with a flat surface of the cue tip, but a rounded off edge of the cue tip supplies more friction for avoiding a miscue when purposely stroking the cue ball off center. A cue tip rounded about the same as a nickel is recommended.

As for cueing high and off a rail for making long distant shots, a successful outcome can also be achieved by cueing slightly off center, but only if you know how far to change the direction of aim in compensating for the resulting effects of spin. For instance, cueing left pushes the cue ball to the right of the aim with clockwise spin that curves the cue ball back and to the left of the aim. How far right and left the cue ball ends up depends on both how fast it moves forward and how fast it spins. Too fast of a stroke on the left could push the cue ball to

the right of its aimed direction whereas a slower stroke with smooth follow through on the left could allow the cue ball to curve too far to the left of its aimed direction. The balls generally curve more when moving slower with the same amount of spin.

Where to look when stroking is somewhat controversial. Hand-eye coordination applies, meaning hands become the eyes. That is to say it is not necessary to see the cue ball when stroking if your mind is trained to stroke as intended. Tom Cruz, in the hustler movie The Color of Money, showed off by staring at Paul Newman while pocketing a ball. Eye contact, however, is still valuable information, as to confirm a proper stroke.

Eyeing the center of the cue ball to ensure you hit it where intended is better for consistent accuracy without otherwise training the mind with enough practice. A natural tendency is to look where the cue ball needs to make contact with the object ball, but a common error made with this approach is another tendency of the mind to stroke towards the point of contact of the cue ball with the object ball instead of where the cue stick needs to hit the cue ball, as whenever there is pressure to make nearly a right angle shot.



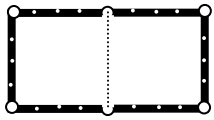
Lining up with the cue ball for it to move the object ball at a preferred angle is illustrated above. The point of impact is not along the center lines of the balls in their directions of motion; it is twice difference in the direction from that of a head-on collision to where contact needs to be. The twice distance is that of both the cue ball and the object ball. The solid arrows represent the actual directions needed to angle the object balls for them to be pocketed; the dotted arrows represent the difference in distances of the cue balls and the object balls. The illustration of the right is measured as the differences in distance between the edges of the cue ball and the object ball, whereas the illustration on the left is measured

as the difference in distances between the centers of the cue ball and the object ball. Still, eye the cue ball when stroking.

Banking

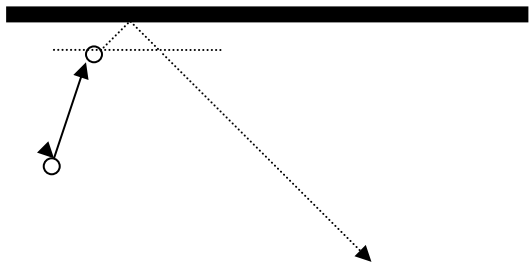
Geometry is also involved in banking either the cue ball off a rail to hit an object ball or to pocket an object ball from off a rail.

Pool tables vary in size, but they are always rectangular of two square lengths. The side pockets are centered at the touching corners of the two squares. The four other pockets are at the outer corners of the rectangle.

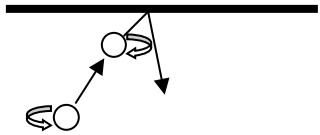


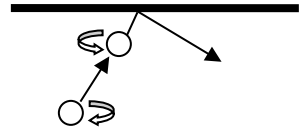
Three dots appear equally spaced between pockets on the railing. The center dot of each three dots is positioned midway between pockets. Let the distance between dots or between centers of pockets be a specified length used to calculate a bank shot in the form of a perfect V. By perfect V here means all corresponding distances to and from the rail are the same, as from parallel with and perpendicular paths from and to the rail.

A path from the center of a corner pocket to the rail in front of a middle dot of the opposite side of the table, and then to the side pocket of the same side of the table, is one perfect V for a bank shot. As illustrated below, the degree of angle of incidence equals the degree of angle of reflection off the rail.

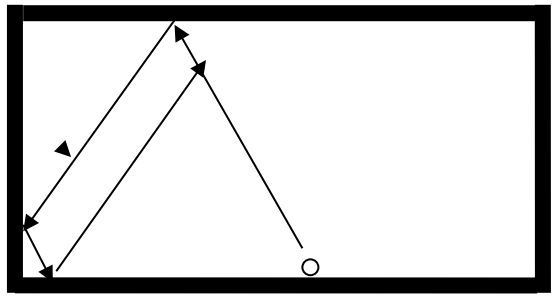


If the blocking path is blocked by another ball, then spin of the cue ball can alter the path of the object ball from that of a perfect V. As illustrated below, counterclockwise spin of the cue ball, for instance, can cause clockwise spin on the object ball for its reflected angle to be less than its incident angle from the rail, as to bank it more to the left of the rail to pocket it in the pocket of the opposite rail. The exact opposite spin of the cue ball is for banking it more to the right of the opposite rail.





The path of a ball bouncing off rails with neither clockwise nor counterclockwise spin also forms a parallelogram after three rails. The parallelogram is similar to a rectangle in that both of them have opposite sides that are parallel; they differ in that only the rectangle has perpendicular sides. As an extension of the V, the parallel sides help calculate the path of a three rail bank, as illustrated below.



The dots beside the rails allow you to measure the directions. The directions from a railing before from a side pocket to the left of the railing in front of a dot on the opposite side rail of the corner pocket continues on to before the first dot of the corner pocket at that table end, then to before the first dot to the left of the side pocket, and then to before the first dot near the right corner pocket on the right-end rail. To bank the ball into the right corner pocket the initial direction needs to be slightly to the left of the first dot.

Kinematics

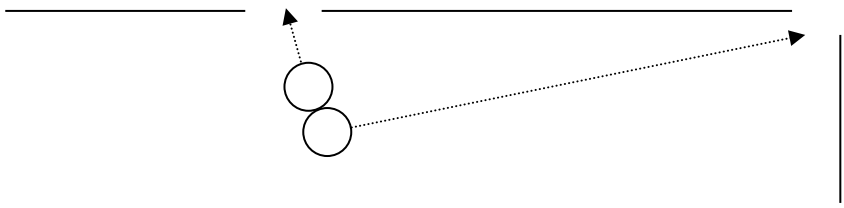
By elastic collision, an object colliding straight on with another object simply transfers its momentum (mass times speed in a particular direction) to the other. If the two objects are equal in mass and size, are round, and collide head on, then they merely exchange relative speed. No matter how fast the cue ball moves, it will just stop after colliding head on with another ball. However, the result is only true insofar as there is no angular momentum involved in the collision. If the cue ball rolls to avoid table friction, or is given spin by the action of the cue tick, then there is rotation as angular momentum or spin to consider.

What all this means is no matter how hard you hit the cue ball without your stroke or the friction of the table causing spin, the force moving the cue ball forward will not allow the

cue ball to either move forward or backward after the collision. The only way for the cue ball to move after a straight on collision is for it to spin by either the friction of the table or by it being stroked off center. Hitting the cue ball easy, for instance, allows table friction to cause the cue ball to roll forward, whereas the cue ball tends to slide more than roll when hit hard, which is necessary for stopping the cue ball for more distance between it and the object ball. Enough friction from longer length between the cue ball and object ball can even reverse backward spin, causing the cue ball to continue forward instead of drawing back after collision with the object ball.

Rolling the cue ball for position is best done by an easier stroke of the cue stick. For the cue ball to roll farther, following through smoothly along with the force of the stroke allows or even increases the forward roll than does stunning the cue ball with a forceful stroke.

A stun shot is for stopping the cue ball after collision, or for causing it to slide off to the left or right at a speed that is depended on the angle the object ball directs from the original direction of the spin-less cue ball. For a head-on collision the cue ball simply stops. Apart from a head-on collision, the directions of the spin-less cue ball and the object ball form a right (90 degree) angle. The speed of the cue ball also changes according to the changed direction of the object ball from the original direction of the cue ball. At a nearly 90 degree angle, the cue ball maintains nearly all of its speed. At a 45 degree angle, the cue ball gives up half of its speed to the object ball for them to have the same speed after collision. At nearly a 0 degree angle, the cue ball maintains nearly all its speed.



With the exclusion of spin, the direction of reflection is unique. No matter from what direction the cue ball comes, it and the object ball recede in perpendicular directions from each other. In the illustration above, the cue ball continues on to scratch in the corner pocket. However, the path can be altered by causing the cue ball to spin. Forward spin of the cue ball decreases the angle to less than 90 degrees whereas reverse spin, or draw, increases the angle to more than 90 degrees. The scratch can thus be prevented by allowing the cue ball to roll forward or by causing it to spin backwards.

Reverse spin is more difficult because it is contrary to the friction of the table. (It is generally consistency of the draw shot that is difficult, sometimes it being too distant; sometimes it not being too short a distance,) If there is relatively little distance between the cue ball and the object ball, then an easy stroke works for either stopping the cue ball or drawing it back on impact. However, if the distance between the cue ball and the object ball is relatively great, then the cue ball needs to be stroked with more speed. Stopping the cue ball when the object ball is at the other end of the table requires a great deal of force. Otherwise, stroke with finesse instead of force. Keep in mind, too, stopping the cue ball after it hits the object ball can be achieved by a soft tap shot with no follow through for slow, natural roll.

For learning how to draw the cue ball back, place the cue ball six inches in front of the object ball. Bridge low and stroke the cue ball as low as you can with a gentle tap. Notice it stops dead after contact with the object ball. Spin the cue ball with a little quicker stroke with follow through, as allowing the stick to continue forward after it hits the object ball. Notice how the cue ball draws back a few inches after contact. Separate the cue ball from the object ball a little farther and notice the same stroke only results in either stopping the cue ball or not even that. A firmer stroke with more follow through is required. At farther separation, even more is required along with a slightly higher bridge and more forceful stroke in a way to prevent miscuing. Stroking downward with a flick of the risk helps obtain the draw.

A drawback of the cue ball that hits the object ball as an angle shot is easier since some of the speed of the cue ball is not transferable to the object ball. Drawing back by cutting the object ball 45 degrees, for instance, will more easily send the cue ball about 90 degrees to the other end of the table, but the angle also varies along with the amount of spin.

There are also other ways to more easily position the cue ball at the other end of the table. For instance, the cue ball can spin off a side rail near the right end of the table with clockwise spin increasing its speed towards the left end of the table.

English

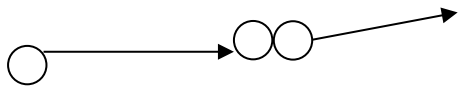
English is pool language for stroking the cue ball either to its left or right to obtain either clockwise or counterclockwise spin. At least four different effects occur. First, the cue ball is partly pushed to the right if you stroked it on the left. Second, it spins clockwise, which tends to cause it to curve to the left. Third, the clockwise spin of the cue ball partly pushes the object ball slightly to the right. Fourth, counterclockwise spin

is given to the object ball for it to also curve slightly to the right. Using English thus complicates the game for it needing to be used with experience and careful calculation in mind.

The amount of effect putting spin on the cue ball depends on several factors. For one, the felt or table cloth on different pool tables varies. Fast tables have less friction. It is easier to draw the cue ball back on them, but it is more difficult to cause it to curve. Slow tables with more friction are just the opposite in effect.

Another factor is with regard to distance and speed. Different effects at medium distance and speed of the cue ball from the object ball reasonably near the pocket usually offset each other. Using low left English, for instance, pushes the cue ball to the right for it to hit the object ball more to the left, but the cue ball compensates by curving to the left and its clockwise spin throwing the object ball to the right. Soft slow shots curve more and can over compensate; hard fast shots move more straight and are less compensating. Distance is thus a compensating factor.

Opposite to the masse is the swerve. Stroking downward high of the cue ball center curves the cue ball sooner by having more spin per forward roll, whereas stroking the cue ball below its center allows more initial speed that slows by the friction of the table for later curvature.



To elaborate on the push of the object ball, consider two balls side by side and touching. If the cue ball strikes the front ball on the right, then the front ball pushes the rear one slightly to the left. If left English is applied to the cue ball in place of hitting the first ball at an angle, then the effect is the same except for different positions of the cue ball resulting after collision.. Similar results occur from the cue ball and object ball touching each other. The cue stick then replaces the effect of the cue ball in the previous situation.

The Masse and Swerve

Left or right English can be used in a variety of ways to curve the cue ball around another ball that is here referred to as a guide ball. When the cue ball and the guide ball are relatively far apart than are the guide ball and the object ball, a swerve is preferred whereby the stroke is at the lower part of the cue ball. When the cue ball and the guide ball are relatively close, a masse is preferred whereby the stroke is at the top of the cue ball. Stroking more downward on the cue ball

increases its amount of curvature, as for it to have more spin per forward motion. Stroking too hard on it nullifies its curvature per distance. Hitting the cue ball hard with left English causes the cue ball to stay more right, whereas hitting the cue ball softly with left English causes the cue ball to curve more left. Following through on the shot also produces both more spin and more push on the cue ball.

The follow through is significant inasmuch as more force on the left pushes the cue ball more to the right. The significance pertains to the aim. Instead of aiming to miss the guide ball, less curvature is needed by aiming to hit the guide ball with enough push to miss it instead. Less English is required, and failure of the masse sometime occurs because of using too much English or stroking the cue ball with too much force.

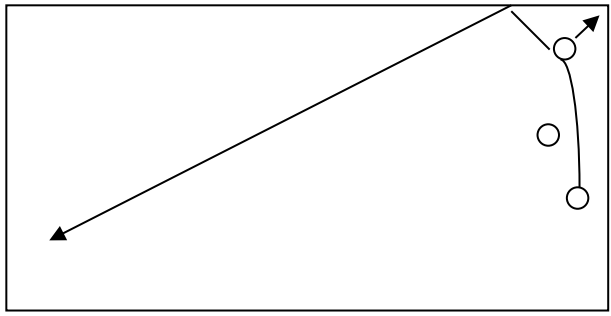
The variety of ways to curve the cue ball is infinite, but whatever way is used needs to be used with predictable effect. The simplest way to curve the cue ball is to just stroke with left or right English. The slower the ball moves the more the friction of the table will take effect. More spin is also created by following through on the stroke. More spin per forward motion is also created by stroking down on the cue ball. Which method you use depends on the path and final position you want the cue ball to take and end up at.

Say you want to make the object ball in a side pocket but another ball is slightly in the way. If the other ball is only about four inches in front of the cue ball, then use it as a guide. Aim to barely cut it. If you stroke down on the cue ball at a 45 degree angle and follow through firmly enough, the cue ball will be pushed to the right enough to miss the guide ball. If you did not stroke it too hard, then the spin given to it from English will bring it back the other way. The success of the shot depends on how skillful you are and the margin of error. If the object ball was close to the pocket with a lot of room for error, then even the beginner is apt to be successful. Start with easy shots to master the technique.

If the guide ball is a foot away from the cue ball, do the same but stroke less downward hitting the cue left of its center to push it right and to curve it left. The spin of a faster cue ball will then be more against the friction of the table.

For a particular example of the benefit of spin, beyond that of the masse, consider an object ball fairly close to a corner pocket, slightly up the rail, as illustrated below. Stroking the cue ball slightly downward or level with left English, as with good follow through for push, spin and curve, results in it hitting the object ball straight on in pushing it to the right into the corner pocket, and in also of the cue ball spinning off the rail to the left. Place another ball in between as a guide ball to

slightly obstruct the straight path of the cue for a dead on hit of the object ball. The result is the same with enough downward stroke of the stick. The only difference is how much downward stroke is used of the masse pushing the cue to the right of the guide ball. The curved path of the masse is more critical to the outcome than is merely using English to push the object ball to the right. of the table to slow it down for gaining curvature.



By the Amateur Pool Association, as for tournament in local leagues, the masse is a legal shot. The grand masse, whereby the back of the pool stick is lifted higher than the shooter's shoulder, the legality is according to house or league rules. Jump shot are generally forbidding because of the damage they can do to the table and the surrounding area. Stroking the stick nearly straight down for a grand masse can also be damaging to the table.