INSTRUCTION

TECHNICALLY SPEAKING

BY STEVE CRUTCHFIELD

The Perfect Stroke

Many instructors and instruction manuals compare the pool stroke to the motion of a pendulum. It makes sense, then, to understand the physics of a pendulum if we are to copy it in our pool stroke. A simple pendulum is just a weight on the end of a string that is attached to a fixed position at the end opposite the weight. (see illustration)

The only variables in a pendulum are the length of the string and the amount of weight. The defining characteristics of a pendulum are the period and frequency. The period is the time required for one complete cycle of the pendulum as it swings back and forth. The frequency (f) is the inverse of the period. In equation form:

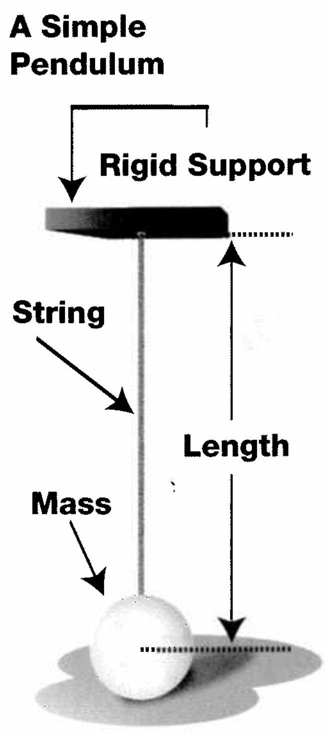
$$f = 1/T$$

For small angles the period depends only on the length of the pendulum and is given by the equation:

$$T = 2\pi \quad \mathrm{SQRT}(L/g)$$

"T" is the period measured in seconds, "L" is the pendulum length, and "g" is the acceleration due to gravity. Apply this to a playground swing with length 12 feet, and you get a period of 3.8 seconds and a frequency of 0.26 cycles/sec. In other words, it takes 3.8 seconds between consecutive pushes of the swing, and the swing makes about 1/4 of a cycle per second. If you want the swing to achieve its maximum amplitude, you have to deliver the push every 3.8 seconds. If you try to push the swing in 3 seconds, you will decrease the amplitude, and if you push it in 5 seconds you will be pushing air. The period that results in what's called the natural frequency of a 12-foot swing is 3.8 seconds. The swing operates most efficiently at this frequency. Natural frequency is a concept common to all kinds of periodic motion, including the earth's rotation on its axis (24-hour period) and middle C on a piano (256 cycles/sec of a vibrating wire).

By now I suspect you see where I'm going with this. If you want to achieve a true pendulum motion with optimum output in the pool stroke, you should do it in a time period that achieves the natural frequency of your arm swinging at the elbow. A typical arm length from elbow hinge to center of fist is about 12 inches for the average male. In the ball-string pendulum it is assumed the string mass is negligible and the system center of mass is at the center of the ball. However, to calculate the period of the arm pendulum we need to shorten the length a little to account for the fact that the center of mass is not at the fist but closer to the wrist since the arm mass is not negligible. The addition of a 20-ounce cue keeps the center of mass near the fist. Ten inches is a good approximation of the length of the arm pendulum. This results in a period of almost exactly 1 second and a frequency of 1 cycle/sec. The resulting natural frequency should produce maximum amplitude in the stroke, more commonly called follow-through. For our purposes the stroke has to be defined as starting at maximum extension of the final practice swing to maximum extension of the shot. That motion should take 1 second and should simulate the motion of any 10-inch pendulum.



To develop this stroke, build a simple pendulum using fishing line, a heavy sinker (2-3 ounces), and a support. Make sure the distance from the pivot point to the center of the sinker is 10 inches. This is the cheapest 1-second timer you'll ever find. Place your pendulum on the table in front of you, set it in motion with a small angle displacement, and keep time with it as you stroke your cue. At the end of your backstroke try to simulate the very slight pause of the pendulum at its maximum amplitude. The beauty of this is that the time period of the natural frequency is independent of the amplitude for small angle arm motion. Whether you take a 3-inch or an 8-inch stroke, you just need to match the period of your pendulum. With enough practice you can train your muscles to develop this natural stroke and summon it when it's time to play. For you, this might be an important aspect of "getting in stroke." The natural follow-through from this stroke will improve shot-making and cue ball range. ♦

Having worked in a poolroom his last two years of high school, Steve was already an accomplished player before entering Purdue University's Indianapolis campus, where he won the campus 14.1 championship his freshman year. He won again his sophomore and junior years after transferring to Miami University of Ohio where he spent the next five years earning his B.S. and M.S. in physics. Having given up pool his senior year of college, Steve maintained his interest in spherical objects by lecturing at Henry Hudson CC in Dearborn, MI, the University of Virginia, and Miami University of Ohio on "Pool and Physics." Mr. Crutchfield has taught college physics as an adjunct professor. Returning to the game that he loves in 1998, Steve joined the APA 9-ball league, where he is a skill level 8 and was MVP in his district in 2001.