Instructor's Corner

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How do you figure out where to hit a rock to get the right angles?

—**Rhee Coyle**

In a previous article, we discussed how to set up angles for raises, runbacks, and doubles. Finding the proper contact point for the desired result is pretty straightforward. The challenging part of the shot is sweeping the shooter to strike the stone at just that point. As far as I know, no skip can do the required mental gymnastics and trigonometry during the execution of the shot to calculate the arc of the stone to strike the target at exactly the right point. Instead, experienced skips are using a far simpler method of aiming for a particular amount of "overlap" between the shooter and target rock when viewed from low and behind. The "overlap" required to make the shot is estimated in advance, and the skip merely has to watch the shooter as it travels down the ice and meter out sweeping to slow the closure of the overlap so that the desired amount of overlap is achieved when the shooter strikes the target. This is actually much easier to do that explain. Full overlap is a nose hit. If you can see half the shooter poking out behind the target rock when viewed from low and behind, that's a "half-rock" overlap. If you can see three-quarters of the shooter, that's a "quarter rock" overlap. Listen to the top teams on TV and you will hear them discussing angles in terms of a "thick half" or "skinny third": they are discussing the overlap of the stones required to achieve the desired angle for the shot.

Mathematics of recoil. So how do you establish the right "overlap" to get the desired angle? Without placing a rock down on the ice next to the target rock—and you are not going to be allowed to do that—you will have to translate some sort of recoil angle into an overlap to make the shot. To do that, you need to remember a little bit of high school geometry. (OK, sleeping through your college physics class was bad enough—now you are going to wish you hadn't slept through your geometry class, too.) Consider Figure 1, which shows the relationship between two stones when they strike one another. The shooter, on the right, is traveling down the ice (up the page). The struck stone will recoil off in the direction of a line drawn between the two centers of the stones. We can draw a right triangle connecting the centers of the two stones, and from there we can figure out a few things. First, the distance between the two stones is equal to one stone diameter ("1") and we can attach that value to the hypotenuse of the triangle. The bottom of the triangle is the offset of the two stone centers, α. So, the overlap of the two stones is ($1-\alpha$) in rock diameters: an offset of "0" is a nose hit, or an overlap ($1-\alpha$ value) of one. A bare tick would have an offset of "1" and a $1-\alpha$ value of 0. The recoil angle, θ, is easily calculated because $\sin\theta = \alpha$. Using this information, it is simple to calculate the recoil angle for various values of overlap, $1- \alpha$. The result of such a calculation is shown in Figure 2. In this figures, the shooter is on the right of the diagram, and is traveling straight down the ice (up the page). To be precise, the recoil angles are 0° (nose), 7° (7/8 rock), 14° (3/4 rock), 30° (1/2 rock), 49° (1/4 rock), and 61° (1/8 rock).

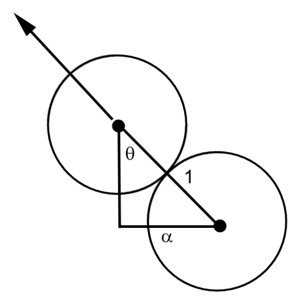

Figure 1

Making it simpler. These numbers are too hard to remember, so let's simplify. Every scientist and engineer knows there are 5 important angles to remember: 0, 30, 45, 60, and 90 degrees. In our case they represent recoil angles for straight back, to the side in a 1:2 ratio (1 inch sideways for every two back), to the side in a 1:1 ratio, to the side in a 2:1 ratio, and a tick directly sideways, respectively. So here is the simple version: a nose hit is a full overlap; 30 degrees back is a half-rock; 45 degrees is around a third or quarter rock, 60 degrees is about 1/8 of a rock; a tick is 90 degrees. When you are setting up angles in the house, look at the approximate angle you need from these "common" angles, and then select your overlap value with confidence.

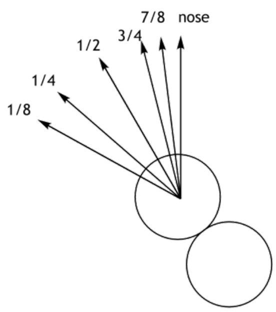

Figure 2

Precision of shots—not all angles are equal! Most experienced curlers know that straight-back shots are easier to execute than sharp angle raises. This is true, and based in the mathematics of the sine function again. For nose hits, a small error in the contact point (or stone overlap) results in a likewise small error in the recoil angle. However for sharper angle raises, a small error in the stone overlap results in a much larger error in the recoil angle. The distance the rock must be raised (or distance from the stone run back and the target) also affects the precision required to make the shot. The longer the raise or runback, the more precise you must be in establishing the correct overlap. For a 10 foot nose-hit runback, the margin of error is ±5%, or about ±1/2 inch. The overlap precision scales with distance: for a 5 foot straight-back runback, the tolerance is ±10%; for a 20 foot runback, the tolerance is ±2.5%. Tolerance falls off slowly with overlap at first, then rapidly as the overlap becomes smaller. This is shown in Figure 3, which is calculated for moving a struck rock accurately over a distance of 10 feet to strike another stone, or for a raised rock to land within a stone diameter of a particular spot. At a half-rock, tolerance is still over 80% of that of a nose hit. At a quarter rock, tolerance is down to 60% of a nose hit. At 1/8th of a rock, tolerance is under 50% of a nose hit. So, for a 5 foot angle raise at 45-60 degrees, you need to hit the target overlap within less ±5% or ±1/2 inch or less of the desired overlap. If you need to catch a target rock thick—say, for a runback-and-stick— then you need to reduce these tolerances by half.

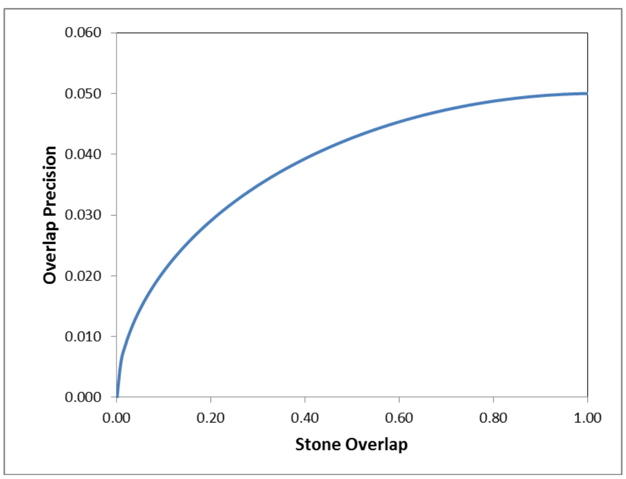

Figure 3

Drag effects. The angles calculated here are based on ideal behavior: frictionless ice, perfectly elastic stones, etc. Real stationary stones "stick" to the ice, and collisions are not perfectly elastic. As a result some "drag" is imparted to the struck stone, which will make the recoil angles slightly smaller (more directly backwards) than ideal. This will be more pronounced and more noticeable for "thin" hits than for "thick" hits, and will be more pronounced for heavy shots (takeouts and runbacks) than for taps and raises. If trying to take out a stone through a hole, or for making angle takeouts, plan on the struck stone traveling slightly more straight back than shown here.

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