

# HIP RAFTER LAYOUT BASICS

by Rob Dale Gilbert



**A good framing square has all the information you need to lay out any hip roof**

The carpentry trade goes back seven generations in my family. In my grandfather's day, you had to know the framing square to get anywhere. Today, sad to say, the "secrets" of the square that he passed on to me really *are* secrets — too many carpenters have no idea why a framing square has numbers on it.

But it's well worth learning about the framing square. Once you get comfortable with it, the square is your fastest and most reliable tool for figuring roofs. Knowing how to use it can save your day if your calculator batteries die, or if you lose your little blue rafter book. If nothing else, learn to use the square to check your results — it can save you from blunders like reading the wrong line on the rafter table or hitting the wrong key on the calculator.

In this article, I'll explain how to use the framing square to mark cuts and calculate lengths for hip and jack rafters. For a basic introduction to laying out common rafters with the framing

square, see "Stepping out Rafters" by Don Zepp in the Winter 1996 issue of *Tools of the Trade*, JLC's sister publication. (If you didn't see the article, send a self-addressed stamped envelope to Rafter Square, *Tools of the Trade*, RR 2, Box 146, Richmond, VT 05477.)

With hips and jacks, you have to modify the layout method used for common rafters. As an example, I'll use a 24-foot-wide building with a roof that has a 6-in-12 pitch — 6 inches of rise per foot of run. We'll rely on the basic ratio of 12 to 17 every step of the way. (To understand why, see "The Magic Numbers" on the next page.)

## Plumb Cut

To mark the plumb cut for a common rafter, you hold the 12-inch mark on the blade (or body) of the square and the 6-inch mark on the tongue (or arm), then draw your line along the tongue. To lay out the hip plumb cut, hold the same number on the tongue of the square, but on the blade, hold 17 instead of 12.

Again, draw your line along the tongue (see Figure 1, next page).

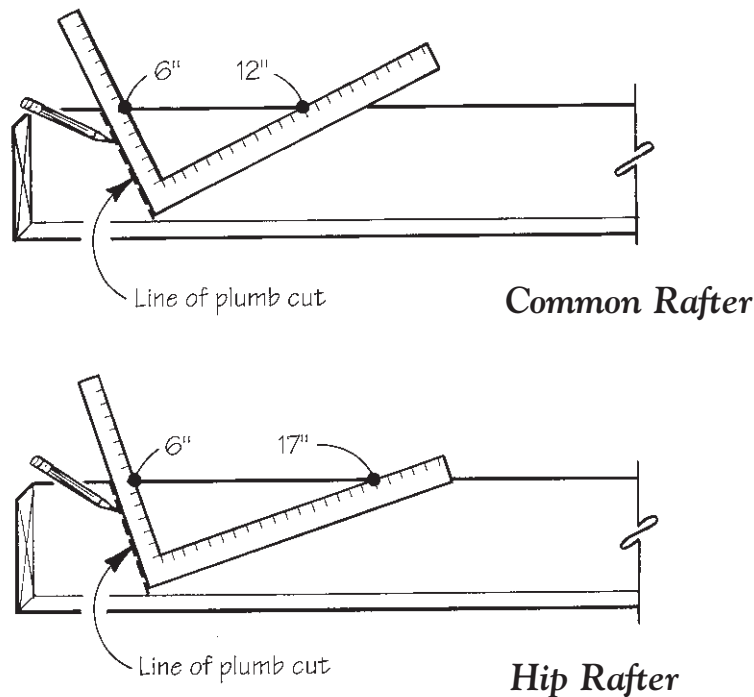
**Side Cut.** The plumb cut on the common rafter is a square cut. But the plumb cut on the hip rafter must be a double bevel so that the rafter can fit into the corner where two common rafters meet the ridge. The line we've drawn represents the long point of this bevel. To find the short points, measure back square from the plumb line, half the thickness of the piece (for dimensional stock, that's  $\frac{3}{4}$  inch). Make a cut line parallel to the first line, and transfer that same line to the other side of the board. Set your saw on a 45-degree angle, and cut along both lines.

## Rafter Length

Now you're ready to find the rafter lengths. For long rafters, I generally use the tables etched on the side of the square (Figure 2, page 31).

**Common.** Reading across the table labeled "Length of common rafters per foot run," and looking under the 6-inch

## Marking the Plumb Cut (6/12 pitch)



**Figure 1.** To lay out plumb cuts for common rafters, align the number corresponding to the rise (in this case, 6 inches) on the tongue and the 12-inch mark on the blade with the edge of the rafter (top). For hips, use 17 inches (instead of 12) on the blade (bottom).

## The Magic Numbers

Long ago, a wise man named Pythagoras proved a basic mathematical fact: For every right triangle, the sum of the squares of the lengths of the two short sides of the triangle equals the square of the length of the long side.

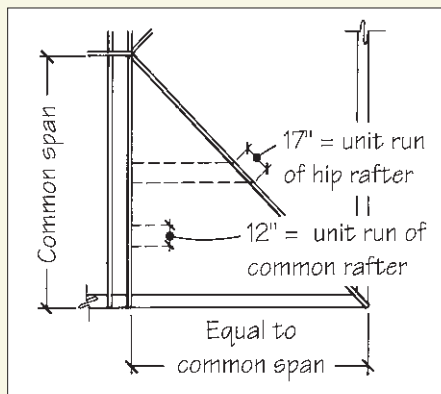
Simpler men used a simple version of the Pythagorean Theorem to square the walls of buildings: the 3-4-5 triangle ( $3^2+4^2=5^2$ , or  $9+16=25$ ).

Much later, a much simpler man discovered that the diagonal of a square 12 inches on a side measures 17 inches: 12 squared plus 12 squared equals 17 squared ( $144+144=288$ ). The square root of 288 is 16.97 and change — close enough to 17 for a simple man. Take out your tape and measure between the 12-inch marks on the blade and tongue of your framing square. Yep — 17 inches.

That's why 17 is the magic number for framing hip roofs. The ratio between the *length* of a common rafter and the *length* of a corresponding hip

rafter varies depending on the roof's pitch (which is why rafter tables are so complicated). But the ratio between the *horizontal* distances the rafters span — the *run* — is always the same: 12 to 17. For every foot your common rafters span, your hip rafter will span 17 inches (minus a whisker). You use the same units of run to figure every roof — all that varies is the rise.

— R.D.G.



mark, we see the numbers 13 42 — 13.42 inches. (Numbers that come out to even fractions are marked as fractions — the rest are decimals.) The run of our 24-foot-wide building — half the span — is 12 feet. So for the length of a common rafter, we multiply 12 by 13.42 and get 161.04. The rafter is 161 inches and a shy  $\frac{1}{16}$  inch long — call it  $161\frac{1}{8}$  inches for good measure. (Rounding up to the nearest eighth is safer than rounding down: You can always shorten the rafter, but you can't lengthen it once it's cut.)

This is the distance to the exact center of the building — a point that actually falls right in the center of the ridge board. We have to allow for the ridge board, so before we actually cut the rafter, we'll shorten, or "back," the rafter  $\frac{3}{4}$  inch (for a 2-by ridge). Just measure back  $\frac{3}{4}$  inch square to the first plumb line, draw a new plumb line there, and cut.

**Hip length.** You can find the hip rafter length the same way, by reading the table labeled "Length hip or valley per foot run." Under the 6, the table says 18 — an even number for once. Multiply 12 by 18 and you get 216 inches — bingo. To mark the rafter length, make the plumb cut, then hook your tape on the tip of the rafter and measure along the top edge of the stick. The mark you make at 216 inches shows you where the back of your birdsmouth will be.

As in the case of the common rafter, the length we calculate or step off would make the rafter long enough to reach the exact center of the building — a point that actually lies inside the ridge board. So the hip rafter also has to be backed — this time, by the *diagonal* thickness of the ridge board, or about  $\frac{1}{16}$  inches. For practical reasons, I make this correction after test-fitting the hip rafter (see "A Note on Accuracy," page 32).

## Stepping Off

For a small roof, like a dormer, or for an unusual roof with a nonstandard pitch (a pitch that falls between those listed on the tables), I usually step off the rafter lengths.

**Common.** To do this for a common rafter, you start at the plumb cut line, holding 12 on the blade of the square, and the rise (6 in our example) on the tongue. As we step off the horizontal distance, we'll automatically come

down the vertical distance of 6 inches per foot. Holding the tongue right on the plumb cut, you make a mark at the 12 on the blade. Then slide the square down the rafter until the edge is on the mark you made — you've stepped over a foot. Repeat the process until you have stepped off the whole 12 feet of our sample span. You should end up at the same point as when you measured: 161 inches down the length of the rafter. (You can also lay out the birdsmouth first instead of the plumb cut, and step up the rafter instead of down — it makes no difference.)

**Hip.** To step off the hip (Figure 3), you take the same number of steps you took with the common rafter. But because the hip rafter spans the space diagonally, each horizontal step is 17 inches instead of 12, even though the vertical steps are the same. So you hold 6 on the tongue, 17 on the blade, and step off 12 times. Your last mark will be in the same place as if you had multiplied and measured: in our example, 216 inches.

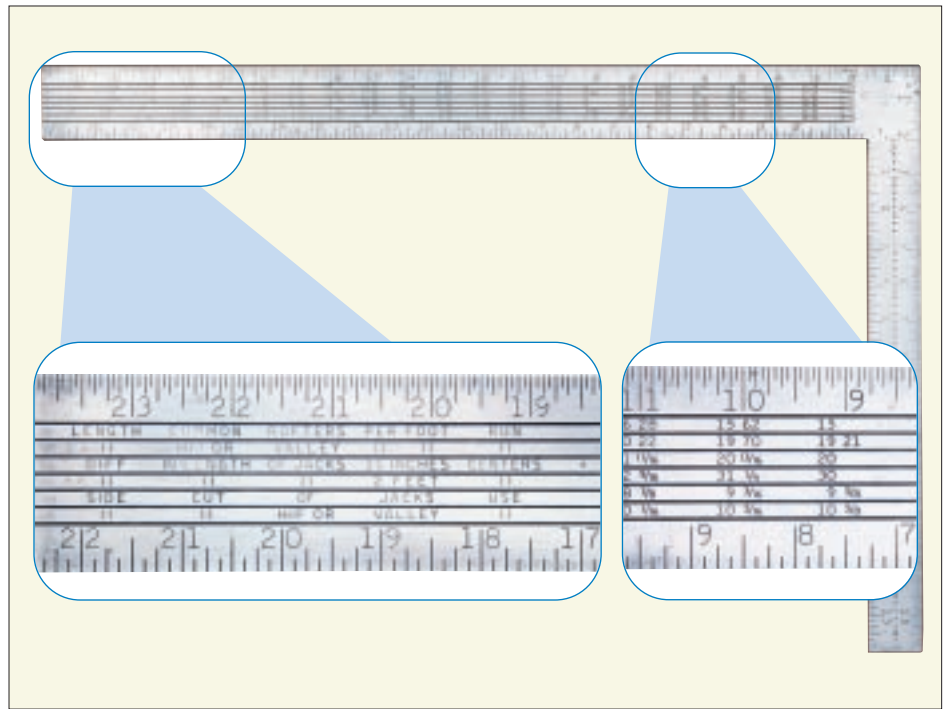
**Partial steps.** If the run of your rafters isn't an even number of feet, you'll have to make one last partial step. For instance, if the building were 25 feet wide, and each common rafter had to span 12 feet 6 inches, your last step would be a 6-inch step. Holding the tongue and blade at 6 and 12 respectively, you would make one last mark at the 6 on the blade, then slide the square down to that point for your heel cut mark.

For hip rafters, that last partial step-off gets complicated — you have to maintain the proportions of 17 and 12. So you multiply the partial step by 17/12: Instead of 6 inches, your last step would be  $17/12 \times 6$ , or  $8\frac{1}{2}$  inches (still holding 17 on the blade, and measuring along the blade, as shown in Figure 3).

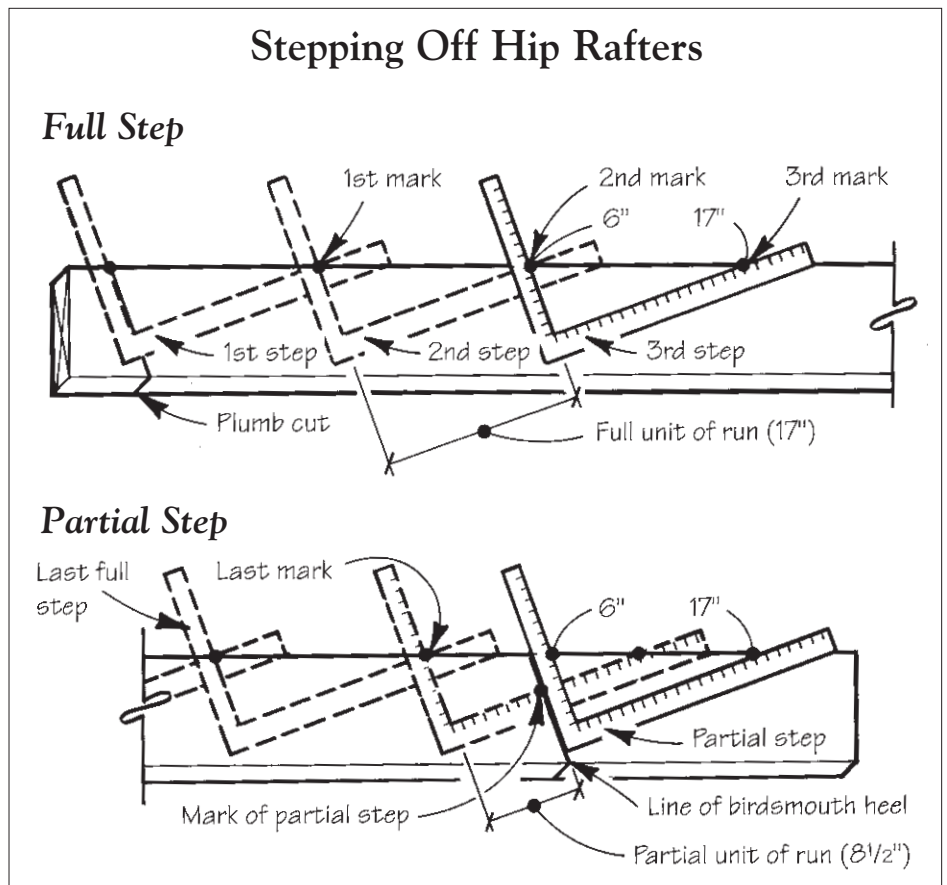
### The Birdsmouth

At the eaves end of the rafter, draw a plumb line exactly like the line you drew for the plumb cut, holding the number for the rise (in this case 6) on the tongue of the square, and either a 12 or a 17 on the blade (12 for a common rafter, 17 for a hip). The plumb line represents the point where the back, or "heel," of the birdsmouth snugs up against the outside wall.

**Common seat.** Next comes the seat cut, where the rafter sits on top of the



**Figure 2.** To use the tables on the framing square to find the length of a common or hip rafter, read across the edge of the square to find the number that corresponds to the rise of the roof — 6, in this case. Multiply the number on the appropriate line — 13.42 for commons, 18 for hips — by the rafter's total run in feet.



**Figure 3.** Instead of calculating a rafter's length from the tables on the square, you can step off the length. For common rafters, each step accounts for 12 inches of run; for hip rafters (shown), each step accounts for 17 inches of run.

When the span falls on an uneven dimension (such as 12 feet 6 inches), use a partial step. For hips, maintain the ratio of 17/12. For example, a partial step of 6 inches for a common rafter would become a partial step of  $8\frac{1}{2}$  inches on the hip (shown).

## A Note on Accuracy

Using the framing square is as accurate a method of laying out cuts as any other. It's certainly as accurate as using a speed square.

On the other hand, using the square to find rafter lengths isn't as accurate as a calculator. The numbers on the tables for length per foot of run are mostly approximations (though a few are exact). When you multiply, you compound the inaccuracy. By the same token, as you step off a length, you may accumulate an inaccuracy. (That's no big deal, though — just make sure you come out long rather than short. If it's long you can always shorten it, but if it's short you have to start over.)

For common rafters, if your test pair is a shade long, the joint where they meet will be open at the top. But don't recut the angle — fix the length instead by backing the plumb cuts a little (keep the same angle, but trim off  $\frac{1}{8}$  inch or so). When the pair fits right, go on and use them as a pattern to cut the rest of your commons.

The same is true of the hip rafter — you want one that's too long, not one that's too short. The magic number we use for stepping off, 17, is an approximation that's  $\frac{1}{32}$  inch bigger than the actual number. Multiplied out, it can give you a hip rafter that's too long. That's okay — in fact, I never even back my hip rafters to allow for the ridge board.

Instead, I let them run about an inch too long. Then I hold them in place to see how they fit. Usually the cuts fit snugly into place, but because the rafter is a shade long, the heel of the birdsmouth is gapped away from the plate a bit, and the whole piece sits a shade high. Holding the rafter in place, I measure the gap at the plate. Then I take the rafter down and back the plumb cut just enough to close the gap and make a perfect fit.

— R.D.G.



**Figure 4.** When laying out seat cuts, it is critical to maintain the same height above the plate on both hip and common rafters.

wall. For the common rafter, you slide the square down so the blade intersects the plumb line, still holding 12 on the blade and the rise on the tongue. Your seat cut should be just as long as the width of the wall — for a 2x6 wall, you need 6 inches including the sheathing. So you set the square so that the 18-inch mark (12 plus 6) crosses your plumb line, and draw along the blade from 18 to 12 — 6 inches.

**Hip seat.** The seat cut for the hip is a little more complicated. When the rafters are set in place, the top of the hip rafter must be even with the top of the common rafters in order for the roof sheathing to lie smoothly across them. So in laying out the cuts, the distance up the plumb line from the corner of the birdsmouth to the top edge of the rafter — the height above the plate — must be the same for both. Measure the height above the plate on the common rafter, and measure down the plumb line you made for the heel cut on the hip rafter. Mark the point, then make a line square off the heel cut for the seat cut (Figure 4).

### Rafter Tails

You can make all your tail cuts before you set the rafters. But if you do, any little curves or bumps in your wall plates will telegraph out to the fascia and soffit. I generally cut all my rafter tails in place, after the roof is framed. That way, I can snap a line along the whole set of rafters and the cuts line up perfectly. But for anyone who wants to make those cuts in advance, here's how to lay them out.

**Common.** First, determine your soffit overhang (let's use 12 inches as an

easy example). For the common rafter, hold 12 on the blade and the rise on the tongue, and slide the square until the 12 intersects with the mark for the heel cut. Then simply mark your fascia cut along the tongue. (Note: For this step, you'll have to flip the square around so that the tongue is on the downhill side of the rafter. The fascia cut is just like the ridge cut, only upside down.) Make sure you mark on the same side you measure on.

**Hip.** For the hip rafter, hold 17 instead of 12, then slide as before. To determine the distance from the heel cut to the fascia cut, take the number you used on the common rafter and multiply by  $17/12$ . In this case, since we're using a 12-inch overhang, it comes out to 17 inches. Let the 17 intersect with the heel cut line, and mark the fascia cut along the tongue of the square (Figure 5).

This is the short point of the cut. Mark the cut on both sides of the board by squaring across the edges and connecting the points. Set your saw on a 45-degree angle and cut on both sides of the board to form the pointed end of the hip rafter.

**Soffit.** To lay out the soffit cut, you'll need to know how wide your fascia boards will be and how far below the soffit your fascia will extend. Let's assume we're using 1x6 fascia board and we've decided that a  $5\frac{1}{4}$ -inch fascia cut will work well.

Once you know this measurement, you measure down the fascia cut line  $5\frac{1}{4}$  inches and make a mark where the soffit cut will intersect. Then, holding 12 on the blade and the rise on the tongue, mark along the blade for the soffit cut.

For the hip rafter, you must make sure the vertical cut is the same length as the cut on the common rafter — just as you did earlier for the height above the plate. Measure down the fascia line  $5\frac{1}{4}$  inches, the same distance as on the common rafter fascia, and make a mark. Holding 17 on the blade and the rise on the tongue, let the blade intersect the mark, and mark your cut line along the blade.

### Jack Rafters

Jack rafters are just like common rafters, but instead of meeting the ridge they meet the hip rafter. So they have to be cut to a succession of different

lengths, and their plumb cuts must be beveled to fit against the hip.

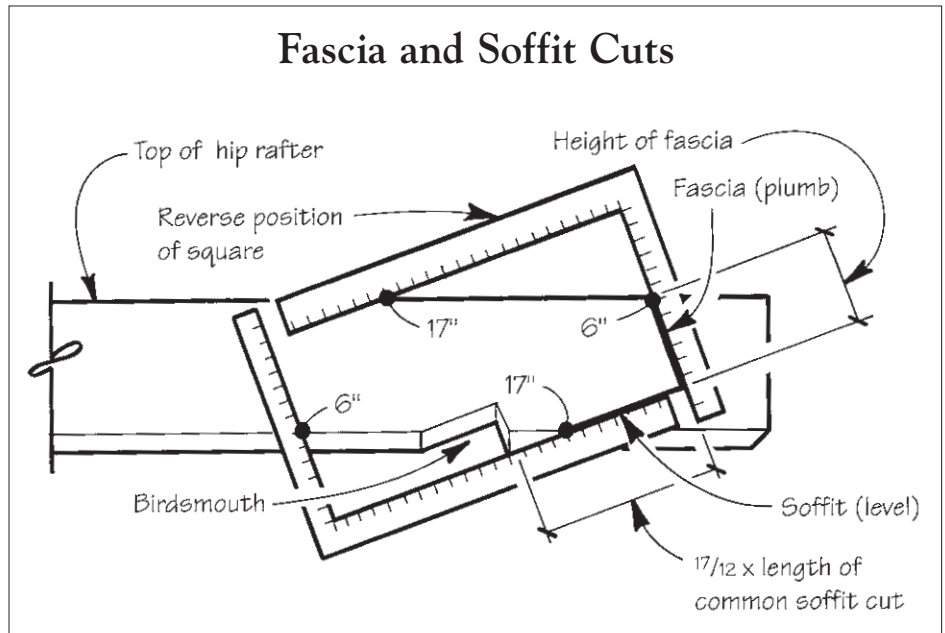
To find the lengths of the jacks, look on the square for the table labeled "Difference in lengths of jacks, 16 inches on-center," or, if appropriate, "24 inches on-center." Read across to the number that falls under the pitch you're using. The number you find ( $17\frac{7}{8}$  for a 6-pitch roof with jacks 16 inches on-center) is the number we'll use to find the length of each jack. We'll subtract this number from the length of the longest jack to find the second longest, and so on until we have all the jacks.

To start with, we need to know the length of the longest jack. Instead of going through the geometry of figuring that out theoretically, I just take the simplest route: I use the length of the last common rafter from the heel of the birdsmouth to the point where it meets the face of the hip rafter. Starting with that number and subtracting over and over gives me the length of each succeeding jack rafter.

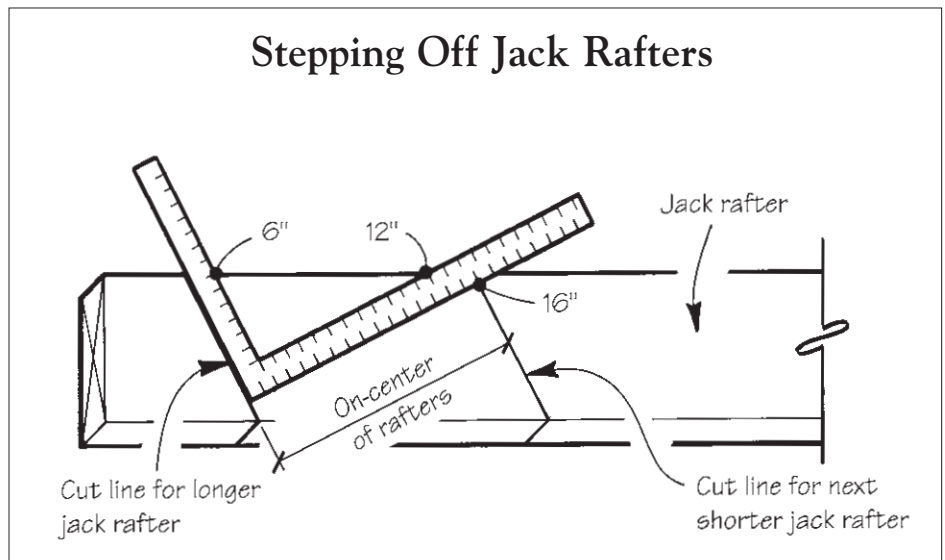
**Stepping off jacks.** For odd pitches that aren't included in the tables — say, an unusual pitch like a  $7\frac{3}{4}$  in 12 — you can step off the jacks. Hold the 12 and the rise, just like stepping off a common rafter. But instead of stepping horizontally one foot at a time, step 16 inches (or 2 feet if your layouts are on 2-foot centers). For partial layout steps, such as you might need to calculate jacks that frame in a skylight opening, you can make partial steps as you would for a common rafter (Figure 6). If the jack you need will be set 10 inches over from the one next to it, start with the length for the neighboring jack and step forward or back the 10 inches. The lengths will work out correctly.

You cut jack rafters in pairs: One pair at each length for each hip rafter. Set your saw on a 45-degree angle and cut along the line. Save the offcut — it already has the bevel on it for the opposite side of the hip, and needs only the birdsmouth cut to become a jack rafter, too. (Check the crown before you use it that way, though — if the crown's noticeable, you'll have to make the plumb cut the other way.)

I usually cut my middle pair of jacks first and test-fit them. They may need to be adjusted by  $\frac{1}{4}$  inch to fit, though that's rare. Nailing the center pair on first straightens the hip rafter and locks it in



**Figure 5.** The height of the fascia cut will be the same for both common and hip rafters (although the hip cut is double-beveled). The length of the hip's soffit cut, however, will be  $17/12$  times that of the common.



**Figure 6.** To step off successive jack rafters, hold the rise and run on the tongue and blade of the square (in this case, 6 inches and 12 inches), but mark the rafter to correspond to the on-center spacing of the jacks (in this case, 16 inches). Cut along the line with your saw set at 45 degrees.

place. The rest of the jacks should drop into place with no argument.

There are methods for making layout marks on the hip rafters to show where the jacks will fall, but they aren't worth getting into. If your jacks are the right length, they'll fall in the right place. To check, just pull a measurement off one of the common rafters on the main roof (or off the center common if you're on that end). If you're within  $\frac{1}{4}$  inch of 16-inch centers, you'll be fine.

When you install the jacks, make sure each pair lines up across the hip, both at the top and bottom. If you nail

them up so they match at the top but not at the bottom, you'll build a twist into the hip rafter.

When the hips have been cut and fitted into place, and the center jacks are nailed up, I like to pull a measurement from a common rafter and make sure my 16-inch centers are falling out okay. If everything looks right, I feel comfortable handing the rest of the jack rafters up to the guys on the plate and walking away. ■

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