

# CHAPTER 18

# Hip, Valley, & Jack Rafters

## Section 18.1

Hip Rafters

## Section 18.2

Valley Rafters

## Section 18.3

Jack Rafters

## Chapter Objectives

After completing this chapter, you will be able to:

- **Explain** how to lay out a hip rafter for a given roof.
- **Explain** how to lay out a valley rafter for a given roof.
- **Determine** the rafter overhang for a hip or valley rafter.
- **Define** a dormer.
- **Explain** how to lay out a jack rafter for a given roof.
- **Summarize** why the intersection of two roofs calls for more complex framing.



### Discuss the Photo

**Rafters** Rafters are made up of geometric shapes. *What shapes and types of angles do you see in this picture?*



### Writing Activity: Categorizing Information

As a class, observe or find photographs of at least sixteen different roofs on houses in your community. Place like roofs together. After you have finished reading the chapter, categorize each roof by type: gable roofs, hip roofs, and intersecting roofs (including dormers). Create a brief description of each type of roof.

# Chapter 18 Reading Guide



## Before You Read Preview

Roof framing with hip, valley, and jack rafters is more complex than framing entirely with common rafters. Choose a content vocabulary or academic vocabulary word that is new to you. When you find it in the text, write down the definition.

### Content Vocabulary

- hip rafter
- valley rafter
- jack rafter
- seat cut
- backing the hip
- dropping the hip
- addition
- dormer
- doghouse dormer

### Academic Vocabulary

You will find these words in your reading and on your tests. Use the academic vocabulary glossary to look up their definitions if necessary.

- hypotenuse
- significant
- ensure

### Graphic Organizer

As you read, use a chart like the one shown to organize information about the three types of rafters.

hip rafter	valley rafter	jack rafter
forms a raised area, or hip, usually extending from the corner of the building diagonally upwards to the ridge		

Go to [glencoe.com](http://glencoe.com) for this book's OLC for a downloadable version of this graphic organizer.

### Academic Standards



#### English Language Arts

Use information resources to gather information and create and communicate knowledge (NCTE 8)  
Participate as members of literacy communities (NCTE 11)



#### Mathematics

**Measurement:** Understand measurable attributes of objects and the units, systems, and processes of measurements (NCTM)

**Geometry:** Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships (NCTM)



#### Science

**Science and Technology:** Abilities of technological design (NSES)

#### Industry Standards

Framing in Wood  
Roof, Ceiling, and Wall Framing

**NCTE** National Council of Teachers of English

**NCTM** National Council of Teachers of Mathematics

**NSES** National Science Education Standards

# Hip Rafters

## Understanding Complex Roofs

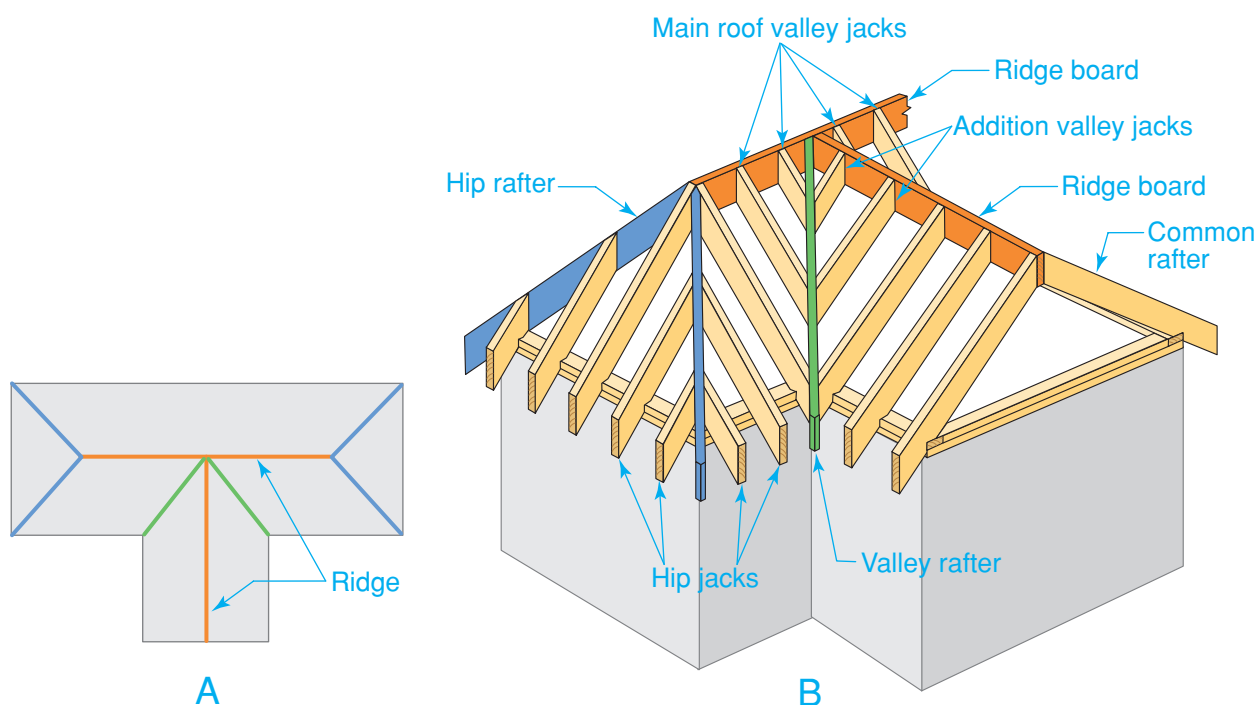
### When is a hip rafter called for?

A simple gable roof can be built entirely with common rafters. However, a carpenter must also know how to lay out and cut hip, valley, and jack rafters. These rafters, shown in **Figure 18-1**, are required when framing complex roofs, such as hip roofs and intersecting gable roofs (for more on roof types, see Chapter 17, “Basic Roof Framing”). A **hip rafter** forms a raised area, or *hip*, usually extending from the corner of the building diagonally upwards to the ridge. A **valley rafter** forms a depression in the roof instead of a hip. Like the hip rafter, it extends diagonally from the top plate to the ridge. A hip

rafter is called for only when framing a hip roof, but a valley rafter is needed on both hip and gable roofs whenever roof planes intersect. A **jack rafter** is a shortened common rafter that may be framed to a hip rafter, a valley rafter, or both. Thus, there are *hip jack rafters* and *valley jack rafters*.

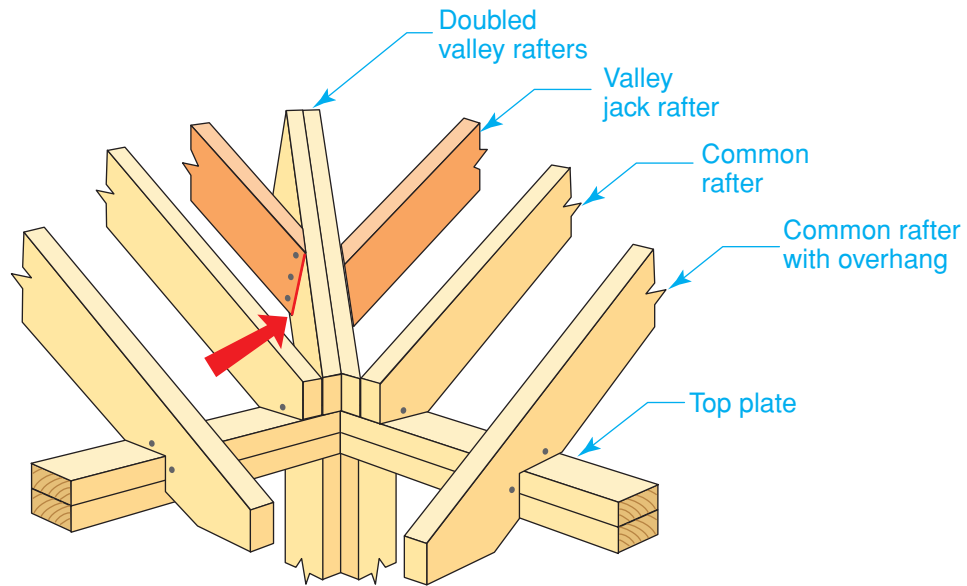
The total rise of hip and valley rafters is the same as that of common rafters. They are also the same thickness as common rafters. However, they should be 2" wider in their nominal dimension. For example, if you use 2×6 common rafters, use 2×8 hip rafters to provide full bearing for the end of intersecting jack rafters, as shown in **Figure 18-2**.

A mastery of roof framing with hip, valley, and jack rafters is what distinguishes the true



**Figure 18-1 Hip, Jack, and Valley Rafters**

**Roof Anatomy** **A.** The roof framing plan. **B.** The general arrangement of rafters shown in the larger drawing.



**Figure 18-2 Width of Hip and Valley Rafters**

**How the Parts Fit** The doubled valley rafter in this drawing has been cut off at the top plate. Normally it is extended to become part of the overhang. Doubled valleys are sometimes used to provide more bearing for the roof sheathing.

professional from the casual carpenter. This chapter describes how to figure rafter layouts manually using a standard framing square. On the job, construction calculators and triangular framing squares are often used for this purpose. A calculator works quickly and with great precision. This makes it invaluable when laying out hip, valley, and jack rafters. Most construction calculators have built-in functions to make roof calculations even easier.



**Recall** What tools are used to figure layouts?

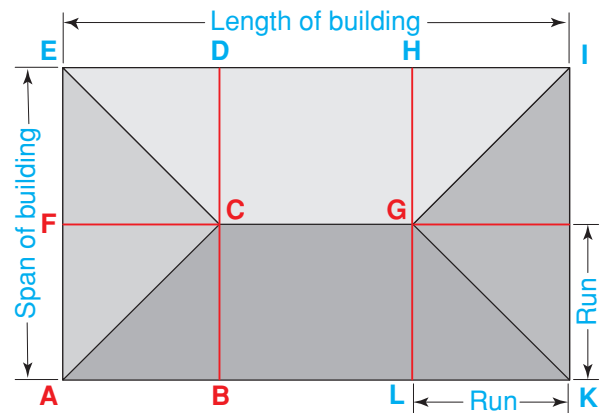
## Hip Rafter Layout

*What is a hypotenuse?*

Any of the methods for determining the length of a common rafter may be used for determining the length of a hip rafter (see Chapter 17, “Basic Roof Framing”). However, some of the basic data used is different.

Part of a framing plan for a hip roof is shown in Figure 18-3. Remember that a line on the framing plan indicating a rafter represents the

total run of the rafter, but not its actual length. On a hip roof framing plan, the lines that indicate the hip rafters (EC, AC, KG, and IG in Figure 18-3) form 45° angles with the edges of the building. You can see from the plan that the total run of a hip rafter is the **hypotenuse** of a right triangle. The two shorter legs of this triangle are each equal to the total run of a common rafter, or half the span of the roof.



**Figure 18-3 Hip Roof Framing Plan**

**Framing Plan** This is the framing plan for a small rectangular building with a hip roof.

In **Figure 18-4**, one corner of the roof framing plan (ABCF in **Figure 18-3**) has been drawn in perspective. This shows the relative position of the hip rafter to the common rafter.

The unit run of a hip rafter is the hypotenuse of a right triangle with the shorter sides each equal to the unit run of a common rafter, as shown in **Figure 18-5**. The unit run of a common rafter is 12". Using the Pythagorean theorem,  $a^2 + b^2 = c^2$ , the unit run of a hip rafter is the square root of  $144 + 144$  which is 16.97" (which can be rounded up to 17"), as shown in **Figure 18-6A**.

Like the unit length of a common rafter, the unit length of a hip rafter may be obtained from the rafter table on the framing square. In **Figure 18-6B**, the second row in the table is headed "Length Hip or Valley per Foot Run." This means "for every 12" of a common rafter in the same roof." Another way to state this would be "per 16.97" run of hip or valley rafter." For example, the unit length for a unit rise of 8" is 18.76". To calculate the length of a hip rafter, multiply the unit length by the number of feet in the total run of a common rafter.

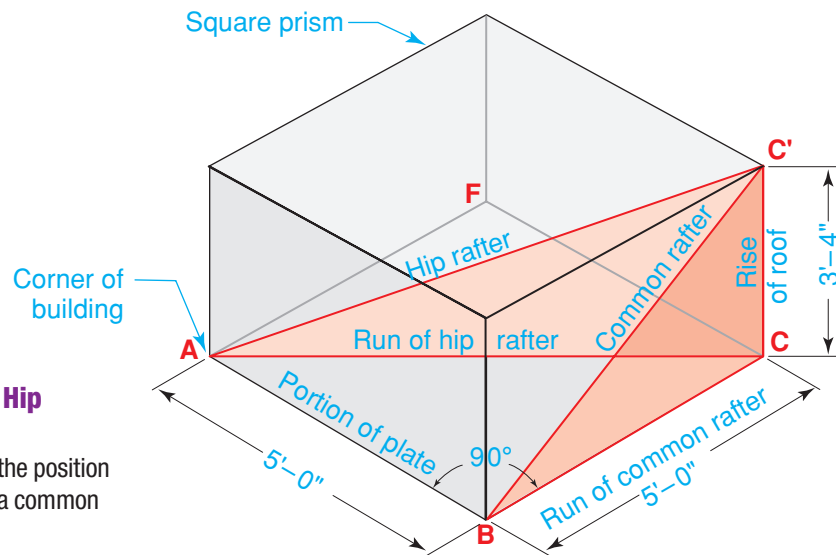
JOB SAFETY

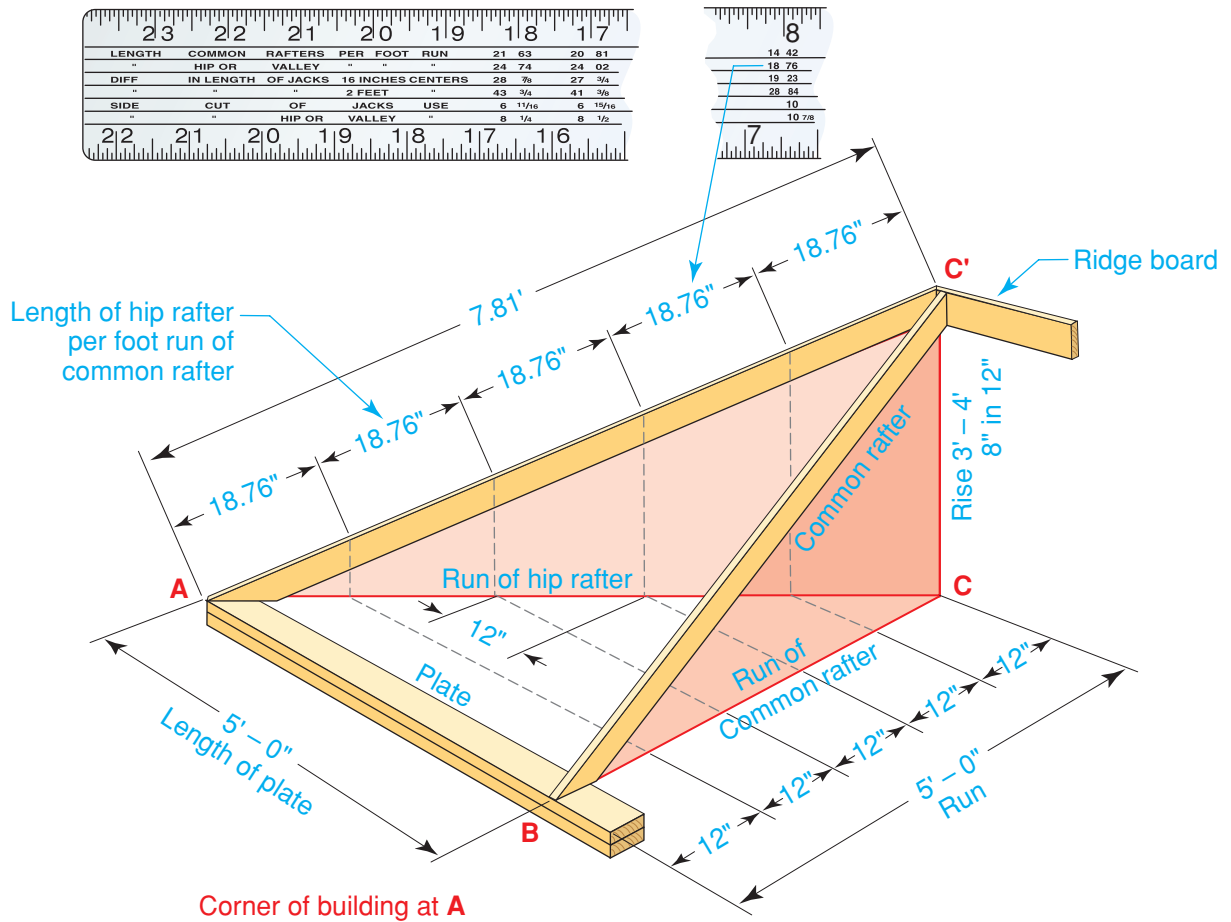
**CUTTING COMPOUND ANGLES** The cuts made on hip jack and valley jack rafters are typically made at compound angles. To make such cuts, tilt a portable saw at a bevel angle. Then guide it across the rafter stock at a miter angle. Secure the stock so it will not move during the cut. To prevent the blade guard from binding, retract it to get the cut started. Then release it to complete the cut. Never disable or remove the guard to make a compound-angle cut.

Go to [glencoe.com](http://glencoe.com) for this book's OLC for more on job safety.

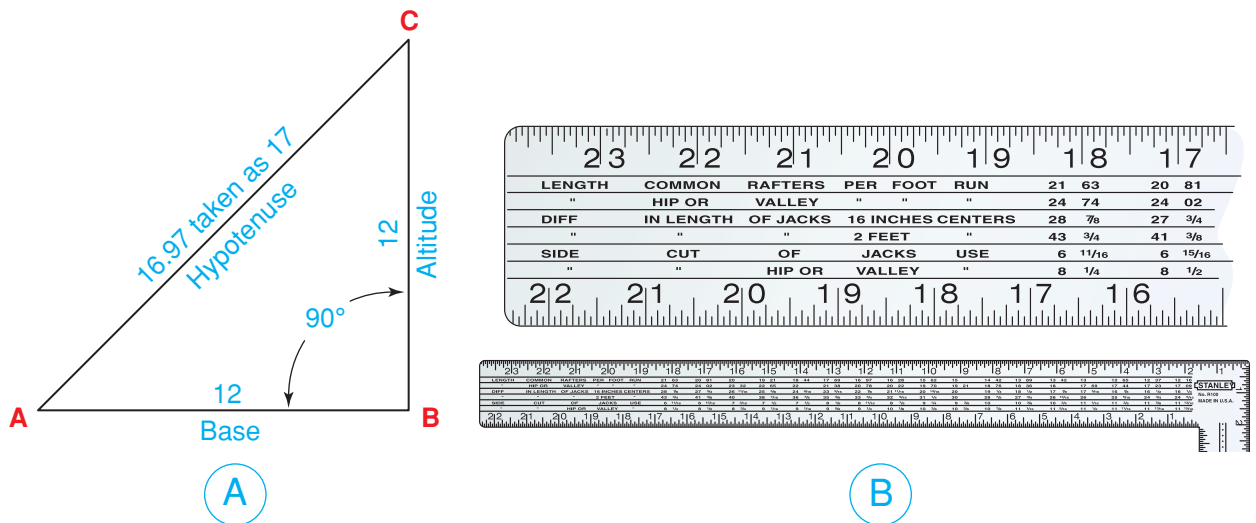
Look again at **Figure 18-5**, which shows the corner of the building shown in **Figure 18-3**. In this example the total run of a common rafter is 5'. The unit rise is 8" and the unit length of the hip rafter for this unit rise is 18.76". The unit length multiplied by the total run in feet is the length of the hip rafter in inches ( $18.76" \times 5 = 93.8"$ , or  $7'-9\frac{13}{16}"$ ). As in the case of common rafters, this is the theoretical length. To obtain the actual length, the ridge board shortening allowance and the rafter tail length will have to be calculated and laid out.

**Figure 18-4 Comparison of Hip and Common Rafters**  
**Hip and Common Rafters** Here, the position of a hip rafter is shown relative to a common rafter. *Which one is longer?*





**Figure 18-5 Comparing Unit Runs**  
**Visualizing Unit Run** The relationship between the unit run of a hip rafter and the unit run of a common rafter.



**Figure 18-6 Unit Run and Unit Length**  
**Finding the Units** Finding unit run and unit length. **A.** The hypotenuse of a right triangle, the shorter sides of which each equal 12", is 16.97". This can be rounded off to 17". **B.** Unit length can be obtained from the framing square.

**Pythagorean Theorem** Find the run of a hip rafter if the run of the common rafter is 10 feet. Round to the nearest tenth.

**Starting Hint** The run of the hip rafter is the hypotenuse of a right isosceles triangle. The length of the legs is the length of the common rafter.



**Roof Styles** A roof is a very important element in the architectural style of a house. The style of a house can change dramatically by changing features as basic as roof pitch. For example, a hip roof with a steep pitch would typically indicate a French style of architecture that is often seen in the Gulf Coast region, particularly in Louisiana. A low-pitched hip roof characterizes Prairie style houses often found in the Midwest. The type of roof framing that carpenters become familiar with depends on the style of house most common where they work.

Go to [glencoe.com](http://glencoe.com) for this book's OLC for more information about regional concerns.

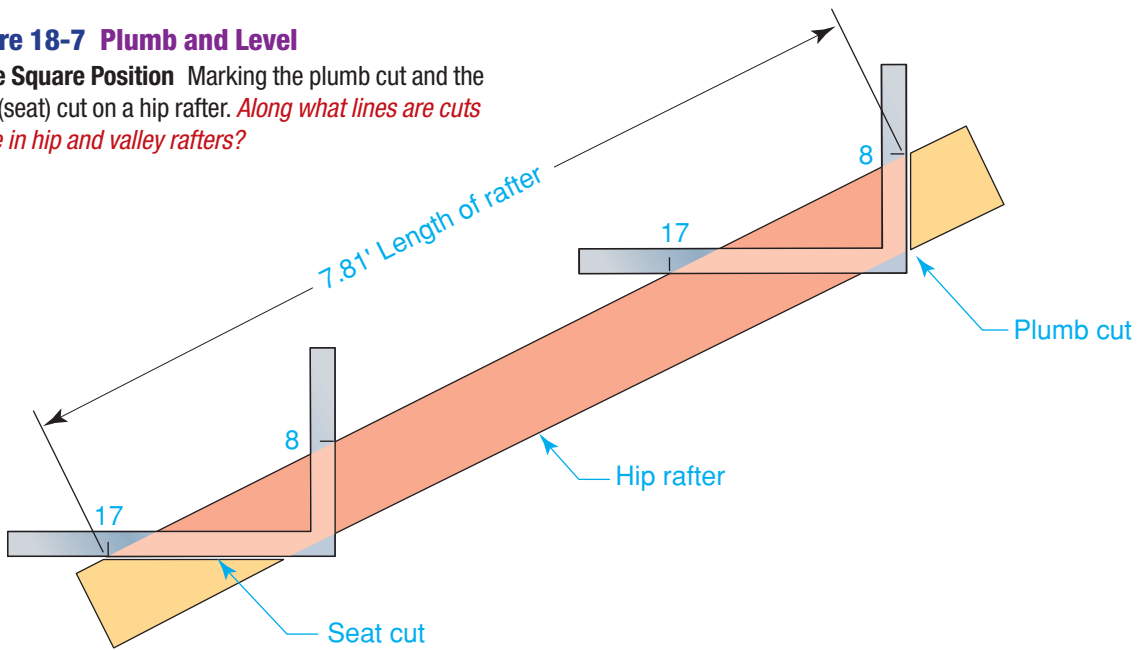
### Plumb and Level Lines

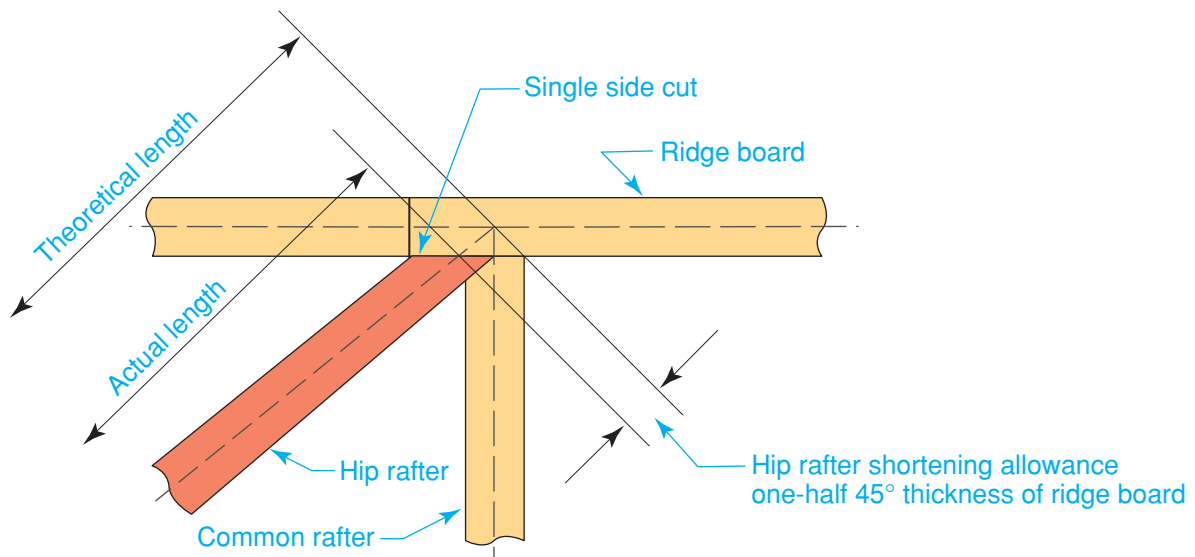
Cuts made in a hip or valley rafter are made either along *plumb lines* (plumb cuts) or along *level lines* (level cuts), as shown in **Figure 18-7**. To lay out the plumb and level cuts of the hip or valley rafters, set off 17" on the *blade* (the long leg) of the framing square. On the *tongue* of the square (the short leg), set off the rise per foot of common rafter run. A line drawn along the tongue then indicates the plumb cut. A line drawn along the blade indicates the level cut. When the completed rafter is to rest on its level cut, the level cut is sometimes referred to as the **seat cut**.

### Shortening Allowance

The theoretical length of a hip rafter does not take into account the thickness of the ridge board. This must be allowed for by deducting the shortening allowance. The *shortening allowance* for a hip rafter depends on the way the rafter is cut to fit against the other structural members. Some carpenters make a single side cut, as in **Figure 18-8**. Other carpenters prefer a double side cut, as in **Figure 18-9**.

**Figure 18-7 Plumb and Level**  
**Same Square Position** Marking the plumb cut and the level (seat) cut on a hip rafter. *Along what lines are cuts made in hip and valley rafters?*





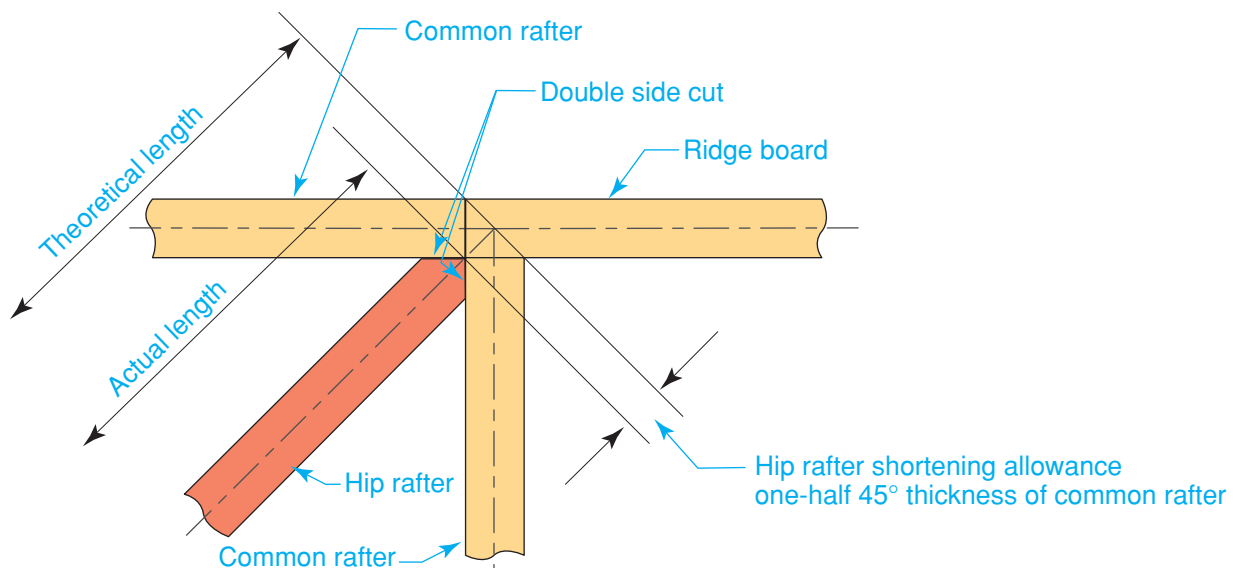
**Figure 18-8 Single Side Cut**

**One Cut** A hip rafter framed against the ridge board calls for a single side cut. Depending on the layout of common rafters, the end common rafter may require a 45° plumb cut so that it will fit against the side of the hip rafter.

If the ridge board is a different thickness than the rafters, the shortening allowance must take this into account. If the hip rafter is framed against the ridge board, using a single side cut, the shortening allowance is one-half the 45° thickness of the ridge board. (The 45° thickness is the length of a line laid at 45° across the thickness of the board.) However, if the hip rafter is framed against

the common rafters, using a double side cut, the shortening allowance is one-half the 45° thickness of a common rafter.

To lay out the shortening allowance, set the tongue of the framing square along the rafter's plumb line. Measure the shortening allowance along the blade and mark this point, as shown in Step 1 of **Figure 18-10** on page 510. Then slide the square sideways



**Figure 18-9 Double Side Cut**

**Two Cuts** A hip rafter framed against the ridge-end common rafters requires a double side cut.

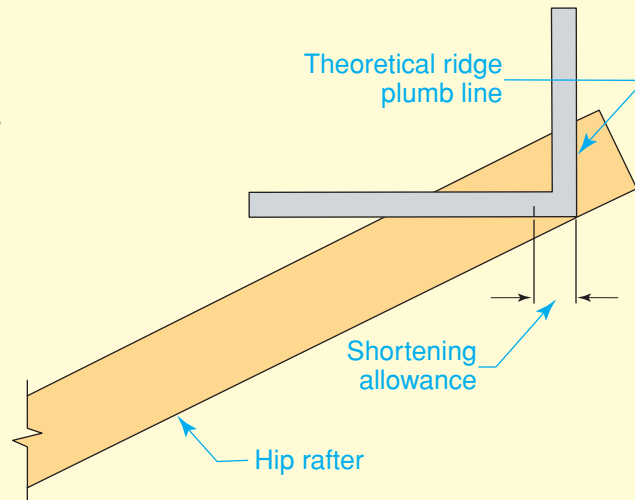


## Figure 18-10 Shortening Allowance for Hip Rafter

**Laying Out Shortening Allowance** Start by setting the tongue along the plumb line.

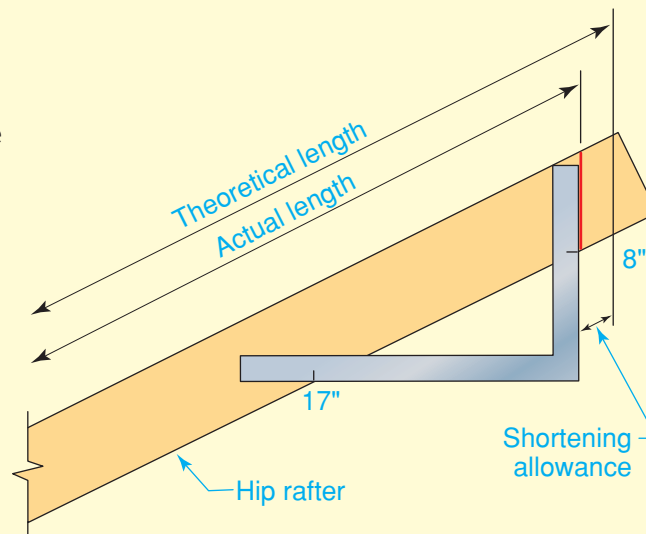
### Step 1

Place the tongue of the square along the plumb line and measure the shortening allowance along the blade of the square (level line).



### Step 2

Set the square to the cut of the roof (8" unit rise for this example) with the tongue on the shortening allowance mark. Draw the actual ridge plumb line along the edge of the tongue.



until the tongue is lined up with the mark and draw another plumb line, as shown in Step 2. This line marks the actual plumb cut for the rafter.

### Hip Rafter Tail Cut

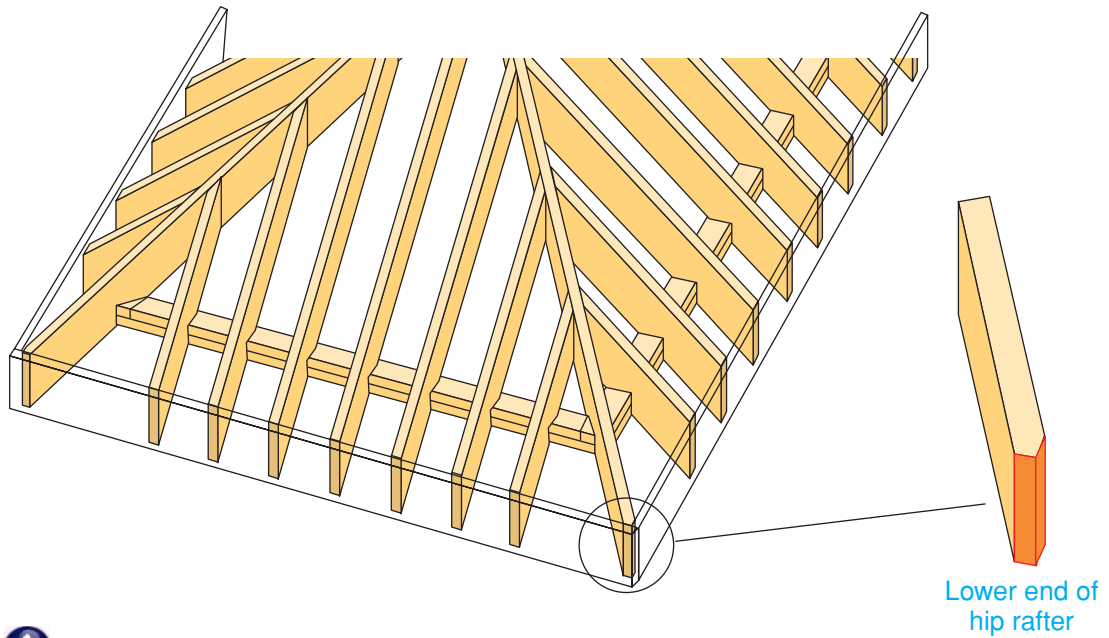
A common rafter tail has a single plumb cut at its lower end. A hip rafter tail, however, will butt against the corner of two intersecting planes, and requires two cuts. See **Figure 18-11**.

The face of each cut should be in the same plane as cuts on the ends of adjacent common

rafters. The steps for making a hip rafter tail cut are shown in **Figure 18-12** on page 511 and **Figure 18-13** and **Figure 18-14** on page 512.

### Overhang

The amount of rafter overhang has a **significant** impact on the appearance of a house. The amount is often related to the climate. Deep overhangs protect walls from rain or shade them from intense sun. Shallow overhangs (or no overhangs) help to prevent ice dams caused when melted snow refreezes



**Figure 18-11 Hip Tail Cut**

**Fit for Fascia** The end of the hip rafter has a double side cut so that the fascia (installed later) will fit properly.

## Step-by-Step Application

**Making Hip Rafter Side Cuts** The end of a hip rafter joins the ridge board (or the ends of the common rafters) at an angle. The cut is called a *side cut* or sometimes a *cheek cut* (see Figures 18-8 and 18-9 on page 509). The side cut may be laid out in one of two ways.

### Method 1

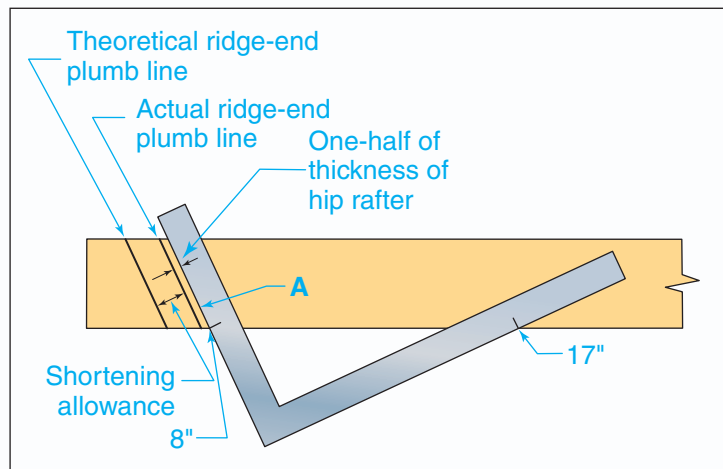
**Step 1** Place the tongue of the framing square along the actual ridge board plumb cut line, as shown in Figure 18-12. Measure one-half the thickness of the hip rafter along the blade (level line) and place a mark.

**Step 2** Shift the tongue to the mark, set the square to the cut of the rafter (17" and 8" in this example), and draw a plumb line (A).

**Step 3** Turn the rafter on edge and draw a centerline along its edge, indicated by the red arrow in Figure 18-13 on page 512.

**Step 4** Extend the plumb lines from the face of the rafter to intersect the centerline at 90°. The side cut line is drawn from line A through the intersection of the centerline and the actual ridge-end plumb line.

*Note:* A hip rafter that will be framed against the ridge board has only a single side cut. A hip rafter framed against the ends of the common rafters requires a double side cut.



**Figure 18-12 Drawing a Plumb Line**

**Step 5** The tail of the rafter must have a double side cut at the same angle, but in the reverse direction, to allow attachment of the fascia board, as in Figure 18-11.

(continued)

## Step-by-Step Application

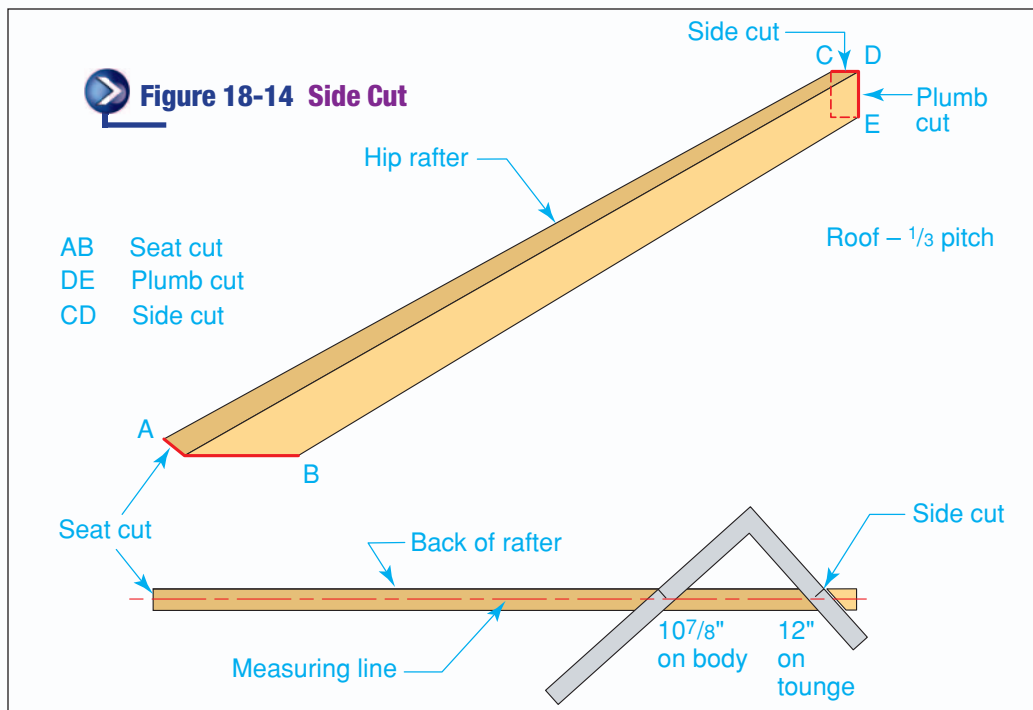
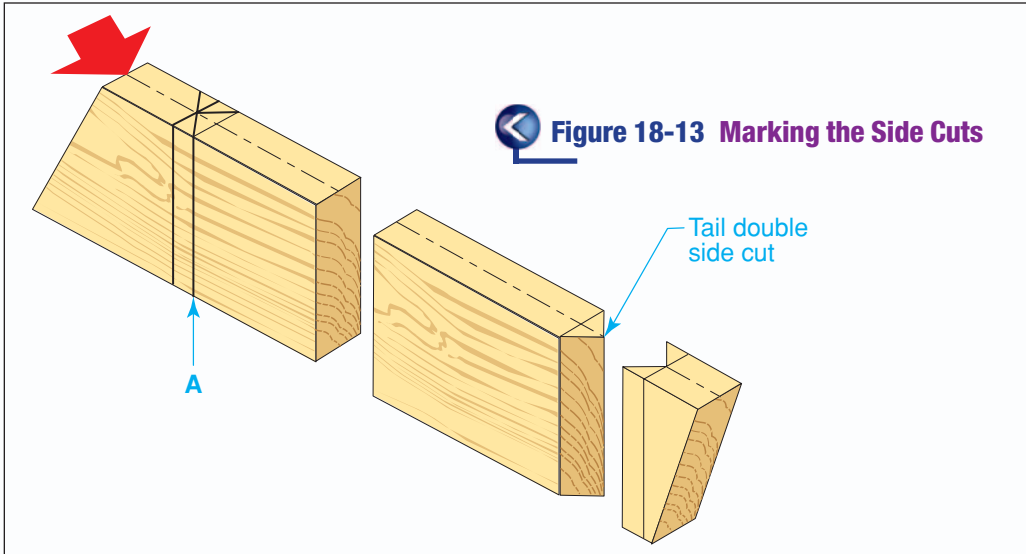
**Method 2** For this method, refer to the rafter table on the framing square.

**Step 1** On the framing square, the bottom line of the table is headed "Side Cut Hip or Valley Use" (see Figure 18-6B on page 507). Follow this line over to the column under the number 8 (for a unit rise of 8"). The number shown is  $10\frac{7}{8}$ .

**Step 2** Place the framing square face up on the rafter edge, with the tongue on the ridge-end plumb cut line (see line A in Figure 18-13).

**Step 3** Set the square to a cut of  $10\frac{7}{8}$ " on the blade and 12" on the tongue, as shown in Figure 18-14. Draw the side cut angle along the tongue.

To determine the overhang, see the Step-by-Step Application on page 513.



Go to [glencoe.com](http://glencoe.com) for this book's OLC for additional step-by-step procedures, applications, and certification practice.

## Step-by-Step Application

**Determining the Overhang** As with a common rafter overhang, a hip or valley rafter overhang is figured as if it were a separate rafter. The run of this overhang, however, is not the same as the run of a common rafter overhang in the same roof, as shown in Figure 18-15. Instead, the run of a hip or valley overhang is the hypotenuse of a right triangle whose shorter sides are each equal to the run of a common rafter overhang. If the run of the common rafter overhang is 2' for a roof with an 8" unit rise, the length of the hip or valley rafter tail is figured as follows.

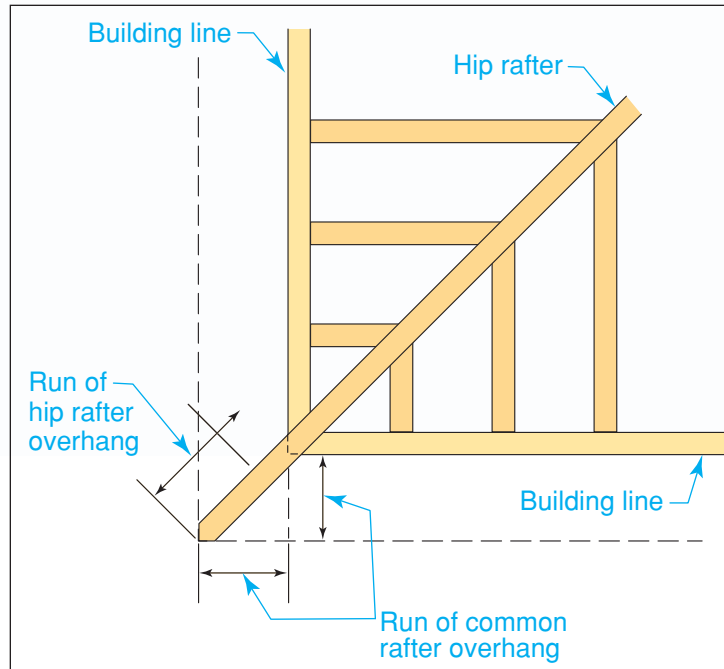
**Step 1** Find the unit length of the hip or valley rafter on the framing square (see Figure 18-6B). For this roof, the unit length is 18.76".

**Step 2** Multiply the unit length of the hip or valley rafter by the run of the common rafter overhang:  $18.76''$  (unit length of hip or valley rafter)  $\times$  2 (feet of run in common rafter overhang) =  $37.52''$ , or  $37\frac{1}{2}''$ .

**Step 3** Add this product to the theoretical rafter length.

The overhang may also be stepped off as described in Chapter 17 for a common rafter. When stepping off the length of the overhang, set the 17" mark on the blade even with the edge of the rafter. Set the unit rise, whatever it might be, on the tongue, even with the same rafter edge.

 Go to [glencoe.com](http://glencoe.com) for this book's OLC for additional step-by-step procedures, applications, and certification practice.



 **Figure 18-15 Run of a Hip Rafter Overhang**

at the overhang. Deep overhangs are also typical of certain architectural styles, such as Arts and Crafts, Italianate, or Mission styles.

The parts of a hip rafter overhang are shown in Figure 18-15.

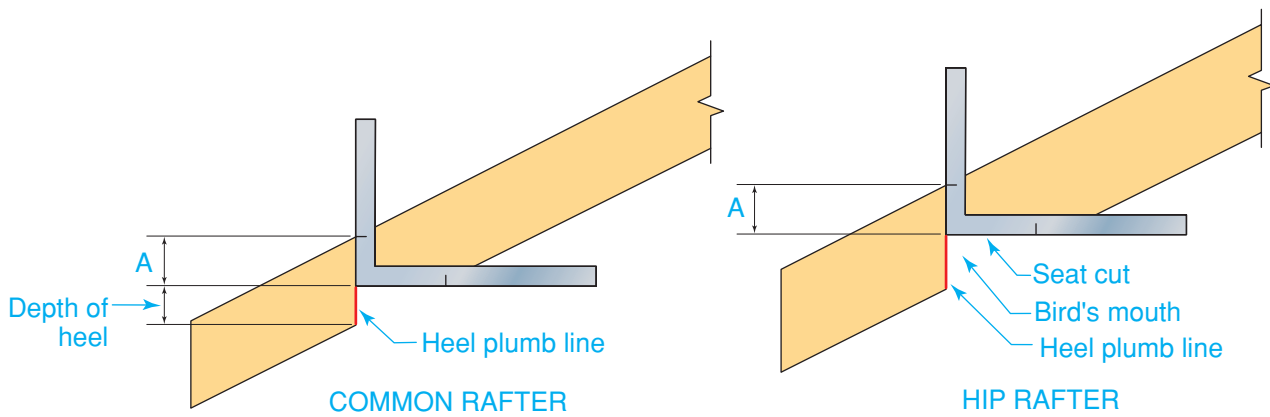
### Bird's Mouth

Laying out the bird's mouth for a hip rafter is much the same as for a common rafter. However, there are a couple of things to remember. When you lay out the plumb (heel cut) and level (seat cut) lines on a hip rafter, set the body of the square at 17" and the tongue to the unit rise (depending on the roof pitch; see Figure 18-7 on page 508). When laying out the depth of the heel, measure along the heel plumb line down from the top edge of

the rafter, as shown in Figure 18-16 on page 514. This must be done because the hip rafters are usually wider than common rafters, and the distance should be the same on both. An additional step must also be taken to **ensure** that the top edge of a hip rafter will be in alignment with jack rafters. In this step, the hip rafter must either be *backed* or *dropped*.

### Backing or Dropping a Hip Rafter

If the top edge of the hip rafter extends slightly above the upper ends of the jack rafters, it will interfere with the sheathing. **Backing the hip** means to bevel the upper edge of the hip rafter, as shown in Figure 18-17 on page 514. This allows the roof sheathing to be installed without hitting the



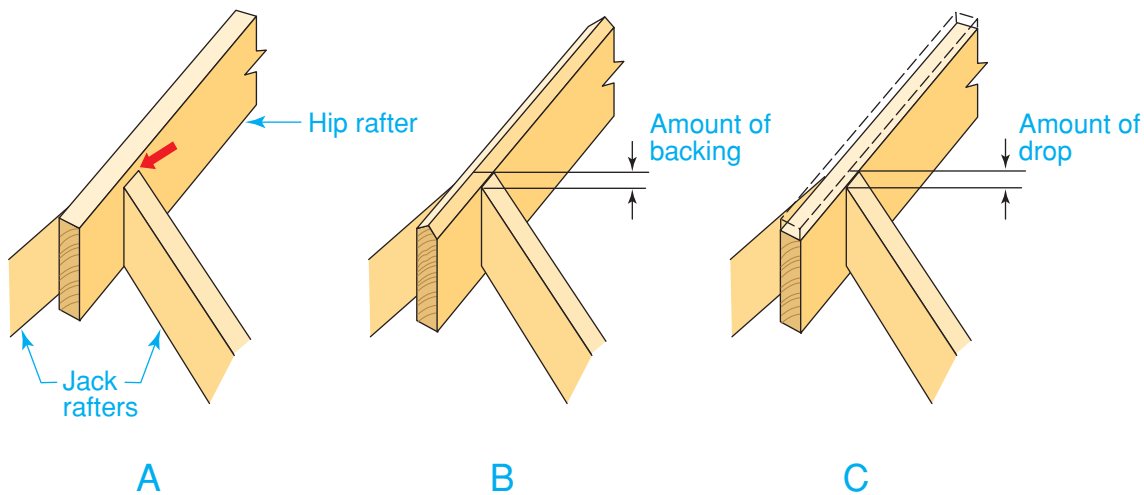
**Figure 18-16 Layout of the Bird's Mouth**

**Measure Down** When laying out the bird's mouth on a hip rafter, measure down from the top edge. Dimension A must be the same for both common and hip rafters so that the tops of all the rafters will be level for the application of sheathing.

corners of the hip rafter. **Dropping the hip** means to deepen the bird's mouth so as to bring the top edge of the hip rafter in line with the upper ends of the jacks.

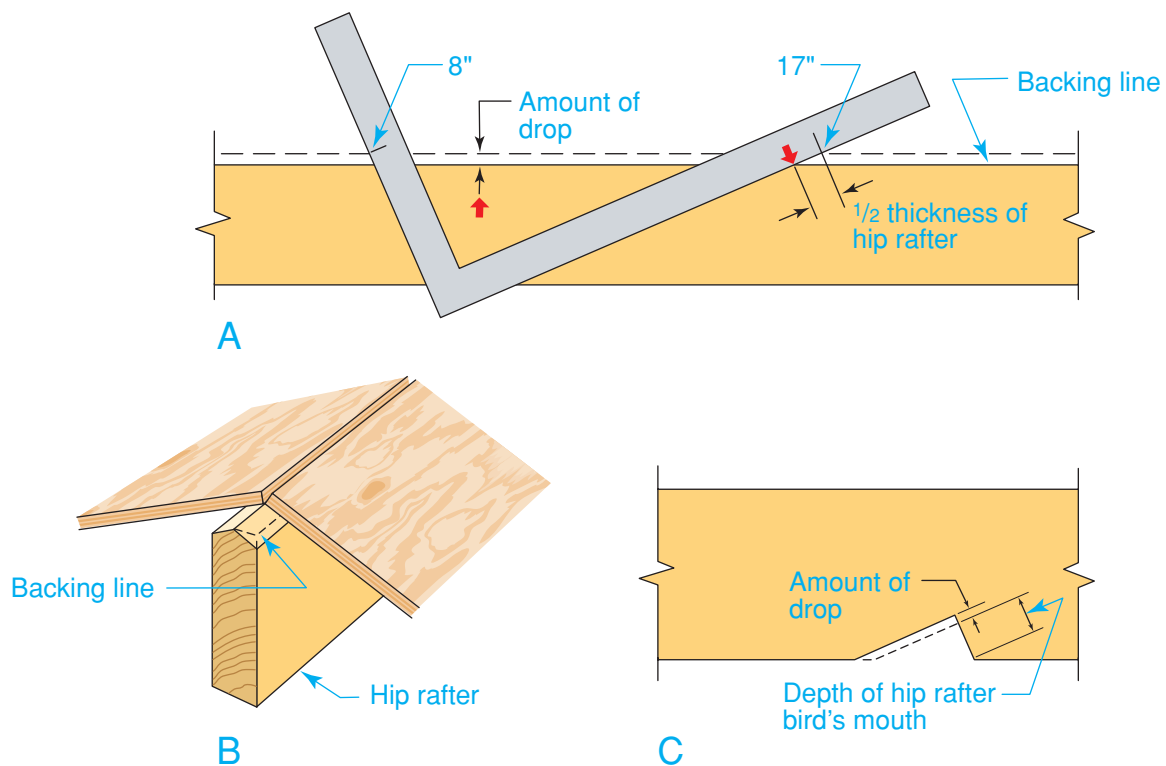
The amount of backing or drop required is calculated as shown in **Figure 18-18A**. Set the framing square to the cut of the rafter (8" and 17" in this example) on the upper edge. Measure off one-half the thickness of the rafter from the edge along the blade. For

backing, a line drawn through this mark and parallel to the edge will indicate the bevel angle, as in **Figure 18-18B**. For dropping, the perpendicular distance between the line and the edge of the rafter will be the amount of drop. This is the amount by which the depth of the hip rafter bird's mouth should exceed the depth of the common rafter bird's mouth, as in **Figure 18-18C**.



**Figure 18-17 Backing or Dropping a Hip**

**Two Solutions** A. The top of a hip rafter may extend above the upper ends of the jack rafters. B. Backing the hip rafter. C. Dropping the hip rafter.



**Figure 18-18 Determining Backing or Drop**  
**Fine-Tuning the Rafter** **A.** Determining the amount of backing or drop. **B.** Bevel angle for backing the rafter. **C.** Deepening the bird's mouth for dropping the rafter.

## Section 18.1 Assessment

### After You Read: Self-Check

1. What is the main difference between a hip rafter and valley rafter?
2. What does *backing the hip* mean?
3. What is the shortening allowance for a hip rafter when the ridge end is framed against the ridge board?
4. What is the amount of overhang often related to?

### Academic Integration: Mathematics

5. **Explaining Unit Run** The unit run of a hip rafter is 17" and the unit run of a common rafter is 12". Explain how to calculate the hip rafter's unit run using an equation.

**Math Concept** The unit run of a rafter is also the hypotenuse of a right triangle. The Pythagorean theorem is an equation that shows the relationships of the lengths of the sides of a right triangle.

**Step 1:** Review the Pythagorean theorem.

**Step 2:** Substitute known values into the formula.

**Step 3:** State the formula and tell how to use the Pythagorean theorem to find the unit run.

Go to [glencoe.com](http://glencoe.com) for this book's OLC to check your answers.

# Valley Rafters

## Valley Rafter Layout

*Could an addition roof have a span and a pitch different from the main roof?*

A valley rafter is necessary where two roofs intersect. It is also needed at the intersection of a dormer roof with the main roof. Most intersecting roofs that contain valley rafters each have the same pitch. The valley rafters always run at a 45° angle to the building perimeter and the ridge boards.

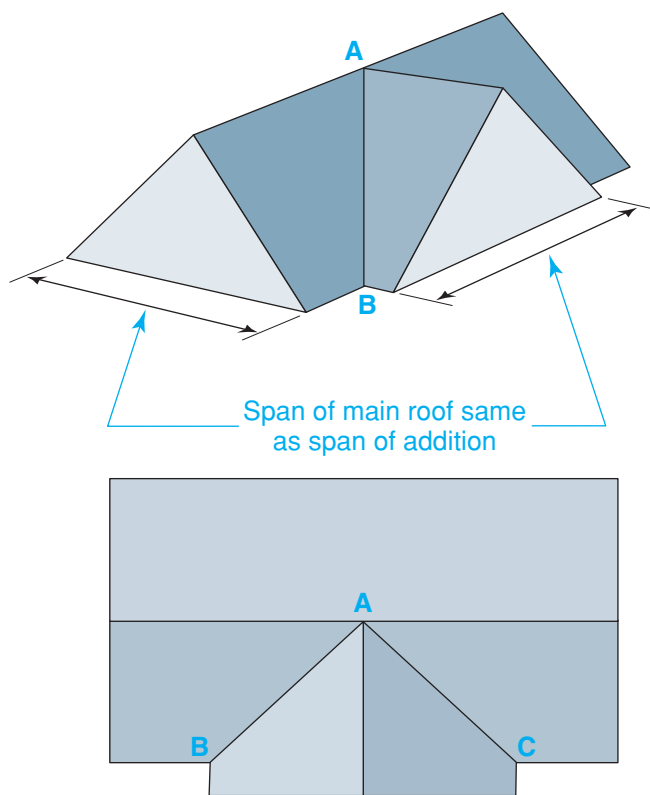
### Equal and Unequal Spans

A roof that intersects the main roof is sometimes referred to as an **addition**. This is because the main roof is generally framed

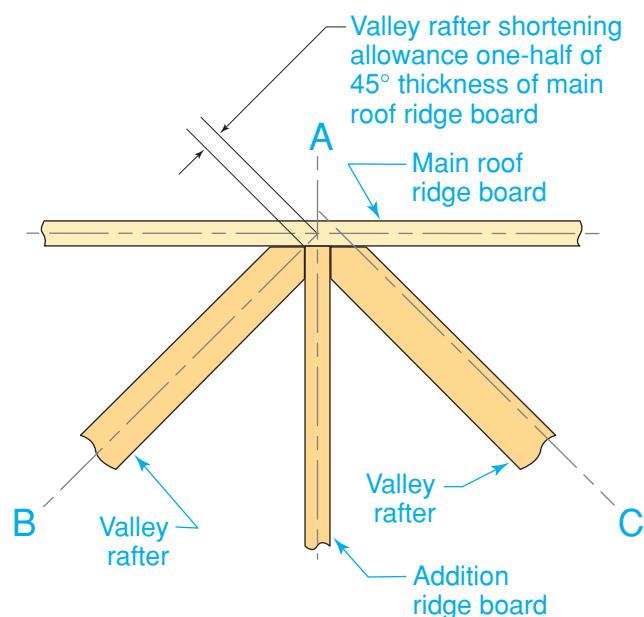
first, and the intersecting roof is then added. Another reason is that a common method for expanding an existing house is to build an addition that intersects the main house.

**Equal-Span Roof** In equal-span framing, the span, or width, of the addition is the same as the span of the main roof, as shown in **Figure 18-19**. When the pitch of the addition's roof is the same as the pitch of the main roof, the ridges of both roofs are at the same height.

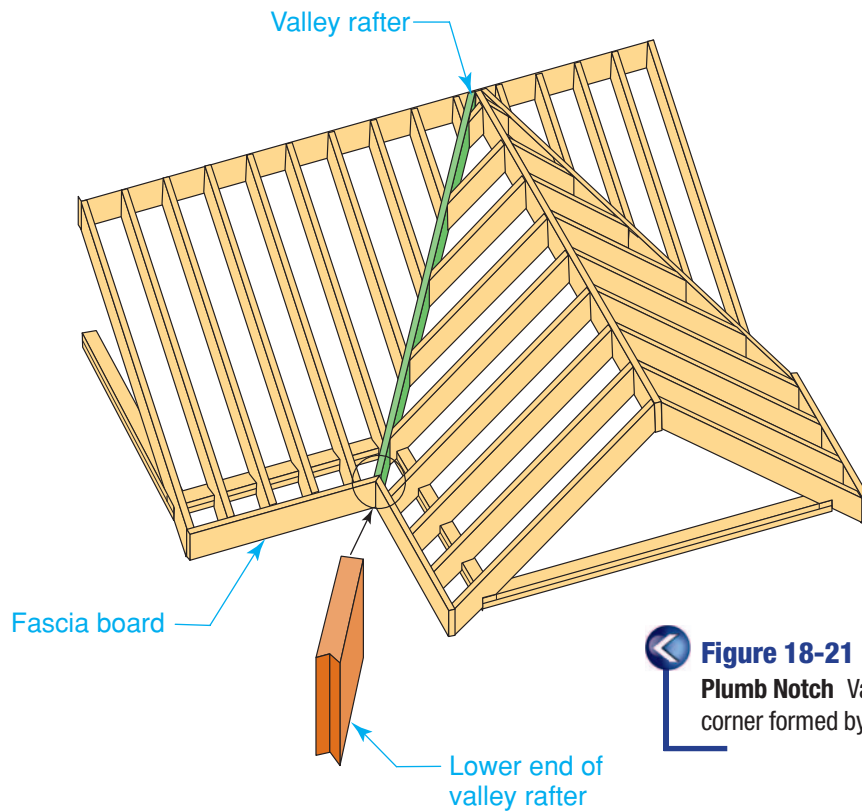
The total run of a valley rafter (indicated by AB or AC in **Figure 18-20**) is the hypotenuse of a right triangle. Each shorter side of the triangle is equal to the total run of a common rafter in the main roof. The unit run of a valley rafter is therefore 16.97", the same as the unit run for a hip rafter. Figuring the length of an equal-span valley rafter is thus the same as figuring the length of a hip rafter.



**Figure 18-19 An Equal-Span Roof**  
**A Common Addition** A roof with an equal-span addition.



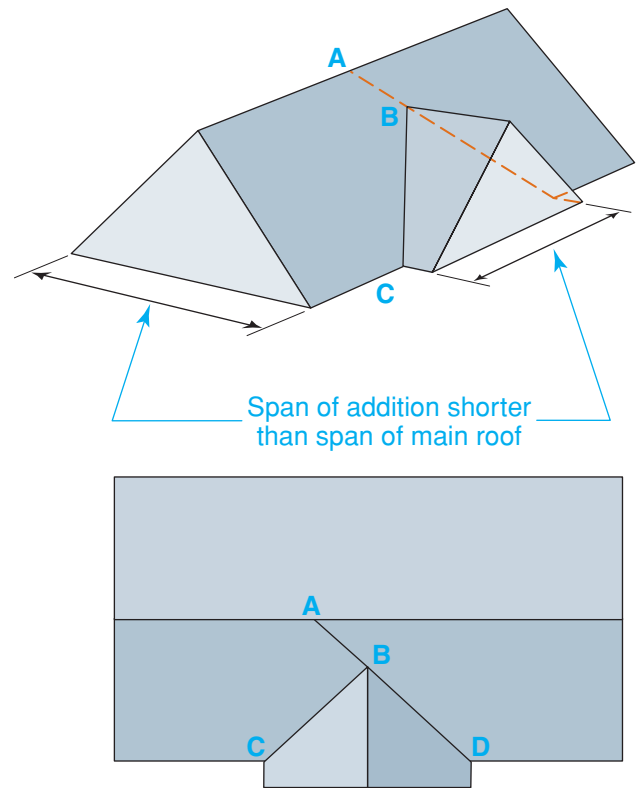
**Figure 18-20 Ridge-End Shortening Allowance**  
**Allow for the Ridge** Ridge-end shortening allowance for an equal-span addition valley.



**Figure 18-21 Valley Rafter Tail**  
**Plumb Notch** Valley rafter framing. Notice the inside corner formed by the fascia boards.

The shortening allowance for an equal-span addition valley rafter is one-half the 45° thickness of the ridge board, as in Figure 18-20. Side cuts are laid out as they are for a hip rafter. The valley rafter tail has a double side cut, like the hip rafter tail, but running in the opposite direction, as shown in Figure 18-21. This is because the tail cut must form an inside rather than an outside corner. The bird's mouth and the overhang, if any, are figured just as they are for a hip rafter.

**Unequal-Span Roof** A single full-length valley rafter (AD in Figure 18-22) is framed between the top plate and the ridge board. A shorter valley rafter (BC in Figure 18-22) is then framed to the longer one at a 90° angle. The total run of the longer valley rafter is the hypotenuse of a right triangle, the shorter sides of which are each equal to the total run of a common rafter in the main roof. The total run of the shorter valley rafter is the hypotenuse of a right triangle with shorter sides each equal to the total run of a common rafter in



**Figure 18-22 An Unequal-Span Roof**  
**One Method** An addition with a span shorter than the main roof span. This addition is formed with a long and a short valley rafter.



the addition. The total run of a common rafter in the main roof is equal to one-half the span of the main roof. The total run of a common rafter in the addition is equal to one-half the span of the addition.

## Determining the Length of a Valley Rafter

When the total run of any rafter is known, the theoretical length can be found by multiplying the total run by the unit length. Suppose, for example, that the addition shown in Figure 18-22 has a span of 30' and that the unit rise of a common rafter in the addition is 9". The rafter table in Figure 18-6B on page 507 shows that the unit length for a valley rafter in a roof with a common rafter unit rise of 9" is 19.21".

To find the theoretical length of the valley rafter, multiply its unit length by the total run of a common rafter in the roof to which it belongs. (The total run of a common rafter is equal to one-half the span.) Therefore, the length of the longer valley rafter in Figure 18-22

on page 517 would be 19.21" times one-half the span of the main roof. The length of the shorter valley rafter would be 19.21" times one-half the span of the addition. Because one-half the span of the addition is 15', the length of the shorter valley rafter is  $19.21" \times 15$ , or 288.15". Converted to feet, this is 24.01'.

The shortening allowances for the long and short valley rafters are shown in **Figure 18-23**. Note that the long valley rafter has a single side cut for framing to the main roof ridge board. The short valley rafter is cut square for framing to the long valley rafter.



**Explain** How can you determine the theoretical length of a valley rafter?

## Framing Dormers

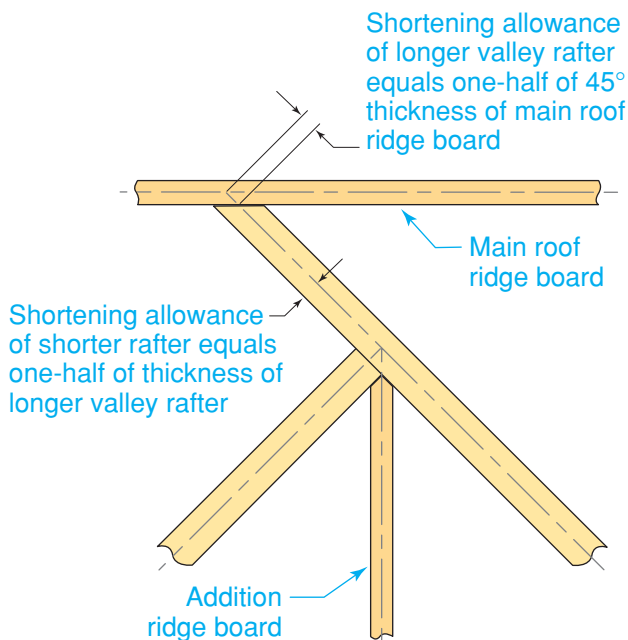
### What do dormers do?

Dormers are often added to a roof. A **dormer** is a roofed projection from a slanted roof. In addition to a roof, dormers typically include a window. They add architectural interest, allow natural light to reach the top floor, and provide more headroom beneath steep slopes. In many respects, framing some kinds of dormers is like framing a small house with a small roof.

### Dormers Without Side Walls

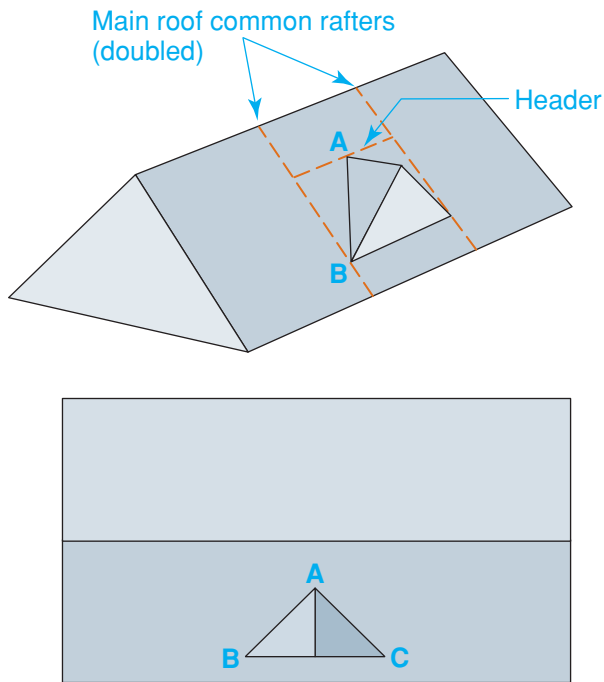
When constructing a gable dormer without side walls, the dormer ridge board is fastened to a header. The header is supported on each end by doubled common rafters in the main roof, as in **Figure 18-24**. The valley rafters are framed between this header and a lower header. The total run of a valley rafter is the hypotenuse of a right triangle, the shorter sides of which are each equal to the total run of a common rafter in the dormer.

The arrangement and names of framing members in this type of dormer framing are shown in **Figure 18-25**. Note that the upper edges of the headers must be beveled to the pitch of the main roof.



**Figure 18-23 Long and Short Valley Rafter Shortening Allowances**

**Long and Short** Long and short valley rafter shortening allowances.



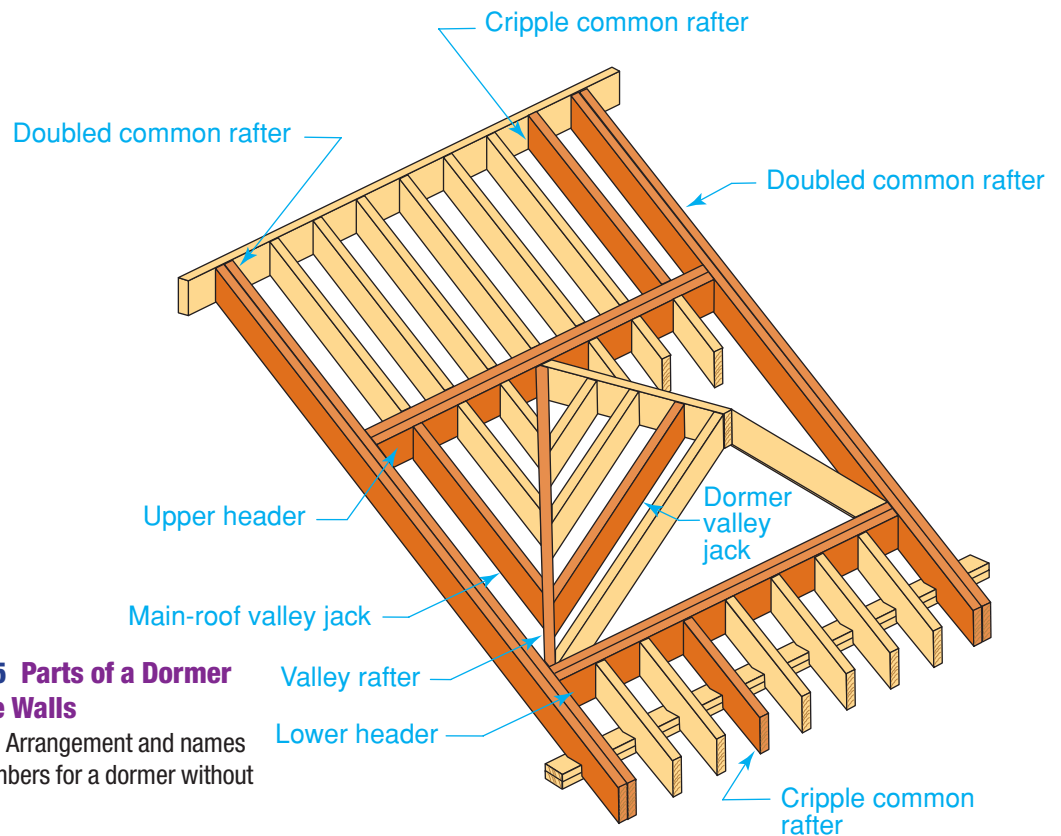
**Figure 18-24 A Dormer Without Side Walls**  
**All Roof** Framing a dormer without side walls.

In this method, the shortening allowance for the upper end of a valley rafter is one-half the 45° thickness of the inside member (the member closest to the dormer) in the doubled upper header. For example, see **Figure 18-26** on page 520. The shortening allowance for the lower end is one-half the 45° thickness of the inside member in the doubled common rafter. Each valley rafter has a double side cut at the upper and lower ends.

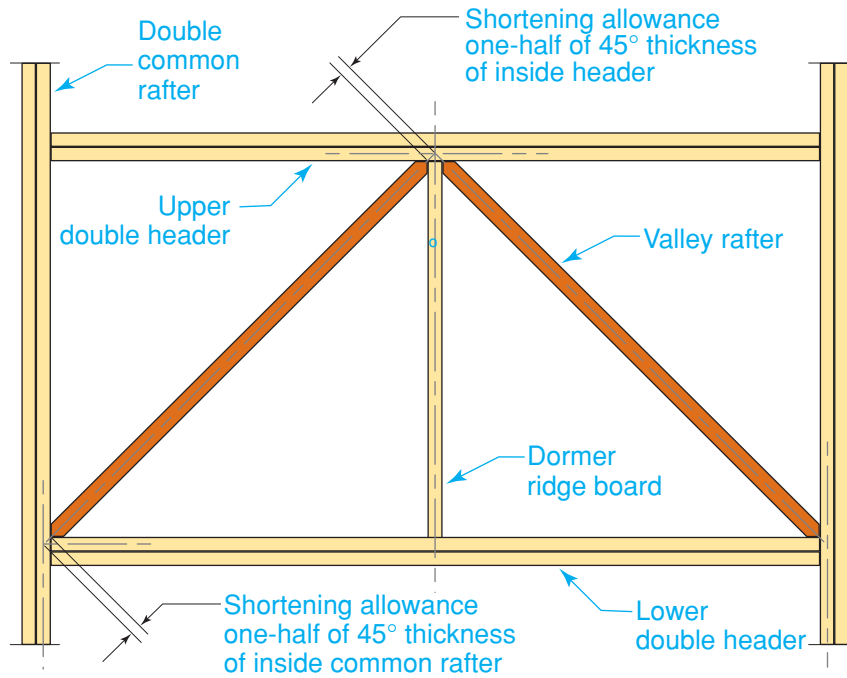
### Dormers With Side Walls

A method of framing a gable dormer with side walls is shown in **Figure 18-27** on page 520. This type of dormer is sometimes referred to as a **doghouse dormer** because of its shape. The total run of the valley rafter is the hypotenuse of a right triangle. The shorter sides of the triangle are each equal to the total run of a common rafter in the dormer.

Figure the lengths of the dormer corner posts and side studs just as you would the lengths of gable-end studs (see Chapter 19,



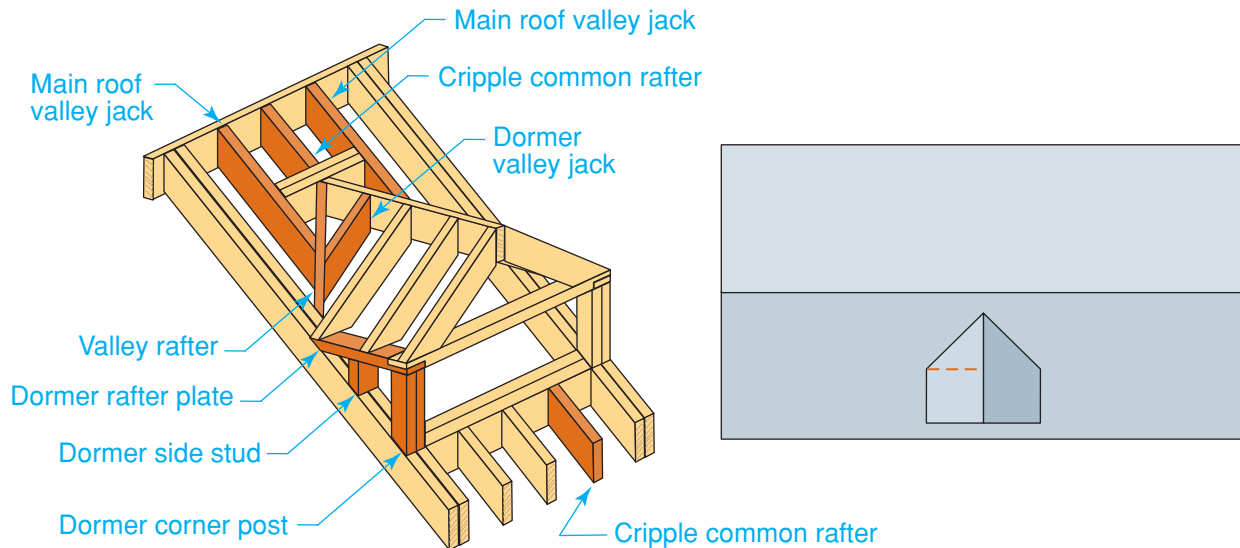
**Figure 18-25 Parts of a Dormer Without Side Walls**  
**Key Elements** Arrangement and names of framing members for a dormer without side walls.



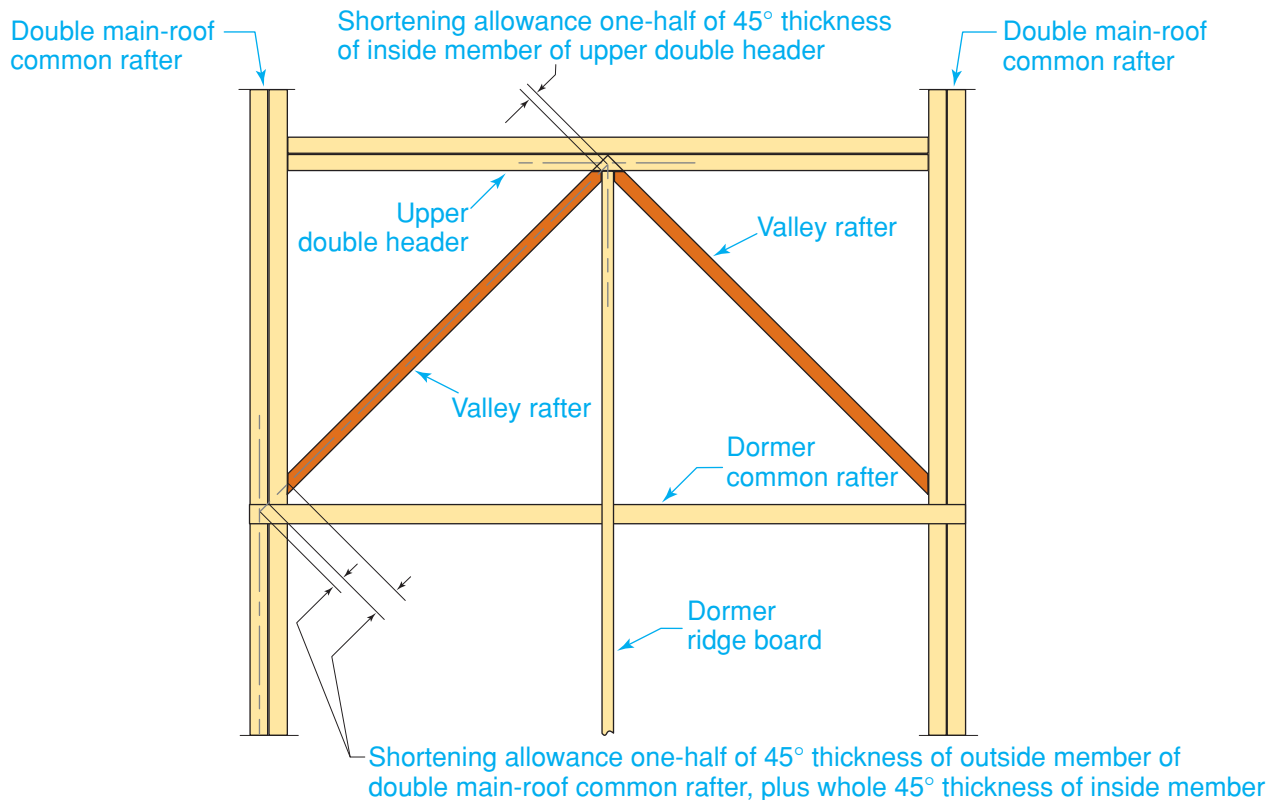
**Figure 18-26 Valley Rafter Shortening: Dormer With Side Walls**  
**A Rigid Structure** Valley rafter shortening allowances for a dormer without side walls.

“Roof Assembly & Sheathing”). Lay out the lower-end cutoff angle by setting the square to the pitch of the main roof. The valley rafter shortening allowances for this method of framing are shown in **Figure 18-28**.

Another type of dormer with side walls is the *shed dormer*. This type is usually tied into a gable roof. This dormer is discussed in detail in Chapter 19, “Roof Assembly & Sheathing.”



**Figure 18-27 A Gable Dormer With Side Walls**  
**Key Elements** Framing a gable dormer with side walls.



**Figure 18-28 Valley Rafter Shortening**  
**Extra Steps** Valley rafter shortening allowances for a dormer with side walls.

## Section 18.2 Assessment

### **After You Read: Self-Check**

1. Describe an equal-span roof.
2. When the pitch and the span of an addition roof are the same as the pitch and span of the main roof, how are the ridge boards positioned in relation to each other?
3. When framing a gable dormer without side walls, what is the dormer's ridge board attached to?
4. When framing a doghouse dormer, how is the run of a valley rafter determined?

### **Academic Integration: Mathematics**

5. **Using Tables** Use the framing square to find the length of the rafter for the two problems below. Round answers to the nearest  $\frac{1}{16}$ ".
  - A. Run = 13'; Slope =  $\frac{4}{12}$
  - B. Run = 15'; Slope =  $\frac{5}{12}$

**Math Concept** The first line on a framing square will give you the length of a common rafter. For example, for a slope that rises 9" for every foot of run, the first line of the table tells you that the length of the common rafter for every foot of run is 15. You would multiply this by the total run to find the length of the common rafter (the hypotenuse).

Go to [glencoe.com](http://glencoe.com) for this book's OLC to check your answers.

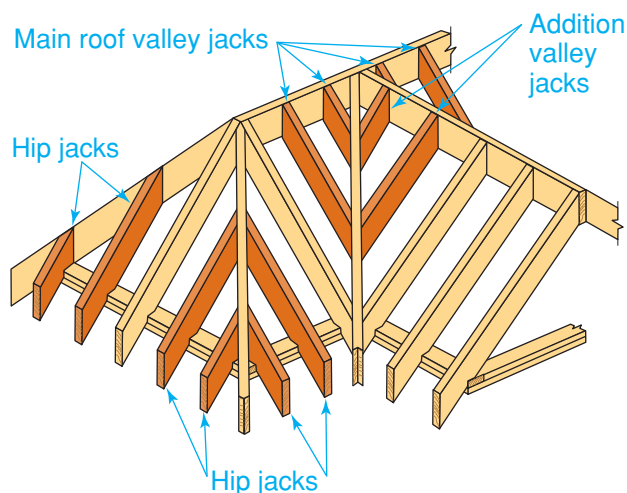
# Jack Rafters

## Jack Rafter Layout

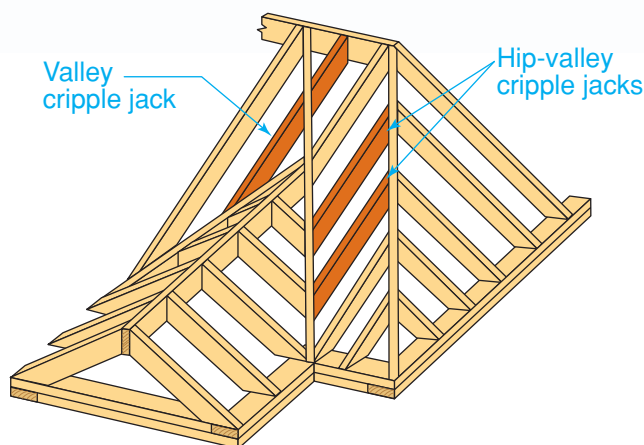
*How does knowing the common difference save a carpenter time?*

A *jack rafter* is a shortened common rafter that may be framed to a hip rafter, a valley rafter, or both. This means that in an equal-span framing situation, the unit rise of a jack rafter is always the same as the unit rise of a common rafter.

There are several types of jack rafters, as shown in **Figure 18-29**. A *hip jack rafter* extends from a hip rafter to a rafter plate. A *valley jack rafter* extends from a valley rafter to a ridge board. A *cripple jack rafter* does not contact either a plate or a ridge board. There are two kinds of cripple jack rafters. The *valley cripple jack* extends between two valley rafters in the long-and-short-valley-rafter method of addition framing. The *hip valley cripple jack* extends from a hip rafter to a valley rafter, as shown in **Figure 18-30**.



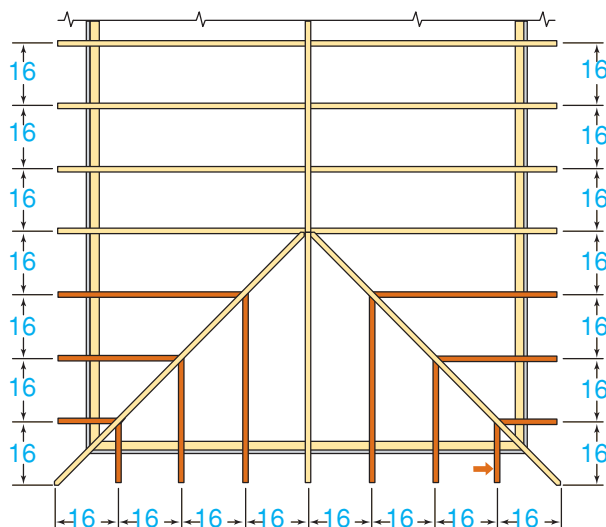
**Figure 18-29 Jack Rafters**  
**Basic Elements** Hip and valley jack rafters.



**Figure 18-30 Other Types of Jack Rafters**  
**Basic Elements** Valley cripple jack and hip-valley cripple jacks.

## Lengths of Hip Jack Rafters

A roof framing plan for a series of hip jack rafters is shown in **Figure 18-31**. The jacks are always on the same spacing as the common rafters. The spacing in this instance is



**Figure 18-31 Framing Plan**  
**How the Parts Fit** A framing plan for a roof with hip jack rafters.

16" on center. You can see in the lower-right part of the plan that the total run of the shortest jack is also 16".

Suppose the unit rise of a common rafter in this roof is 8" per 12" of run. The hip jacks have the same unit rise as a common rafter. The unit length of a common rafter is the hypotenuse of a right triangle with the unit run as base and the unit rise as altitude. The unit length of a hip jack rafter in the example is therefore the square root of  $144 + 64$ , or 14.42. This means that a hip jack is 14.42" long for every 12" of run.

The theoretical total length of the shortest jack rafter (X) can now be calculated using this formula:

$$\frac{12" \text{ (unit run)}}{4.42" \text{ (unit length)}} = \frac{16" \text{ (total run)}}{X \text{ (total length)}}$$

$$X = 19.23"$$

This is the length of the shortest hip jack when the jacks are spaced 16" on center and the unit rise is 8". It is also the *common difference* in length between one jack and the next. This means that the next hip jack will be  $2 \times 19.23"$  long, the one after that  $3 \times 19.23"$  long, and so on.

The common difference for hip jacks spaced 16" on center and for hip jacks spaced 24" on center can also be found in the rafter table on a framing square (see Figure 18-6B

## Builder's Tip

**MAKING REPETITIVE CUTS** When making repetitive angled cuts on roof framing lumber, a radial-arm saw or compound-miter saw can improve the speed and accuracy of your work. Once you have determined the proper angle, set a stop at one end of the saw's outfeed table. All stock resting against this stop will then be cut to the exact same length. Do not let sawdust collect around the stop. It will affect the cut length.

on page 507). For example, the third row of the table reads "Difference in Length of Jacks 16 Inches Centers." Follow this row to the column headed 8 (for a unit rise of 8") to find the length of the first jack rafter and the common difference, which is  $19\frac{1}{4}$ .

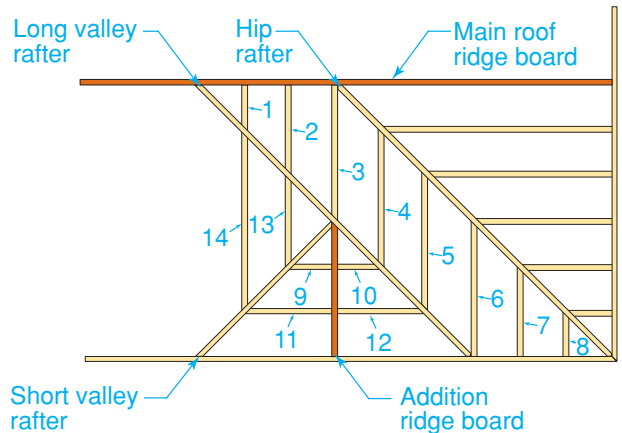
## Lengths of Valley Jacks and Cripple Jacks

The best way to figure the total lengths of valley jacks and cripple jacks is to lay out a roof framing plan. Part of a framing plan for a main hip roof with a long-and-short-valley-rafter gable addition is shown in

**Figure 18-32.**

By studying the plan, you can figure the total lengths of the valley jacks and cripple jacks as follows:

- The run of valley jack No. 1 is the same as the run of hip jack No. 8, which is the shortest hip jack. The length of valley jack No. 1 is therefore equal to the common difference between jacks.
- The run of valley jack No. 2 is the same as the run of hip jack No. 7. The length is therefore twice the common difference between jacks.
- The run of valley jack No. 3 is the same as the run of hip jack No. 6. The length



**Figure 18-32 Framing Plan with Gable Addition**

**Jack Layout** Jack rafter framing plan for a hip roof with a gable addition.

is therefore three times the common difference between jacks.

- The run of hip-valley cripples No. 4 and No. 5 is the same as the run of valley jack No. 3. The length of these rafters is thus the same as the length of No. 3.
- The run of valley jacks No. 9 and No. 10 is equal to the spacing of jacks on center. Therefore, the length of each of these jacks is equal to the common difference between jacks. The run of valley jacks No. 11 and No. 12 is twice the run of valley jacks No. 9 and No. 10. The length of each of these jacks is therefore twice the common difference between jacks.
- The run of valley cripple No. 13 is twice the spacing of jacks on center, and the length is therefore twice the common difference between jacks. The run of valley cripple No. 14 is twice the run of valley cripple No. 13, so the length is twice the common difference between jacks.

**Shortening Allowances** A hip jack rafter has a shortening allowance at the upper end equal to one-half the  $45^\circ$  thickness of the hip rafter, shown in **Figure 18-33**. A valley jack rafter has a shortening allowance at the upper end equal to one-half the thickness of the ridge board. It also has a shortening allowance at the lower end equal to one-half the  $45^\circ$  thickness of the valley rafter. A hip-valley cripple has a shortening allowance at the upper end equal to one-half the  $45^\circ$  thickness of the hip rafter, and another at the lower end equal to one-half the  $45^\circ$  thickness of the valley rafter. A valley cripple has a shortening allowance at the upper end equal to one-half the  $45^\circ$  thickness of the long valley rafter. At the lower end, the allowance is equal to one-half the  $45^\circ$  thickness of the short valley rafter.



**Explain** What are three types of jack rafters?

## Side Cuts

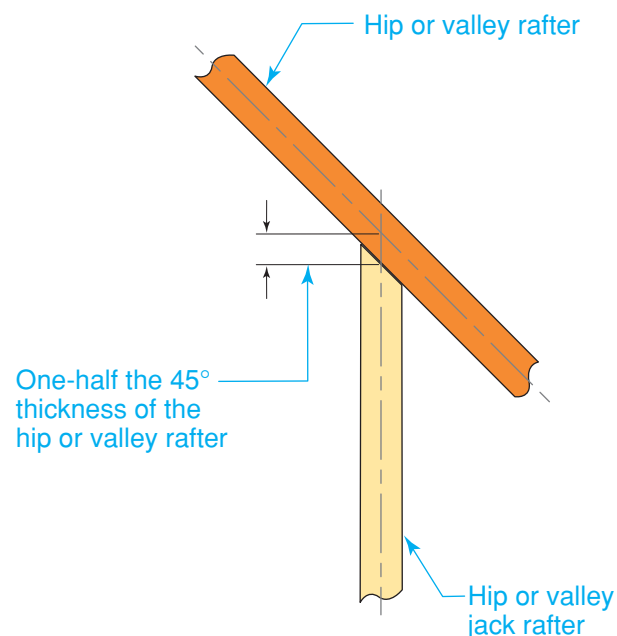
The side cut on a jack rafter can be laid out by the method shown in Figures 18-12 and 18-13 (on pages 511–512) for laying out the side cut on a hip rafter.

Another method is to use the rafter table on the framing square (see Figure 18-6B, page 507). Find the row headed “Side Cut of Jacks Use” and read across to the figure under the unit rise. For a unit rise of 8”, the figure given is 10. To lay out the side cut on a jack with this unit rise, set the square face-up on the edge of the rafter to 12” (the unit run) on the tongue and 10” on the blade. Draw the side cut line along the tongue (see Figure 18-14 on page 512).

A jack rafter pattern can also be used to save time, as shown in **Figure 18-34**.

## Bird’s Mouth and Overhang

A jack rafter is a shortened common rafter. Consequently, the bird’s mouth and overhang are laid out just as they are on a common rafter (see Chapter 17, “Basic Roof Framing”).

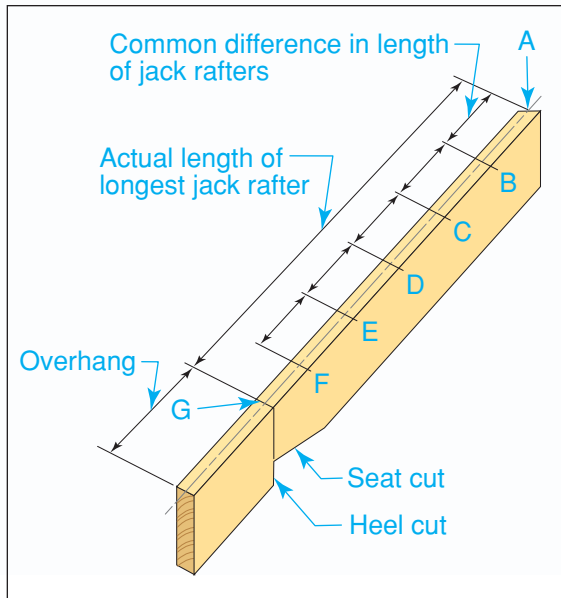


**Figure 18-33 Shortening Allowance for Hip or Valley Jack Rafters**

**Plan View** The shortening allowance for the upper end of a hip jack or the lower end of a valley jack rafter.

## Step-by-Step Application

**Cutting a Jack Rafter Pattern** Rather than lay out and mark each jack rafter individually, a pattern is used to save time. When all the rafters have been cut, the rafter used as a pattern becomes part of the roof frame.



**Step 1** Lay out and cut the longest jack rafter first, including the overhang, if there is one. Be careful to calculate and make all necessary allowances to determine the actual length.

**Step 2** Set the rafter in place on the building and check the fit of all the cuts. See that the spacing between the centers of the rafters is correct.

**Step 3** When everything is correct, use this rafter as a pattern. On the top edge of the rafter, measure down the center line from the ridge end a distance equal to the common difference measurement (found on the framing square rafter table). This is the length of the second-longest jack rafter.

**Step 4** Continue to mark the common difference measurements along the top edge until the lengths of all the jacks have been laid out, as shown in Figure 18-34.

**Step 5** Use the longest jack rafter (AG) as a pattern to lay out all the jack rafters. The second jack rafter is BG, the third jack rafter is CG, and so on.

 **Figure 18-34 Jack Rafter Pattern**

 Go to [glencoe.com](http://glencoe.com) for this book's OLC for additional step-by-step procedures, applications, and certification practice.

## Section 18.3 Assessment

### After You Read: Self-Check

1. What is a jack rafter?
2. What is a valley jack rafter?
3. What is the best way to figure the total lengths of valley jacks and cripple jacks?
4. What is the purpose of a jack rafter pattern?


### Academic Integration: Mathematics

5. **Lengths of Hip Jack Rafters** For a house with a hip roof, the run of a common rafter is 14', the pitch is  $\frac{6}{12}$ , there is a 2' overhang, and the rafters are 16" OC. Figure the length of the shortest hip jack rafter.

**Math Concept** The run, rise, and length of a hip jack rafter are like the base, altitude, and hypotenuse of a right triangle.

**Step 1:** Use the Pythagorean Theorem to find the unit length.

**Step 2:** Set up a proportion comparing the ratio of unit run to unit length with the ratio of total run to total length.

 Go to [glencoe.com](http://glencoe.com) for this book's OLC to check your answers.



# Review and Assessment

## Section

## 18.1

## Chapter Summary

Three types of rafters are hip, valley, and jack rafters. The length of a hip rafter is calculated on the basis of the unit run and unit rise and/or the total run and total rise. Any of the methods previously described for determining the length of a common rafter may be used. However, some of the basic data for hip and valley rafters is different.

## Section

## 18.2

The span of an addition roof may be equal or unequal to that of the main roof. Dormers are framed either with or without side walls. Those with side walls are called doghouse dormers.

## Section

## 18.3

Jack rafters are shortened common rafters framed to a hip rafter, valley rafter, or both. The best way to figure the total lengths of valley jacks and cripple jacks is to lay out a framing plan. A hip jack rafter extends from a hip rafter to a plate. Hip jacks always have the same spacing as common rafters.

## Review Content Vocabulary and Academic Vocabulary

- Use each of these content vocabulary and academic vocabulary words in a sentence or diagram.

### Content Vocabulary

- hip rafter (p. 504)
- valley rafter (p. 504)
- jack rafter (p. 504)
- seat cut (p. 506)
- backing the hip (p. 513)
- dropping the hip (p. 514)
- addition (p. 516)
- dormer (p. 518)
- doghouse dormer (p. 519)

### Academic Vocabulary

- hypotenuse (p. 505)
- significant (p. 510)
- ensure (p. 513)

## Speak Like a Pro

### Technical Terms

- Work with a classmate to define the following terms used in the chapter: *hip jack rafters* (p. 504), *valley jack rafters* (p. 504), *plumb lines* (p. 508), *level lines* (p. 508), *blade* (p. 508), *tongue* (p. 508), *backed* (p. 513), *dropped* (p. 513), *cripple jack rafter* (p. 522), *valley cripple jack* (p. 522), *hip valley cripple jack* (p. 522), *common difference* (p. 523).

## Review Key Concepts

- Demonstrate** how to make hip rafter side cuts.
- Define** a valley rafter.
- Explain** how to calculate rafter overhang.
- List** at least two reasons to add a dormer to a roof.
- Demonstrate** how to construct a jack rafter.
- Explain** why the intersection of two roofs calls for more complex framing.

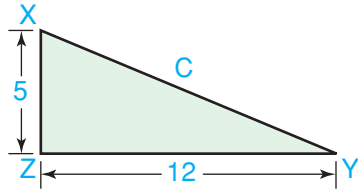
## Critical Thinking

- Explain** Can the actual length of a rafter be taken from the framing plan? Explain your reasoning.

## Academic and Workplace Applications

### STEM Mathematics

- 10. Pythagorean Theorem** The right triangle is the basis for many roof structures. Understanding how to use the Pythagorean theorem will help you in your construction career. Find the length of the hypotenuse,  $c$ , of  $\triangle XYZ$ .



**Math Concept** The Pythagorean theorem states that the sum of the squares of the sides of a right triangle are equal to the square of the hypotenuse. The hypotenuse is the side of a right triangle opposite the right angle. The formula is  $a^2 + b^2 = c^2$ .

**Step 1:** Substitute known lengths for  $a$  and  $b$ .

**Step 2:** Square the two known lengths.

**Step 3:** Find the sum of the squares of the two legs (the base and the altitude).

**Step 4:** Take the square root of the sum to solve for  $c$ .

### STEM Engineering

- 11. Triangles** The triangle is used often in architecture and design. Unlike the shapes of a square or a rectangle, the shape of a triangle is rigid. This means that the shape of a triangle cannot be changed without changing the length of one of its sides or breaking one of its joints. A single truss between two diagonal corners strengthens a square or rectangle by turning it into two triangles. Find three instances of triangles used in design, such as in buildings, bridges, or other structures. You can use structures in your neighborhood or pictures of structures found elsewhere. Describe the structure. Try to determine if the triangles in the structure are used to

decorate or to support the structure. Summarize your findings in a one-page report. Include pictures or drawings.

### 21st Century Skills

- 12. Career Skills: Investigate Roofing Careers**

Interview two carpenters with roofing experience. Ask them to recall their experiences as they were learning to frame roofs with hip and valley rafters. Ask how they learned to do this work accurately. How much practice did it take? What math skills did they use? What tools did they find helpful? Take notes during your interview. Summarize the interview in a one-page document.

### Standardized TEST Practice



#### Multiple Choice

**Directions** Choose the best answer for each of the following questions:

- 13.** The formula you would use to calculate the length of a hypotenuse is \_\_\_\_\_.
- a.  $A = bh$                       c.  $A = 2\pi r$   
b.  $a^2 + b^2 = c^2$               d.  $y = ax + b$
- 14.** In mathematics, a right angle is equal to \_\_\_\_\_.
- a.  $60^\circ$                               c.  $180^\circ$   
b.  $90^\circ$                               d.  $45^\circ$
- 15.** The shortening allowance of a hip jack rafter at the upper end is \_\_\_\_\_.
- a.  $\frac{1}{2}$  the  $45^\circ$  thickness of the hip rafter  
b.  $\frac{1}{4}$  the  $45^\circ$  thickness of the hip rafter  
c.  $\frac{1}{2}$  the thickness of the long rafter  
d.  $\frac{1}{4}$  the thickness of the long rafter

#### TEST-TAKING TIP

Science and mathematics require you to memorize the relationships between groups of numbers as well as specific numbers. Using these relationships in real-world applications, such as measurement, may help you be able to recall formulas and special numbers.

\*These questions will help you practice for national certification assessment.