016
Roof Framing

unit length

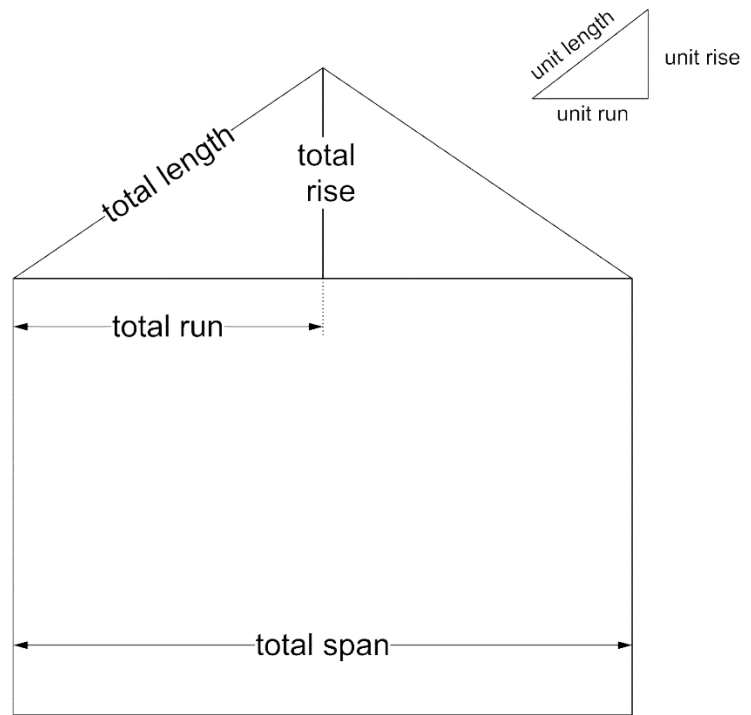unit rise

unit run

total length

total rise

total run

total span

Carpenters Training Committee for Northern California (CTCNC)

CARPENTER APPRENTICESHIP PROGRAM

Course of Instruction

Year	Course	Course Title All Courses 36 Hours
1	001	Introduction to Apprenticeship I
	002	Introduction to Apprenticeship II
	004	Foundations & Floors
	005	Blueprint Reading – Basic
2	006	Wood Framing
	007	Concrete Formwork
	012	Layout Instruments
	009	Blueprint Reading – Advanced
3	010	Concrete Bridge Building
	013	Engineered Structural Systems
	014	Commercial Steel Framing
	018	Commercial Concrete
4	011	Interior Finish
	008	Exterior Finish
	019	Rigging
	015	Stair Building
	016	Roof Framing
	017	Introduction to Welding & Cutting

016
ROOF
FRAMING

Carpenters Training
Committee for
Northern California

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COURSE OBJECTIVES

At the completion of the course, the student will be knowledgeable about the layout and construction of a roof. The student will demonstrate how to correctly calculate and cut common, hip, valley and jack rafters. In addition, the student will be familiar with the proper terminology used in roof framing and will be able to identify the components of a roof. The student will also demonstrate good tool skill and the ability to work in a safe manner.

SPECIFIC OBJECTIVES

Upon completion of this unit, the student will be able to:

1. Read a roof plan and obtain the information needed to frame the roof

2. Apply the principles of the right triangle to the theory of roofs

3. Calculate the theoretical length of common and hip rafters

4. Demonstrate correct use of the framing square

5. Correctly identify the parts of a common rafter

6. Correctly lay out and cut the common rafters of the project

7. Correctly lay out and cut the hip rafters of the project

8. Calculate the amount of drop needed for the hip rafters

9. Correctly lay out and cut both the supporting and the shortened valleys of the project

10. Correctly lay out and cut the jack rafters of the project

11. Exhibit safe work practices in the dismantling of the roof project

CARPENTERS TRAINING COMMITTEE

FOR NORTHERN CALIFORNIA

SEXUAL HARASSMENT & APPRENTICE CONDUCT

Sexual harassment in any form or degree by an employee or apprentice against another individual, regardless of their relationship or respective status, is strictly against the policy of the Carpenters Training Committee for Northern California and will not be tolerated. Any such action or activity shall be reported immediately to the person in charge of the training facility. The matter will be promptly investigated and appropriate action will be taken. Copies of all complaints and actions are to be forwarded to the Assistant Director of Field Operations.

Apprentices shall not use lewd and vulgar language while they are on the premises of the Carpenter's Training Center. Any such action shall be reported immediately to the person in charge of the training facility. The matter will be promptly investigated and appropriate action will be taken.

Any person violating the above policies shall be subject to disciplinary action, which may include suspension or expulsion from the training center and/or cancellation from the program.

CARPENTER APPRENTICE TOOL LIST

Minimum of tools required <u>before</u> dispatch as Carpenter should include

1. Tool Box - 12″ x 12″ x 32″ (wood or metal, should be lockable)
2. Carpenters Pencils and Keil (lumber crayon)
3. Chalk Box with Chalk
4. Measuring Tape 1″ x 20′ min.
5. Combination Square
6. Framing Hammer, 16 or 20 oz.
7. OSHA approved Eye Protection
8. Carpenters Overalls or Nail Belt with two leather pouches
9. Hand Saw, 8 pt. Cross Cut
10. Wood Chisel, $^3/_4$″ min.
11. Pliers, 8″ Side Cutters
12. Screwdriver, 8″
13. Utility Knife
14. Nail Puller, "Cat's Paw"
15. Nail Bar

Additional tools to be obtained as the employer requires or class requires:

1. Hand Saw, 8 pt. Cross cut (spare)
2. Hand Saw, 10 or 11 pt.
3. Claw Hammer, 16 oz. curved claw
4. Hand Level, 24″ or 28″
5. Framing Square with rafter tables
6. Wood Chisels, $^1/_2$″ through $1^1/_2$″
7. Brace
8. Wood bits, #6, #8, #9, #13, #14, #16
9. Wrench, 12″ adjustable open end
10. Block Plane
11. Sharpening Stone
12. Hand Axe, Carpenters
13. Layout Tape, 50′ min.
14. Plumb Bob, 16 oz.
15. Nail Sets, as required
16. Stripping Bar, 30″ min.
17. Straight Cut Aviation Snip

Failure on the part of the student to obtain these <u>required</u> tools could result in:

1. A delay in wage re-rates until requirements are met.
2. Possible job termination for failure to supply proper hand tools.

* You are encouraged to purchase one (1) tool a week to spread out the cost. Tools required for specific classes (listed in class notice) are <u>mandatory</u> and must be in your possession.

CARPENTERS GRADING AND EVALUATION SCHEDULE

Grading

A uniform weighing system will be used as follows:

1. Class Participation and Attitude…………………………….. 10%

2. All Tests Except for Final Exam…………………………… 10%

3. Manipulative Lessons……………………………………….. 50%

4. Final Exam…………………………………………………….. 30%

Assignment of grades will be as follows:

|		
A.	92 - 100%	D. 68 - 72%
B.	82 - 91%	F. Less than 68%
C.	73 - 81%	

Criteria for Evaluation

1. Accuracy   4. Participation

2. Completion of assignments

3. Following instructions

PRE-TEST
016- ROOF FRAMING

Instructions: Circle the correct answer, T for True and F for false

1.   T   F   Roof framing is based on a right triangle.

2.   T   F   The unit run of a common rafter is 12".

3.   T   F   The total run of a common rafter is the overall width of the building.

4.   T   F   A gable roof slopes in two directions.

5.   T   F   Common rafters run at a right angle to the exterior walls.
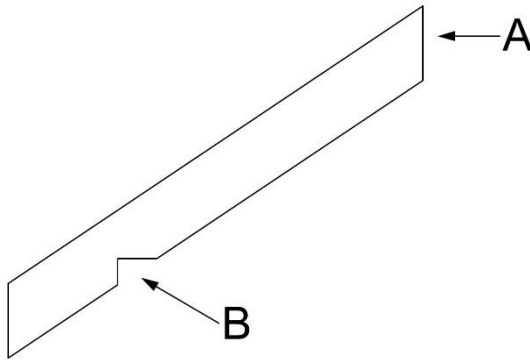
6.   T   F   The letter "A" in the drawing points to the seat cut.

7.   T   F   The letter "B" in the drawing points to the side cut.

8.   T   F   The unit run of a hip rafter is 17 inches.

9.   T   F   A framing square is used to lay out the rise and run on a rafter.

10.   T   F   The theoretical length (line length) of a common rafter is always shorter than the actual length.

11.   T   F   A valley is formed where the slopes of two intersecting roofs meet.

12.   T   F   Hips run at a 30° angle to the outside plates.

13.   T   F   Hip rafters have plumb and level cuts.

14.   T   F   Total run is the width of the building from outside to outside.

15.   T   F   Jacks are interrupted commons.
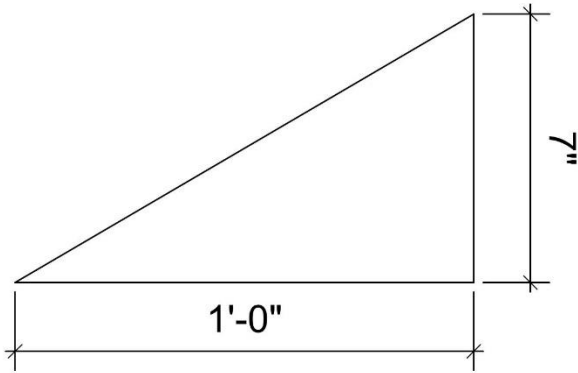
16.   T   F   In the drawing, the unit rise is 7".
17.   T   F   In the drawing, the unit run is 12".

Lesson 1

Begin the project by laying out the project on the floor. It is important that the layout be accurate, that is, it needs to be the proper measurements and it must be square. Shown below is the project, each apprentice will have their own mockup.
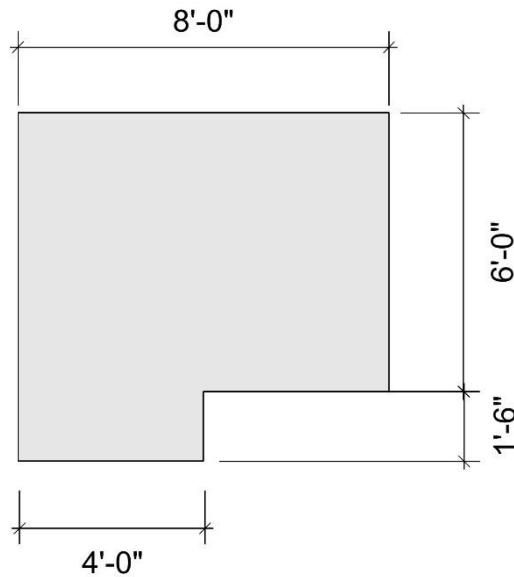
Once it is laid out, place and secure the pre-made walls on the layout marks. Care must be taken to assure the walls are plumb and square.
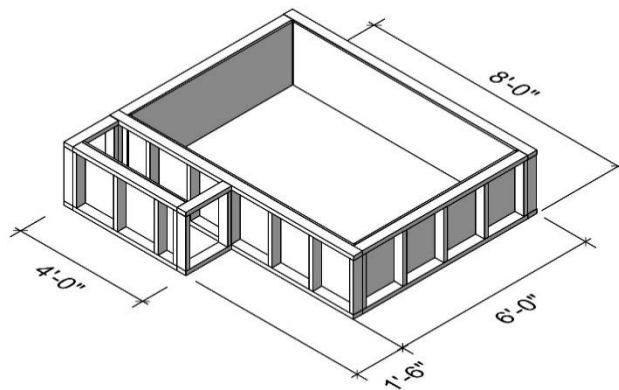
The next step is to add a double plate on top of the premade walls. Be sure to lap the plates so that the plates on the through walls are held back 3 1/2" and the plates on the butting walls extend 3 1/2".
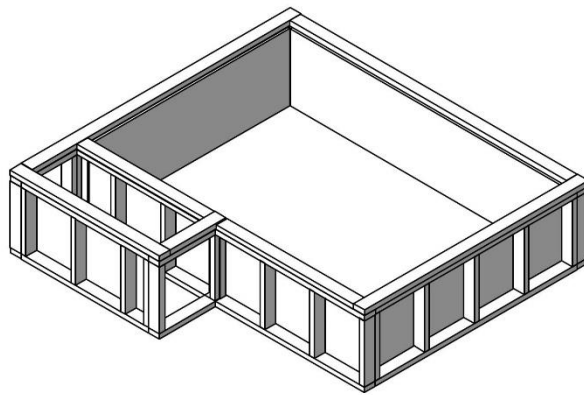
Now that the mock up is complete, we will begin to calculate and cut the common rafters and the ridge for the major span. When there is an intersecting roof with unequal spans (widths), the wider span is the major span and the smaller span is the minor span. With our project, the major span is the 6'-0" section, and the minor span is the 4'-0" section.

Your instructor will give you the pitch of your project, and with this information you can calculate the theoretical length of your common. You should calculate both the length of the common to the building line, and the overall length, including the overhang.

Chapter 1   Roof Basics

Roof cutting is a true test of the carpenter. It involves mathematics, angles, careful layout and good tool skills. A carpenter that can cut and assemble a roof is prepared for any carpentry task.

The principle of a roof is based in mathematics, specifically, the right triangle. Shown below, we see circled the part of the roof that is a right triangle.
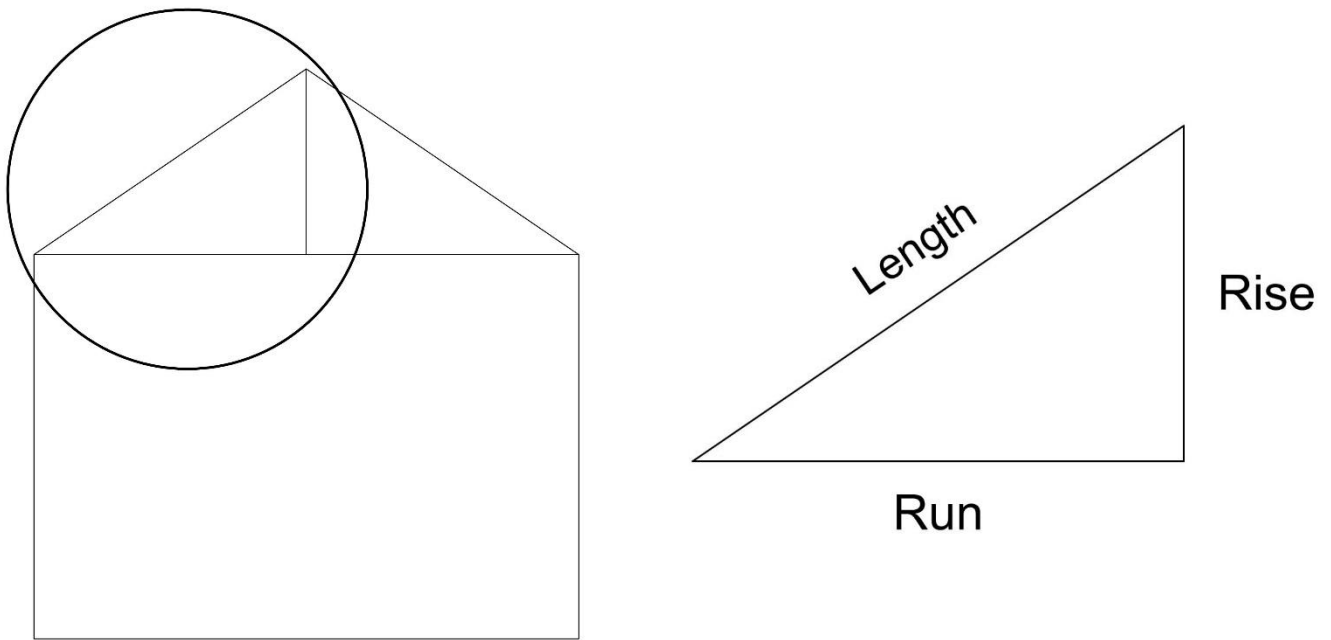
The base of the triangle is the run, which is the horizontal part. The altitude of the triangle is the rise, which is the vertical part. Lastly, the hypotenuse of the triangle is the length of the rafter.

Using the right triangle formula, $\sqrt{A^2 + B^2} = C$, we see that if we know the run and rise, we can calculate the length of the rafter.   For example, if the run is 12" and the rise is 5", the length would be 13". The math looks like this:

12" (A) x 12" (A) =   144

5" (B) x 5" (B)   =   + 25

169        $\sqrt{169}$ = 13"

In order to calculate the rafter length, we need to find the rise and run of the roof. To do this, we will discuss basic roof terminology.
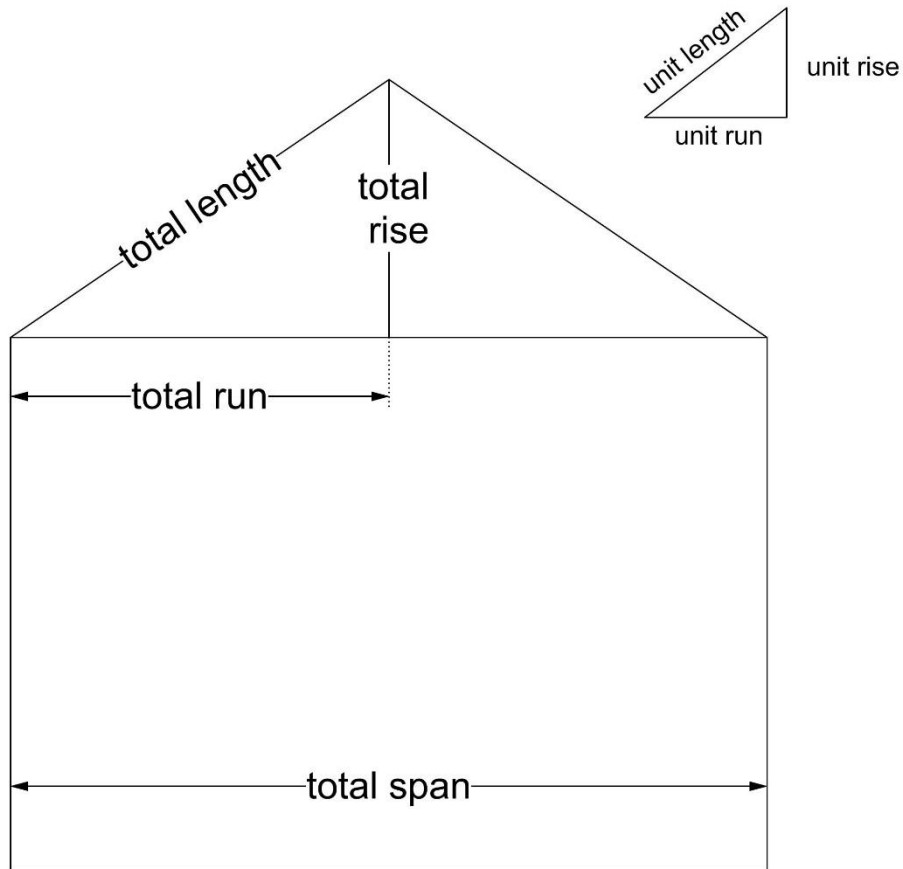
Total span   This is the width of the building from outside to outside.

Total run   This is 1/2 of the total span. This is the key to calculating rafter length. It is 1/2 the total span because there will be a pair of rafters; each covering half the roof.

Total rise   This is the mathematical height from the top of the plate to the peak of the roof.

Total length   This is the mathematical length of the rafter, known as the theoretical length.

Unit run   This is one step of the total run, it is 12"
            for a common rafter.

Unit rise   This is the amount that the roof rises for
            each step of run. This is decided by the
            architect or designer. The larger the unit
            rise, the steeper the pitch of the roof.

Unit length This is the mathematical length of the rafter
   for each step of run.

13"   5"

12"
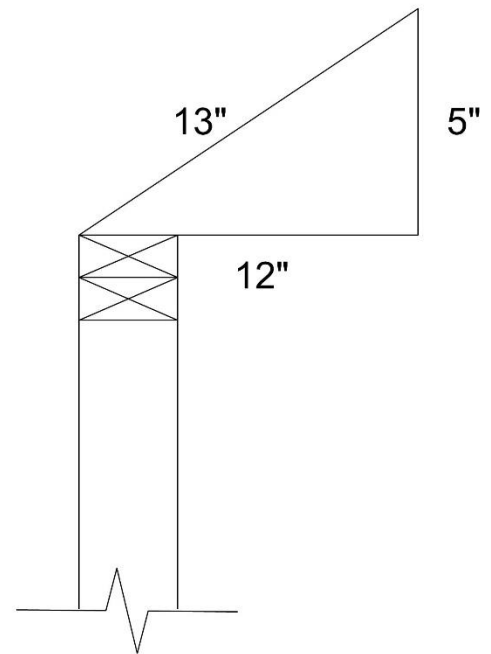
Calculating Total Rise

In order to calculate the total rise of a roof, we need two pieces of information about the roof; the unit rise of the roof and the width of the building.

unit length   unit rise
unit run

total
rise

total run

total span
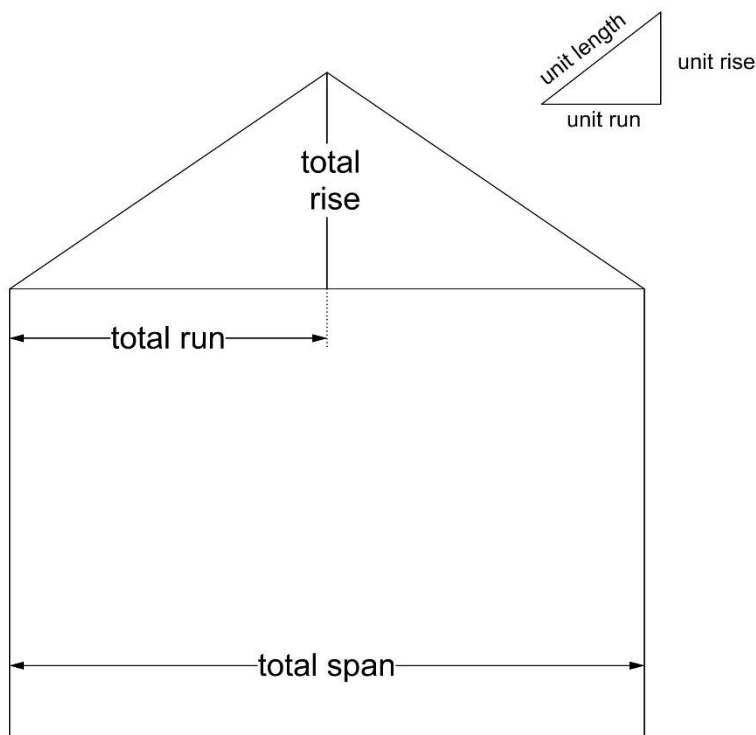
TOTAL RUN X   UNIT RISE = TOTAL RISE
(feet & decimals)   (inches & decimals)   (inches & decimals)

In the formula above, the total run needs to be in feet and decimals, for example, 7' -6" = 7.5'
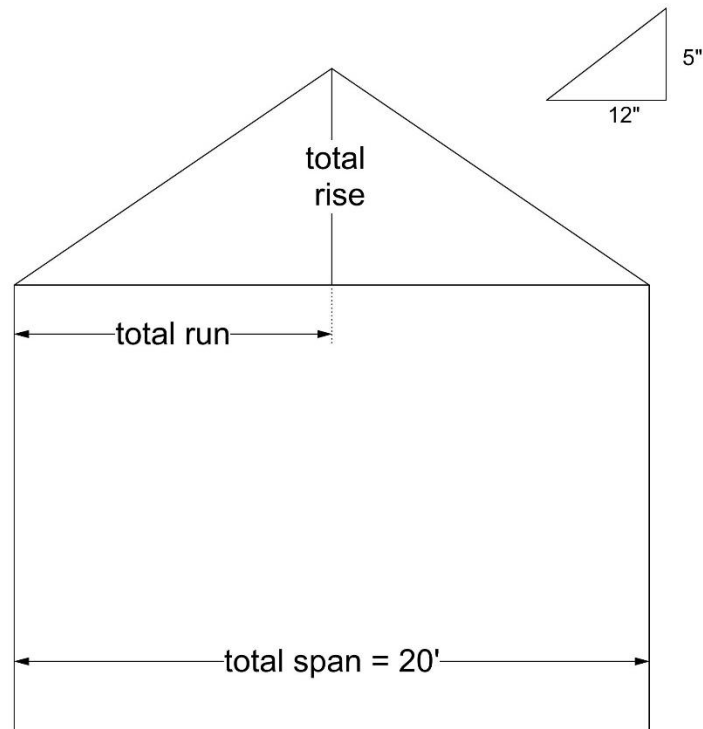
total
rise

5"
12"

total run

total span = 20'

TOTAL RUN X   UNIT RISE = TOTAL RISE
(feet & decimals)   (inches & decimals)   (inches & decimals)

With the above information, we can find the total rise of the example above.

10' (TOTAL RUN) X 5" (UNIT RISE) = 50" (TOTAL RISE)

This means that from the top of the plate to the peak of the roof is 50" or 4' – 2"

Practice: Give the total rise of each of the following problems.

1. A roof with a 26' total span and a 4" unit rise has a total rise of _____**?**

2. A roof with a 30' total span and a 7" unit rise has a total rise of _____**?**

3. A roof with a 19' total span and a 9" unit rise has a total rise of _____**?**

4. A roof with a 22'-6" total span and a 6" unit rise has a total rise of _____**?**

5. A roof with a 13'-10" total span and a 5" unit rise has a total rise of _____**?**

Calculating Total Length

To calculate total rafter length, as with calculating total rise, we need two pieces of information about the roof; the width of the building and the pitch of the roof.
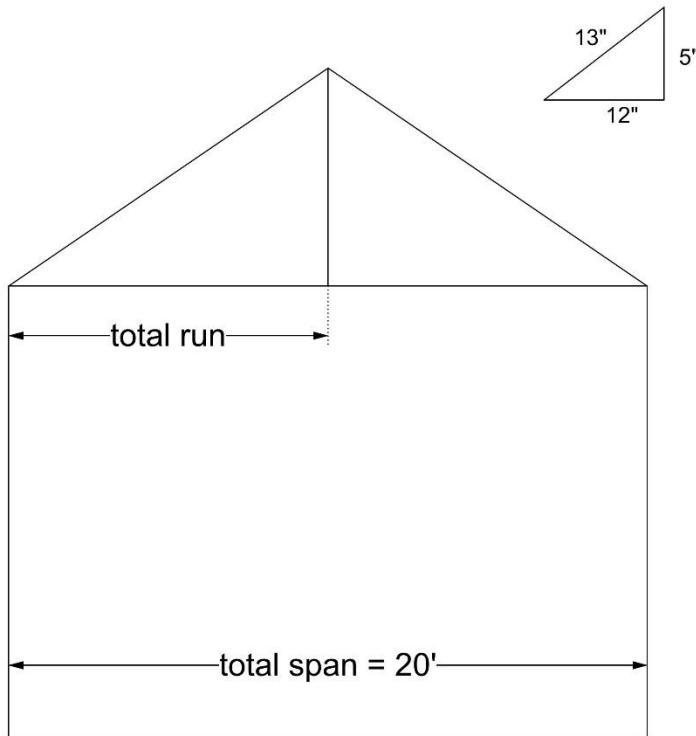
The pitch of the roof is the slope or angle of the roof and it is the ratio of the rise over the run. It is expressed as a 4 and 12 pitch or a 7 and 12 pitch etc.

TOTAL RUN X UNIT LENGTH = TOTAL LENGTH
(feet & decimals)   (inches & decimals)   (inches & decimals)

In the previous section about right triangle math, we established that the hypotenuse of a 5" and 12" triangle is 13". Thus, 13 is the unit length for a 5 and 12 pitched roof. This means that for every 12" step from the exterior wall, the roof rises 5" and the rafter gets longer by 13"

To calculate the theoretical length of the example above we follow the formula:

10' (TOTAL RUN) X 13" (UNIT LENGTH) = 130" (TOTAL LENGTH)

The unit length can be found by mathematically determining the hypotenuse of the unit rise and 12" for whatever pitch of the roof that is needed. However, this information can be found on framing squares that are imprinted with the rafter tables. There is a wealth of information included on the rafter tables and we will be referring to them throughout this class.

As seen below, there is a line that states "LENGTH COMMON RAFTERS PER FOOT OF RUN". This line gives the unit length for each unit rise.
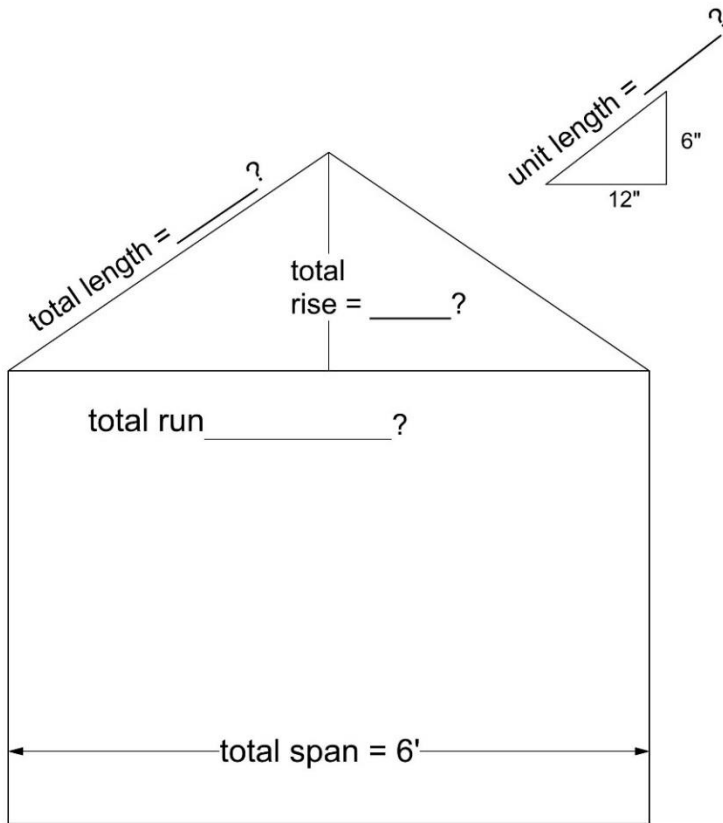
						6	5	4	3
23	**22**	**21**	**20**	**19**	**18**				
LENGTH	COMMON	RAFTERS	PER FOOT	RUN	21 63	13 42	13 00	12 65	12 37
11	HIP OR	VALLEY	11 11	11	24 74	18 00	17 69	17 44	17 23
DIFF	IN LENGTH	OF JACKS	16 INCHES	CENTERS	28 84	17 875	17 33	16 87	16 49
11	11	11	2 FEET	11	43 27	26 83	26	25 30	24 74
SIDE	CUT	OF	JACKS	USE	6 11/16	10 3/4	11 1/16	11 3/8	11 5/8
11	11	HIP OR	VALLEY	11	8 1/4	11 5/16	11 1/2	11 11/16	11 13/16

If we go to the 5" mark and look at the first line below it, we see 13 00. This is 13", which is the unit length of a 5 and 12 pitch.

						6	5	4	3
23	**22**	**21**	**20**	**19**	**18**				
LENGTH	COMMON	RAFTERS	PER FOOT	RUN	21 63	13 42	13 00	12 65	12 37
11	HIP OR	VALLEY	11 11	11	24 74	18 00	17 69	17 44	17 23
DIFF	IN LENGTH	OF JACKS	16 INCHES	CENTERS	28 84	17 875	17 33	16 87	16 49
11	11	11	2 FEET	11	43 27	26 83	26	25 30	24 74
SIDE	CUT	OF	JACKS	USE	6 11/16	10 3/4	11 1/16	11 3/8	11 5/8
11	11	HIP OR	VALLEY	11	8 1/4	11 5/16	11 1/2	11 11/16	11 13/16

In the same way, if we follow the first line to the 6" mark, we see 13 42. What this means is that the unit length for each foot of run for a 6 and 12 pitch roof is 13.42". That is 13 and 42/100 of an inch; this method of calculating rafter length figures to the hundredth of an inch, which is quite accurate.

						6	5	4	3
23	**22**	**21**	**20**	**19**	**18**				
LENGTH	COMMON	RAFTERS	PER FOOT	RUN	21 63	13 42	13 00	12 65	12 37
11	HIP OR	VALLEY	11 11	11	24 74	18 00	17 69	17 44	17 23
DIFF	IN LENGTH	OF JACKS	16 INCHES	CENTERS	28 84	17 875	17 33	16 87	16 49
11	11	11	2 FEET	11	43 27	26 83	26	25 30	24 74
SIDE	CUT	OF	JACKS	USE	6 11/16	10 3/4	11 1/16	11 3/8	11 5/8
11	11	HIP OR	VALLEY	11	8 1/4	11 5/16	11 1/2	11 11/16	11 13/16

In the following example, we will apply what we have learned to this roof.

unit length = _____ ?

6"

12"

total length = _____ ?

total rise = _____ ?

total run _____ ?

total span = 6'

First we need the total run, so we divide the 6' span by 2, which equals **3'** of total run. Next we need the unit length for a 6 and 12; as we saw above, the framing square tells us that it is **13.42".**

To calculate total rise, we multiply 3' of total run x the unit rise of 6". 3 x 6" = **18"** total rise.

Finally, to calculate total length, we multiply 3' of total run x 13.42" = **40.26" or 40 1/4"**

unit length = _____ ?

7"

12"

total length = _____ ?

total rise = _____ ?

total run _____ ?
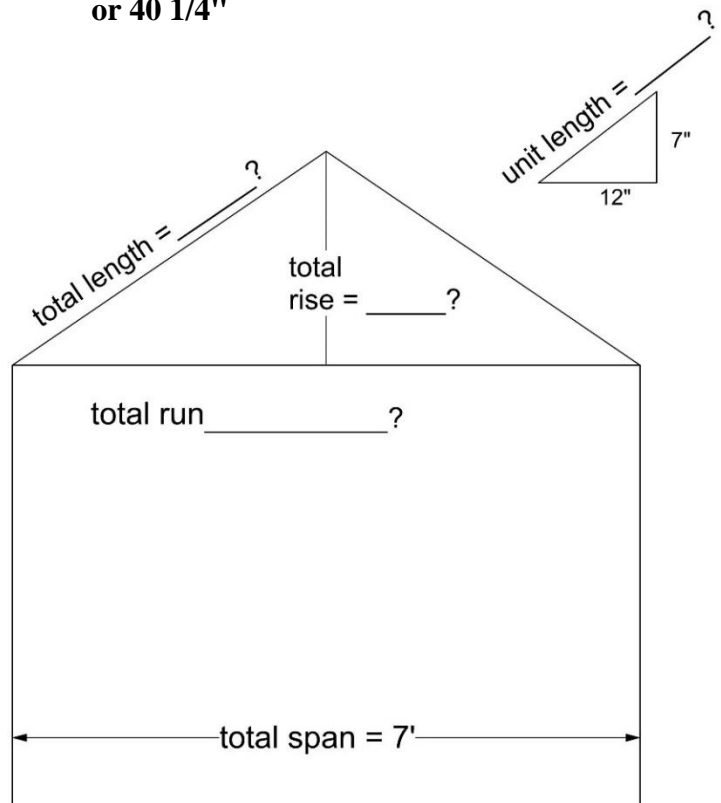
total span = 7'

Fill in the missing figures.

To find the total run, divide the total span of 7' by 2: 7÷2= **3.5'** of total run. This is the proper way to express total run, with feet and decimals. This really means that there are 3 1/2 steps of run in this roof.

Next we need the unit length per foot of run for a 7 and 12 pitch. If we consult the rafter table we see the number **13.89"**, which is found by $\sqrt{12^2 + 7^2}$.

To find the total rise, we multiply 3.5 x 7" =

Lastly, to find the total length, we multiply 3.5 x 13.89" =

Hip and Valley Length

To calculate the length of a hip or valley rafter, we use the second line on the rafter table which reads "LENGTH HIP OR VALLEY PER FOOT OF RUN". Again, we look under the unit rise of the given pitch, for instance, for a 6 and 12 pitched roof we look at the second line under the 6" mark.

LENGTH	COMMON	RAFTERS	PER FOOT	RUN	21	63		13	00	12 65	12 37
11	HIP OR	VALLEY	11 11	11			18 00	17	69	17 44	17 23
DIFF	IN LENGTH	OF JACKS	16 INCHES	CENTERS	28	84	17 27,5	17	33	16 87	16 49
11	11	11	2 FEET	11	43	27	26	83	26	25 30	24 74
SIDE	CUT	OF	JACKS	USE	6	¹¹⁄₁₆	10 ¾	11	¹⁄₁₆	11 ⅜	11 ⅝
11	11	HIP OR	VALLEY	11	8	¼	11 ⁵⁄₁₆	11	½	11 ¹¹⁄₁₆	11 ¹³⁄₁₆

The hip and valley unit length is 18.00" per foot of run. Why is there a difference between the common and the hip? It is because hips and valleys run at a 45° angle to the exterior walls, while common rafters run at a 90°. Hips occur when two sloping surfaces meet at an outside corner, valleys occur when two sloping surfaces meet at an inside corner.
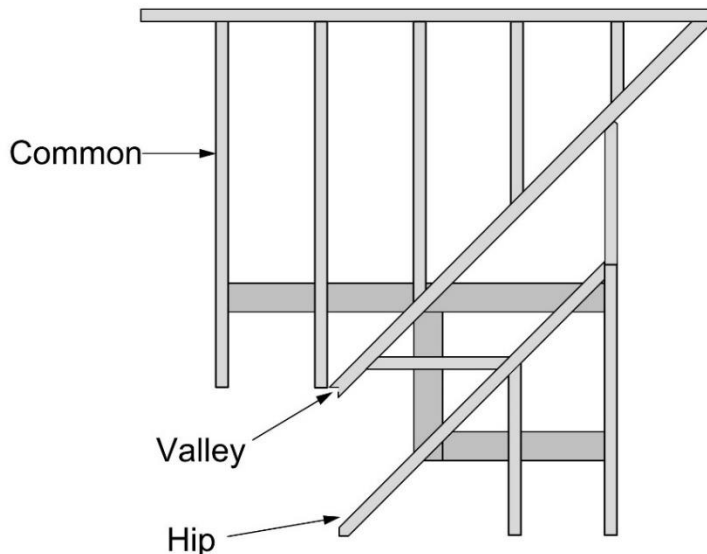
As seen below, the hip must be longer than the common because it is moving diagonally. For every foot of common run, the hip must be 16.97" to cover the same distance.
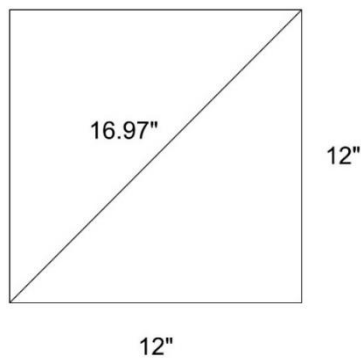
Just as the unit run for common rafters is 12", the unit run for hips and valleys is 17". The hip unit length is found by taking the square root of 17^2 and the unit rise^2. For a 6" unit rise, this equals 18".

Practice: Calculate the length of the following rafters. The unit length is shown.

UNIT RISE	TOTAL SPAN	RAFTER LENGTH
1. 6" Common (13.42)	16'- 0"	
2. 4" Common (12.65)	9'- 6"	
3. 8" Common (14.42)	22'-10 ½"	
4. 5" Hip (17.69)	12'- 7 3/4"	
5. 9" Hip (19.21)	26'- 1 1/4"	
6. 7" Hip (18.36)	19'- 0"	

Lesson 2

Now that we have covered the basics of roofs and have assembled the projects, we can begin framing our roof. We will start with the common rafters of our major span.

Common rafters are named for the fact that there are generally more commons than any other type of rafter. As stated before, commons run at a 90° angle to the exterior walls. They rest on the exterior walls and attach to the ridge at their upper end. The ridge board is at the peak of the roof and provides nailing for the top of the rafters.

Commons
2 x 4s @ 12" o.c.
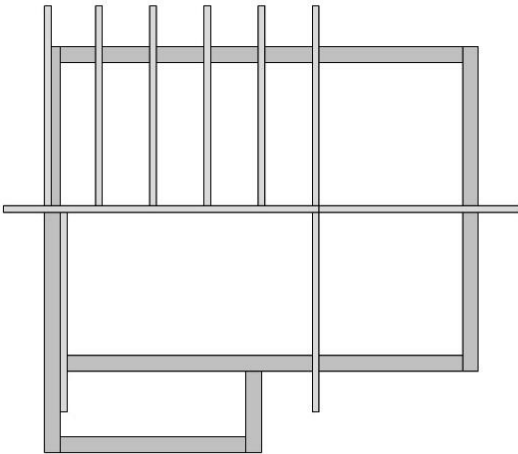
The project will have a section of tripod construction. This simply means that there will be three commons that join at the ridge. Circled here is the area of tripod construction.
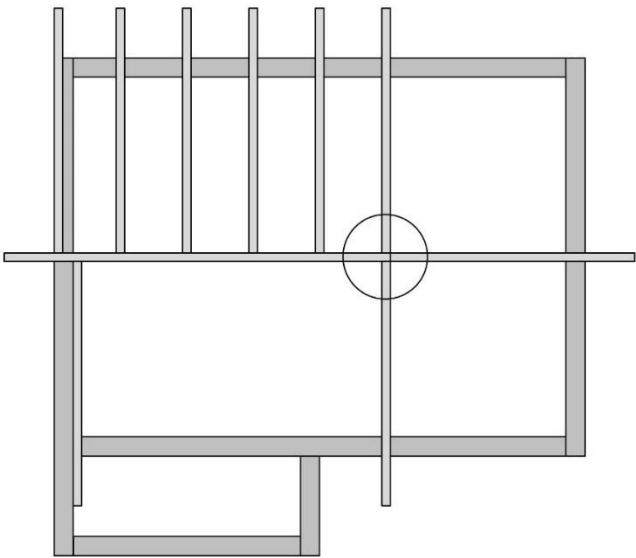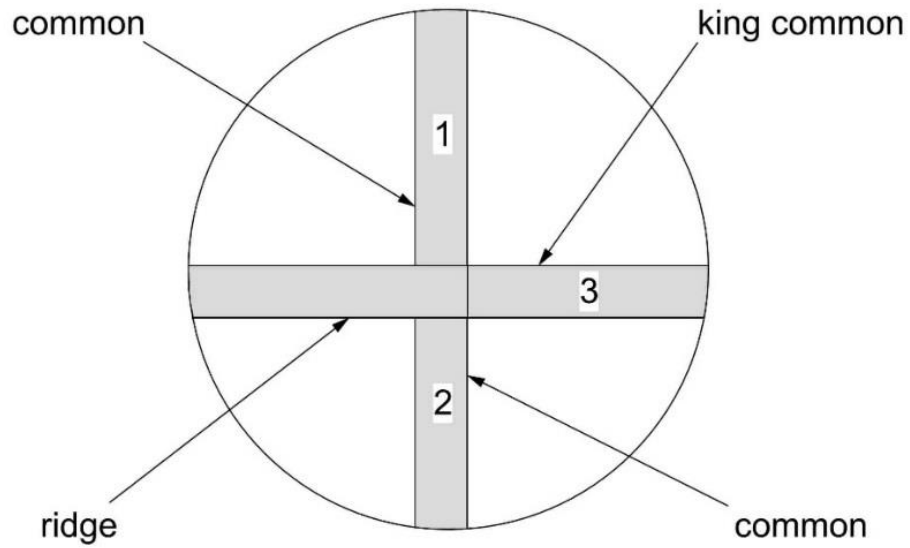
All 3 of the commons are the same length. The center of each common and the center of the ridge all come together at what is known as the framing point. This is the point that each rafter wants to reach.

2 common rafters before shortening
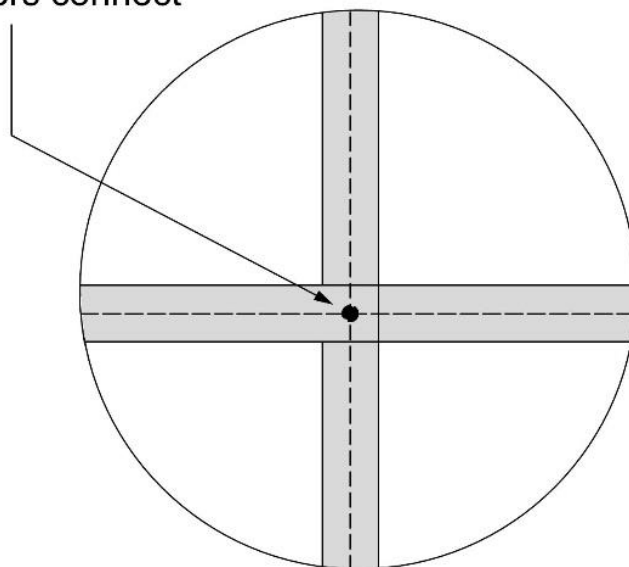
However, the ridge keeps the rafters from reaching this point, so the commons need to be shortened to allow for the ridge. If the two commons met each other without a ridge, securing them would be difficult and they would not be very stable. The ridge allows a positive connection, and adds stability by tying all the rafters together.

Location of the ridge

The top of the common should flush up with the edge of the ridge

The common needs to be shortened 1/2 the thickness of the ridge

As can be seen, the rafters need to be shortened 1/2 of the thickness of the ridge material and it should be measured at 90° to the rafter's plumb line.

The bottom end of the rafter is supported by the exterior wall. In the illustration below we see that if the rafter only touches the wall at one point, there is no good way to secure the rafter to the plate. In addition, the rafter is not well supported.
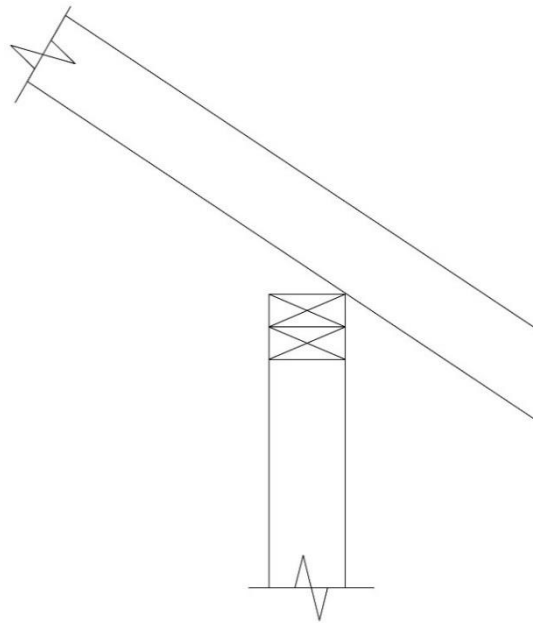
To ensure good nailing and to fully support the rafter, a notch, called a seat cut, is taken out of the rafter. The seat cut consists of one plumb cut and one level cut.
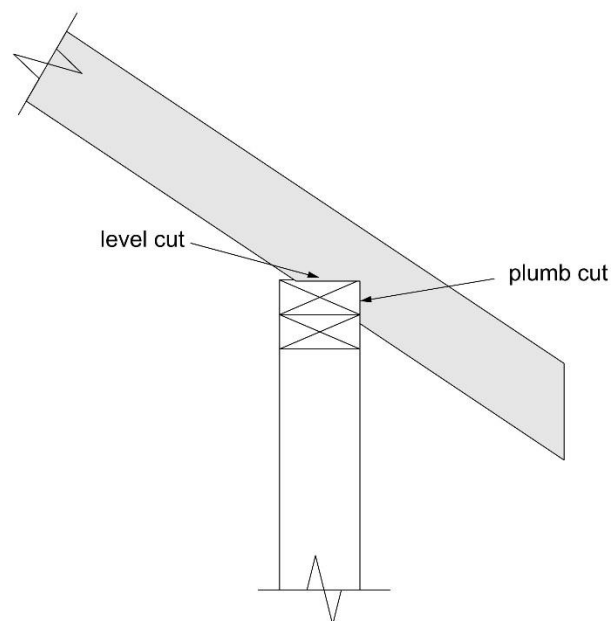
The level part of the seat cut generally should match the width of the wall. However, with a 2 x 4 rafter, to make the level seat cut the width of the wall would require taking too much material out of the rafter, which will weaken it.

The amount of material that remains above the seat cut is known as the HAP, which stands for the Height Above the Plate. The depth of the seat cut should not be more than one third of the rafter measured on the plumb.

HAP
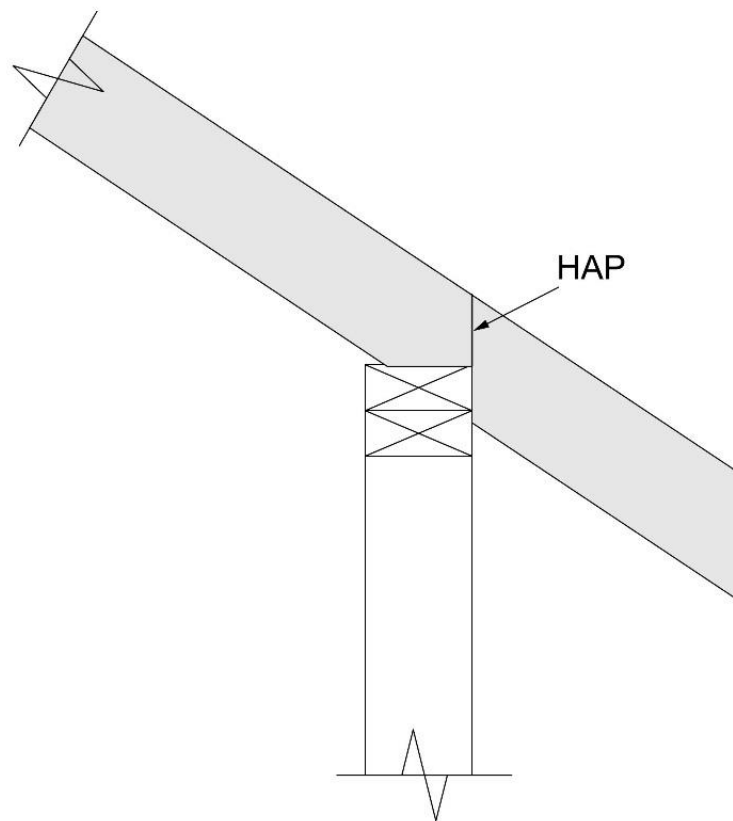
Another thing to consider on the common is the overhang. This is the distance the roof line extends beyond the exterior walls. This is measured horizontally from the wall.

This illustration shows that the total overhang is 10 1/2". The tail of the common is projecting 9" and the 2 x 6 fascia is nailed to the tail of the common. In addition, the HAP we will be using on our commons is 2 1/2".
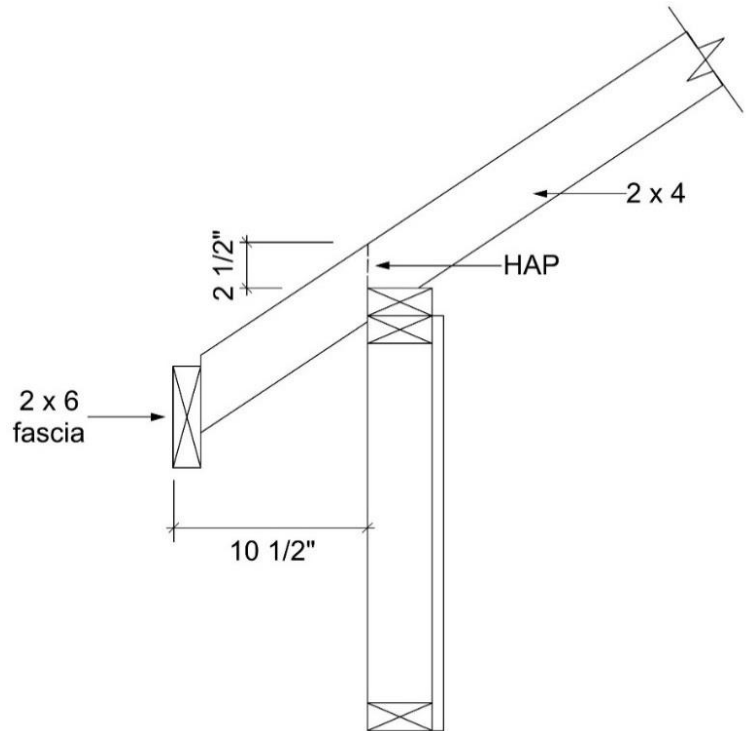
Your instructor will give you the unit rise for your project. Calculate the theoretical length of your common rafter and now you are ready to lay out your commons.

Step 1.   The tongue of the framing square will be used for the unit rise and the blade of the square will be used for the unit run. If using stair gauges, be sure to adjust them so that the numbers (the unit rise and 12") are right on the edge of the board. Begin at the top of your rafter and mark the tongue. This is the ridge plumb line.
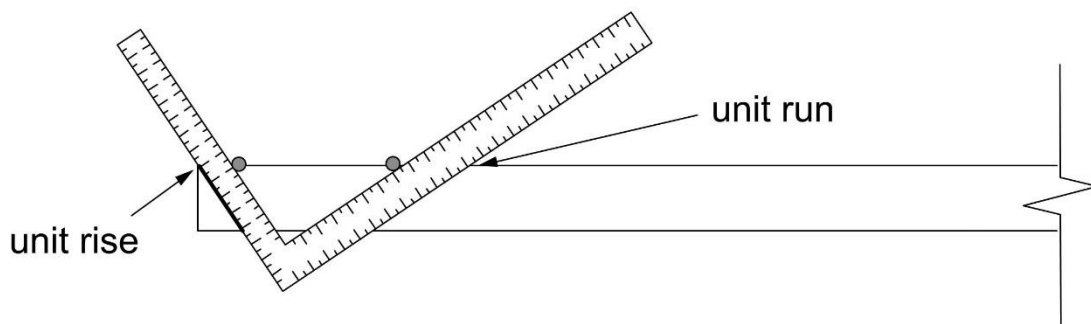
Step 2.   From your ridge plumb mark, measure the calculated length along the top edge of the rafter and make a mark. This represents the outside of the building.

Measure the calculated length
along the top of the rafter
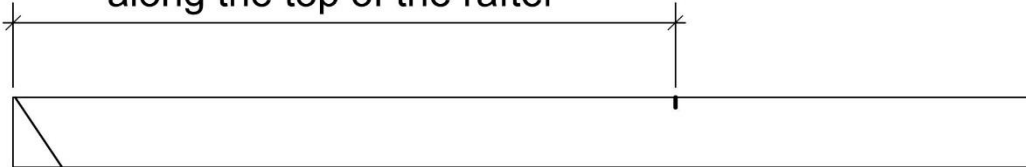
Step 3.   Reposition your framing square to line up the tongue on the mark made in step 2, and draw the plumb line.

Building line
plumb cut
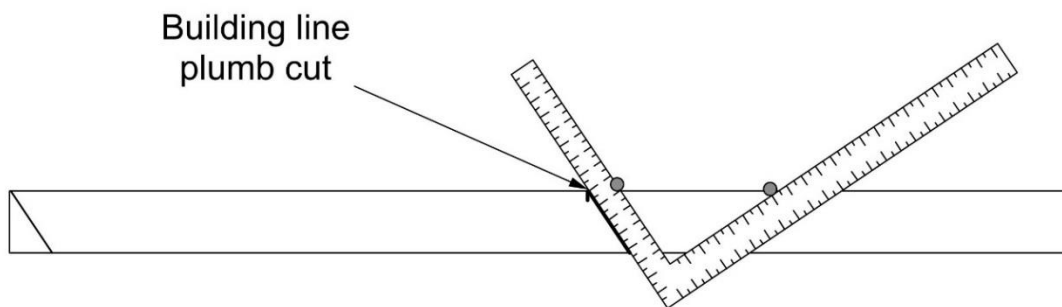
Step 4.   Next, measure down 2 1/2" from the top of the board along the plumb line and make a mark. Slide the square towards the ridge until the level side (blade) is on the mark, and mark the level line of the seat cut.

2 1/2"
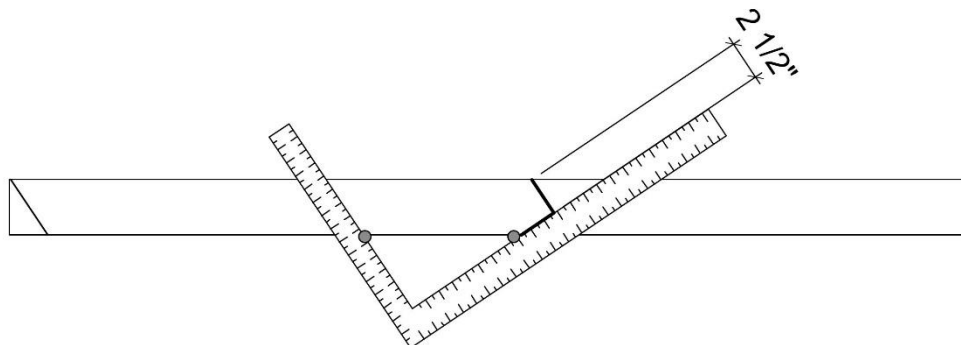
The seat cut is ready to be cut out. The piece that is cut out is the birdsmouth.

Step 5.   To lay out the rafter tail, the amount of projection can be calculated and marked, or, as is shown below, the distance can be stepped off. Holding the same unit rise and unit run marks, line up the tongue of the square with the plumb line. Find the amount of the tail, 9" in this case, on the inside of the framing square and mark it.

Place the square on the plumb line and mark 9".
This is the length of the overhang
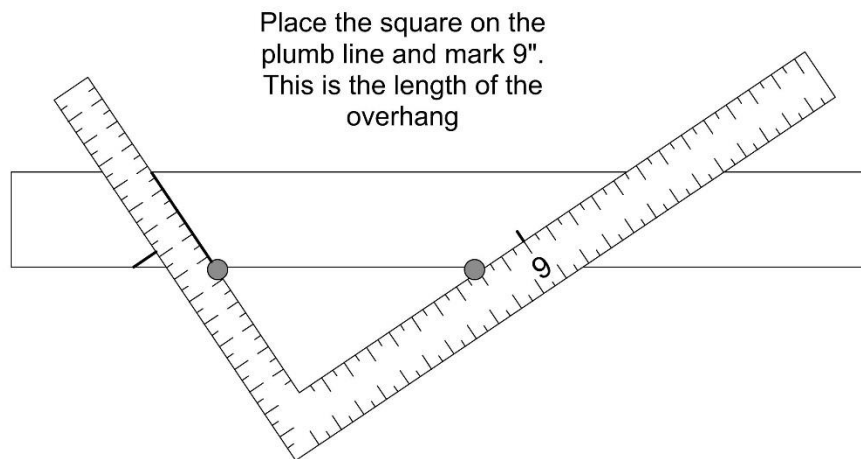
Step 6.   Slide the square towards the tail until the tongue is on the 9" mark and draw in the tail plumb cut.
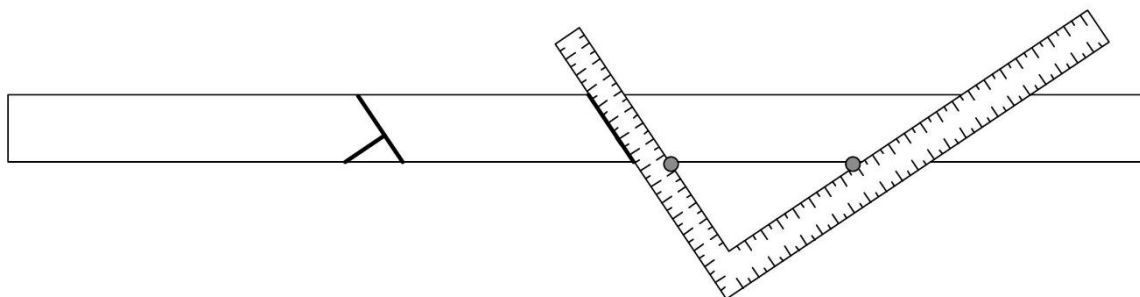
Step 7.   The last step is to return to the top of your rafter and mark the shortening. Since we are using a 2 x 6 ridge, the common needs to be shortened 1/2 the thickness, which will be 3/4".

cut line

3/4"
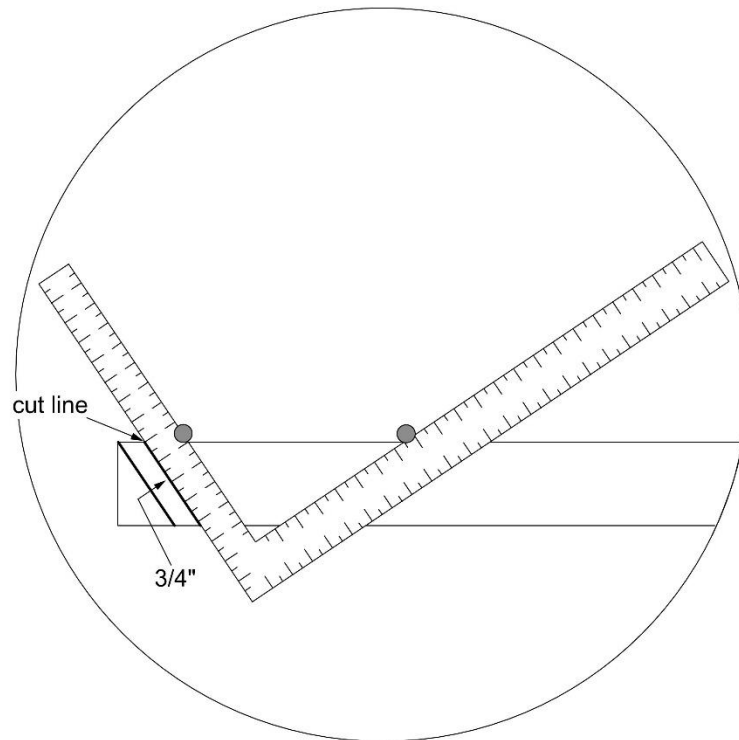
Step 8   Cut the rafter being careful to cut accurately. Do not overcut the seat cut!
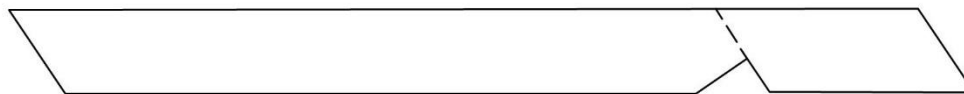
Using this rafter as a template, trace and cut another common.

Take two rafters and tack them to the
plates opposite each other. Place a
1 1/2" block between them and check
the fit at the ridge and the plates
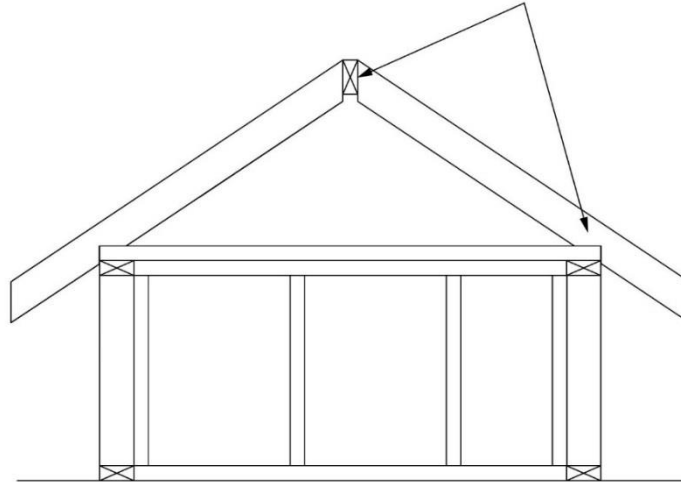
If the fit is good, mark the first rafter as your template and use it to trace and cut the remaining
common rafters.

Ridge Length

Before we install the commons, we need to determine the length of the ridge. On a straight gable
roof, the ridge would equal the length of the building plus any overhang. However, when there
are hips in a roof, that changes the ridge length.

As mentioned before, hips and valleys run at a 45°, which is the diagonal of a square. This
means that whatever the total run of the span, the commons should be that same distance from
the corner where the hip will be located. In the example below, the first common will be located
3' from the corner. This also means that the ridge must be 3' shorter.

6'-0"

3'-0"

3'-0"
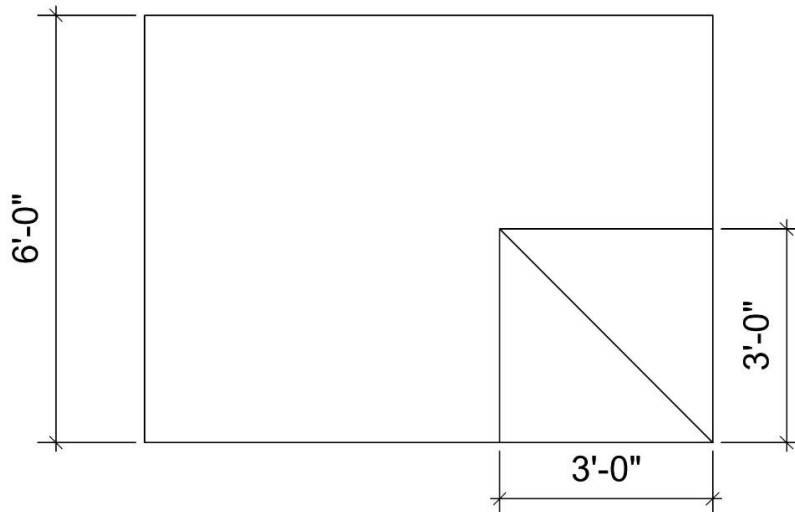
When a roof is a full hip roof (hips at each end), the ridge length is found by taking the length of the building and subtracting the width of the building.

When the roof uses tripod construction such as ours, the length of the ridge has an additional element. Since the king common (the common coming from the end wall) is shortened by 3/4", the ridge must be extended 3/4" to meet the king common.

The ridge is extended
3/4" past the framing point
to meet the king common
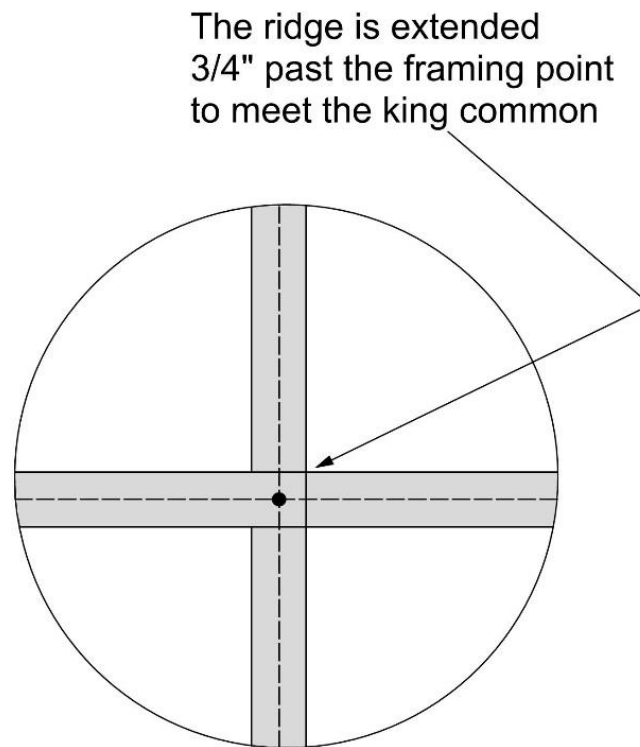
Once the ridge length is determined, the frame of the roof can be erected. Lay out the common rafters on the top plates and then transfer this layout to the ridge. Be sure to line up the top of the rafter with the edge of the ridge. When the commons are in place, the ridge should be level.

016- Roof Framing

Lesson 3

With the commons and ridge installed, we will now turn to our hip rafters. We have already learned how to calculate the length of the hip rafter using the unit length on the second line of the framing table. Once the length of the hip is calculated, we can lay out the hip rafters.

When laying out the hips, we must remember to use 17" for our unit run. This is due to the fact that for each 12" that the common advances, the hip must be 16.97" long to reach the same point.
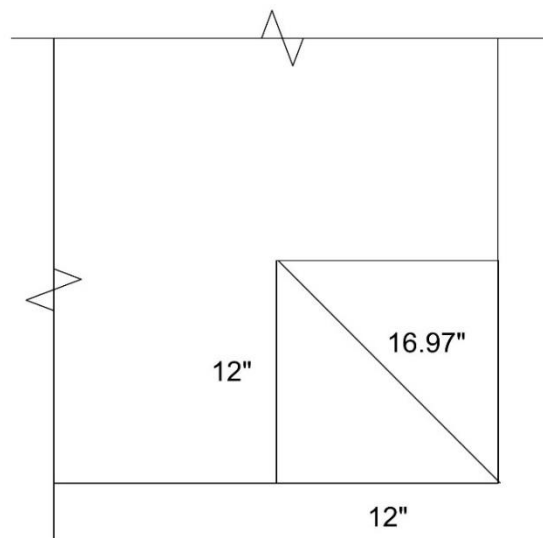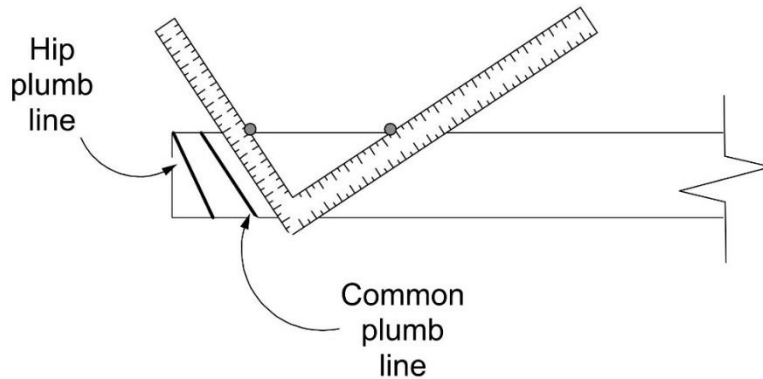

Once the length of the hip is calculated, we can lay out the hip rafters. The hips will be 2 x 6s.

Step 1.   As with the common layout, we begin at the top of our rafter with the ridge plumb cut.
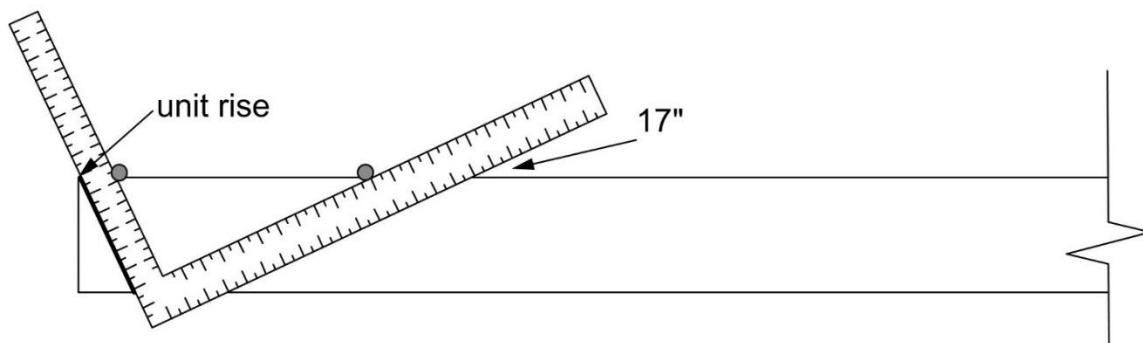
Notice that the plumb cut is at a lower angle than the common plumb line; this is because the hip is not only rising up from the plate, but it is also hitting the ridge at a 45° angle.
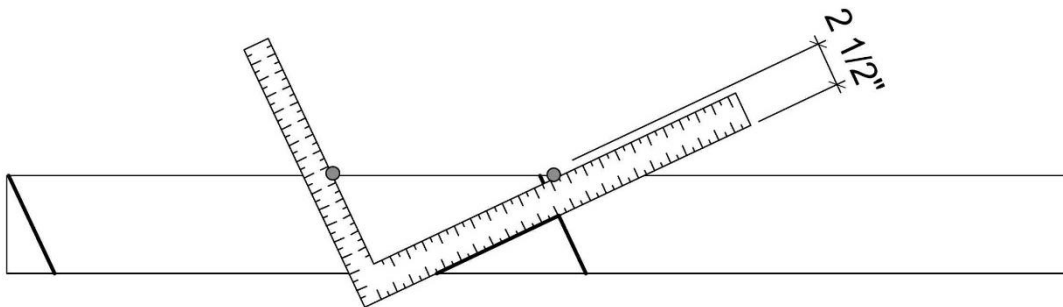

Step 2.   Mark the theoretical length along the top of your rafter.
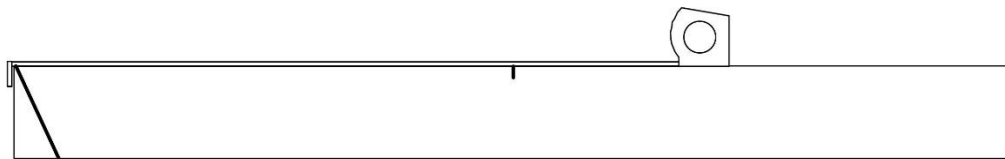
Step 3.   Using the unit rise and 17", draw the building plumb from the mark made in step 2.
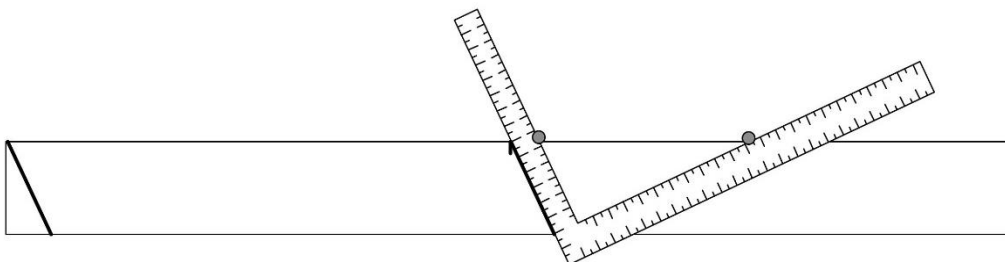
Step 4. Next, measure down along that plumb line the 2 1/2" HAP of the commons. Slide the framing square until the blade of the square is on the 2 1/2" mark and draw the level line.

Drop

Before we continue with our layout, we need to discuss the idea of backing or dropping the hip rafter. If a line is run across the tops of the common rafters, the edges of the hip will be in the way. This would cause a high spot in the sheathing. There are two ways to prevent this. One way is to back the hip rafter. This mean that the high edges of the hip rafter are planed or cut down.

This illustration shows a hip that has been chamfered (backed).

Chamfering is time consuming and therefore, not the preferred method. The second way is to do what is known as dropping the hip. This is achieved by taking more out of the seat cut of the hip. This drops the hip down enough that the sheathing will plane in correctly. The amount of the drop is one half the thickness of the hip, which in this case is 3/4".

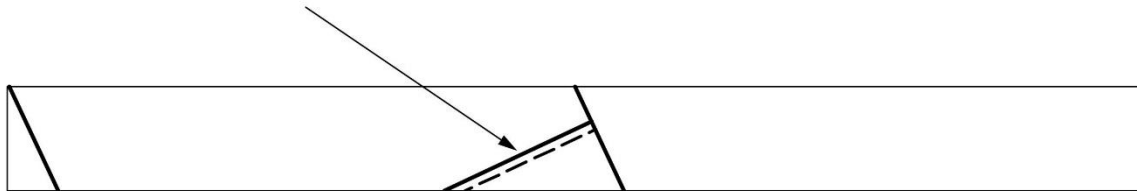Step 5. Without moving the square, measure 3/4" from the plumb side of the square.
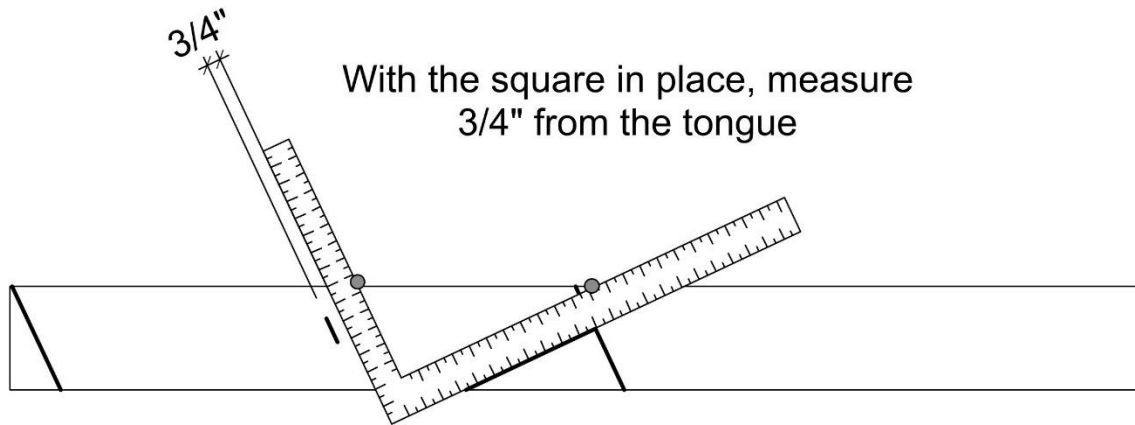
Step 6. Advance the square until it is on the 3/4" mark.
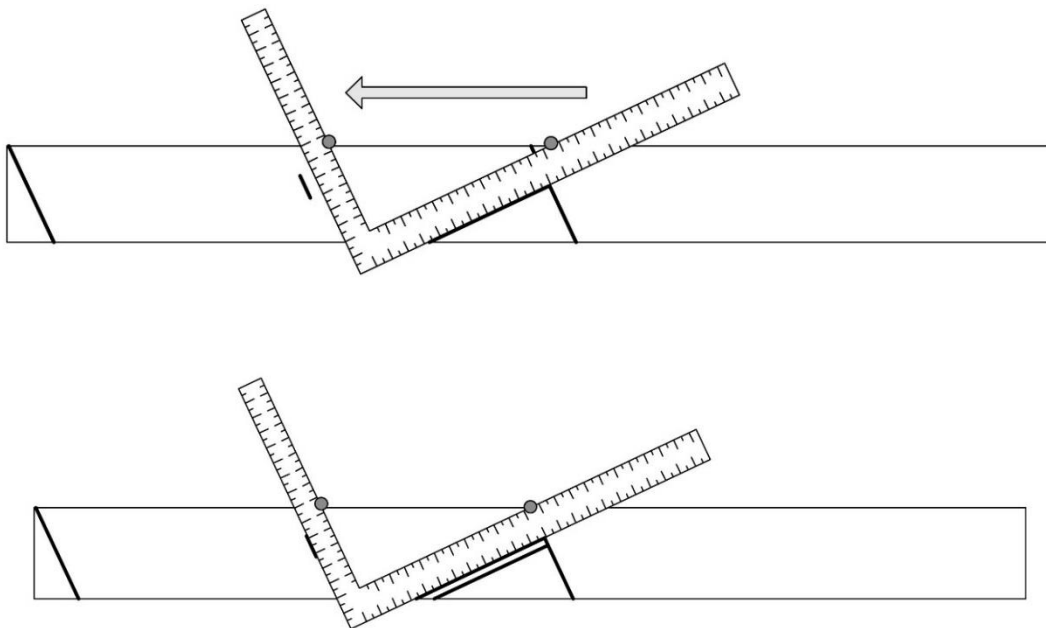
Step 7. Mark the new level line. This is the line that should be cut.

Cut on this line, this is the drop

Shortening the Hip

After laying out the seat cut, we will return to the top of the rafter. Just as we did with the common rafters, we need to shorten the hip so that it will be the correct length.

As we learned in the last lesson, there are roof framing points which are the points where the centers of the rafters meet. Our theoretical length has been figured to the framing point, so material must be removed to accommodate the ridge board.

3/4" at 90 degrees   2 1/8" at 45 degrees

1 1/2"
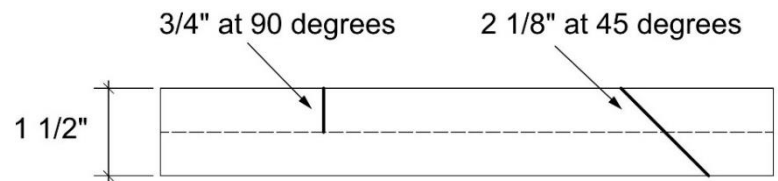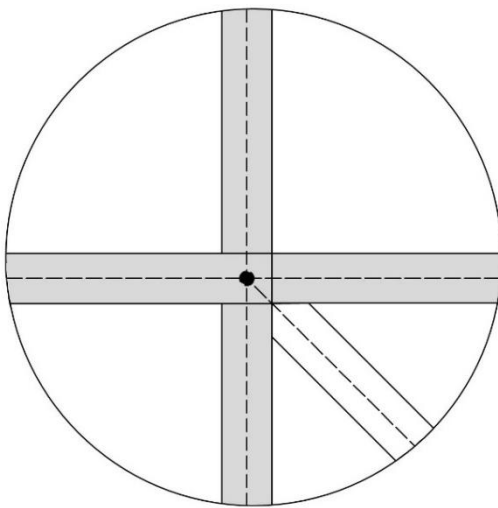
As seen above, the hip intersects the 1 1/2" ridge at a 45° angle. A 45° line across a 2x measure 2 1/8", however, since we are only going halfway across the ridge, the hip must be shortened half of the 2 1/8", which equals 1 1/16".

Shortening is always done at a 90° to the plumb line, so measure back 1 1/16" from the plumb line.
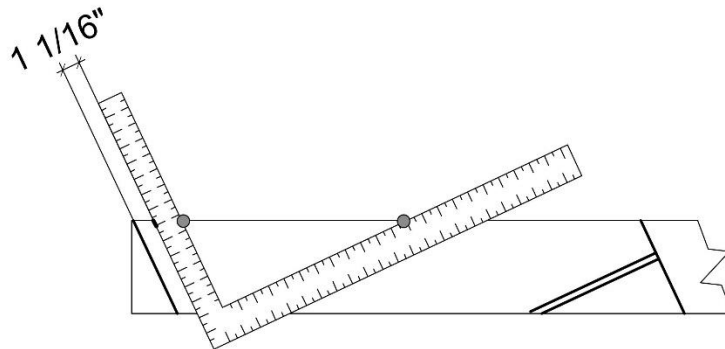
We have been working on the side (5 1/2") of the hip so far, now we need to work on the top of the hip. Square a line across the top of the rafter from the shortened mark.
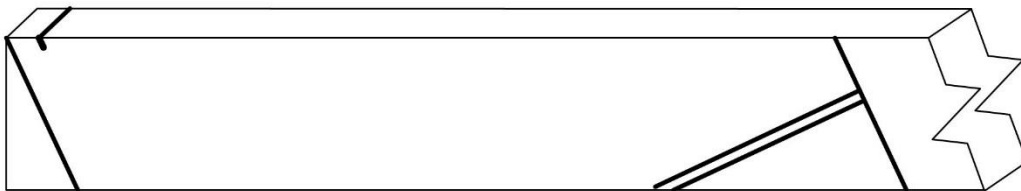
For the hip to fit against the two common rafters, it will need to have a double cheek cut so that it will come to a point. Since the point needs to be in the center of the rafter, find and mark the center of the board.
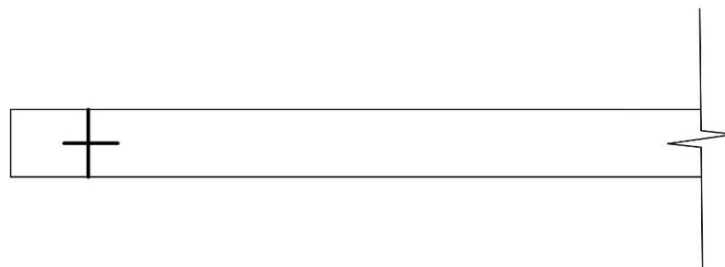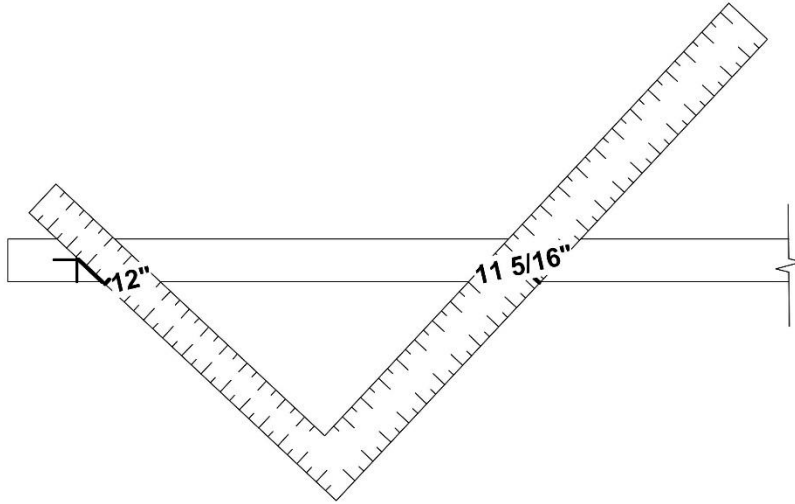
Side Cuts

To compensate for the fact that the hip is intersecting the ridge at an angle, the hip will need to have side cuts at the top of the hip to correctly meet the ridge and the commons. The angle of the side cut varies with the pitch of the roof. As shown here, the side cut is different from a 45° angle
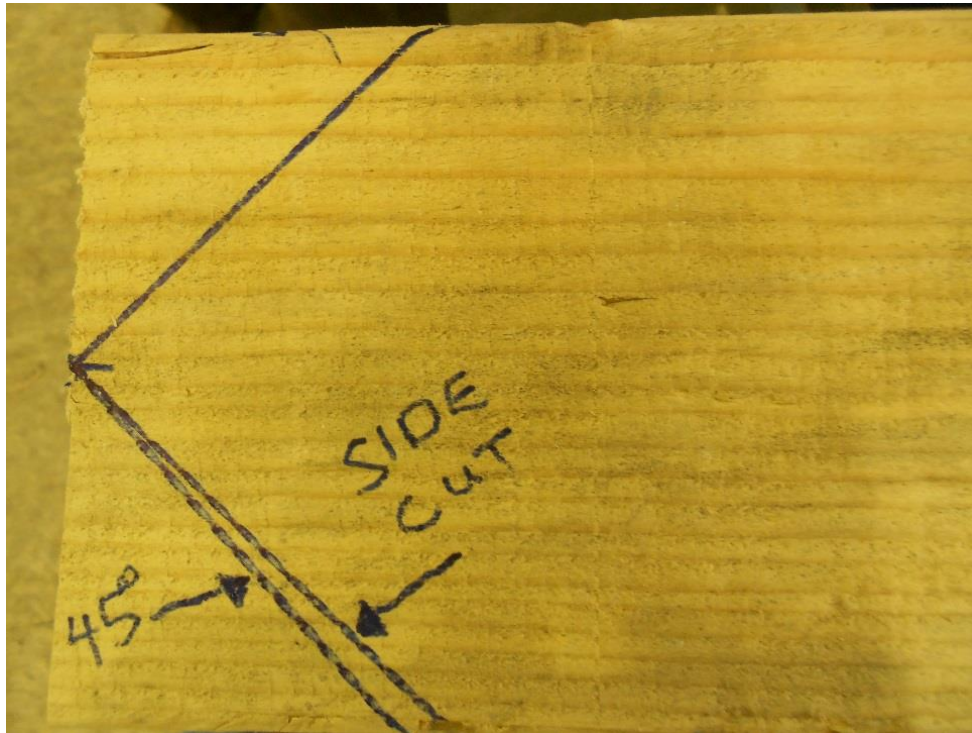

The rafter table on the framing square tells what numbers to use to create the proper angle. The last line on the table reads "SIDE CUT HIP OR VALLEY USE" and under each unit rise there is a number. For example, on the square below, the number given is 11 5/16".

LENGTH	COMMON	RAFTERS	PER FOOT	RUN	21	63		13	42	13	00	12	65	12	37
11	HIP OR	VALLEY	11 11	11	24	74		18	00	17	69	17	44	17	23
DIFF	IN LENGTH	OF JACKS	16 INCHES	CENTERS	28	84		17	875	17	33	16	87	16	49
11	11	11	2 FEET	11	43	27		26	83	26		25	30	24	74
SIDE	CUT	OF	JACKS	USE	6	¹¹⁄₁₆		10	³⁄₄	11	¹⁄₁₆	11	³⁄₈	11	⁵⁄₈
11	11	HIP OR	VALLEY	11				11	⁵⁄₁₆	11	¹⁄₂	11	¹¹⁄₁₆	11	¹³⁄₁₆

The second number to lay out the side cut is always **12"**. Thus, to lay out the side cut of a 6 and 12 roof, you would use 11 5/16" **and 12".**

Always mark the 12" side of the square, this is the side cut. Once this is done, square across to the other side of the board. Next draw a new plumb line from the side cut mark down the side of the hip. This is the short point cut line. Set the saw at 45° and cut both sides of the hip.
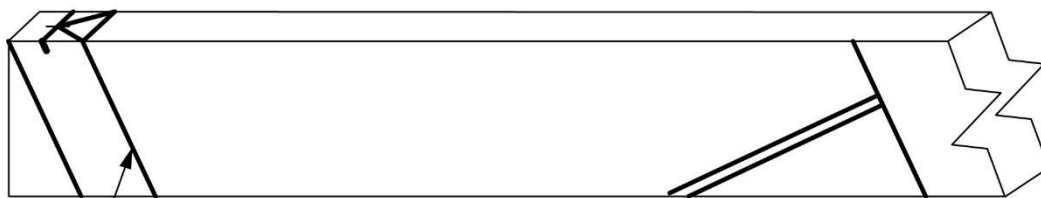
Set saw at 45 degrees
and cut this line.
Repeat on the
other side

The hip is almost complete, now it is time to lay out the tail. When laying out the tail of the common rafter, we stepped off the overhang. With the hip, we will instead, calculate the length of the tail and then lay it out. To calculate the length of the tail, simply take the amount of overhang (in feet and decimals) and multiply it by the hip unit length. For example, if I wanted a 9" projection on a 6 and 12 pitched roof, the math would look like this:

9÷12 = .75'

.75' x 18.00 (the unit length for a 6 and 12 hip) = 13.5"

.5 x 16 = 8/16 or 1/2"

The overhang on the hip will measure 13 1/2" from the building line to the point of the tail.

total calculated
length of the overhang
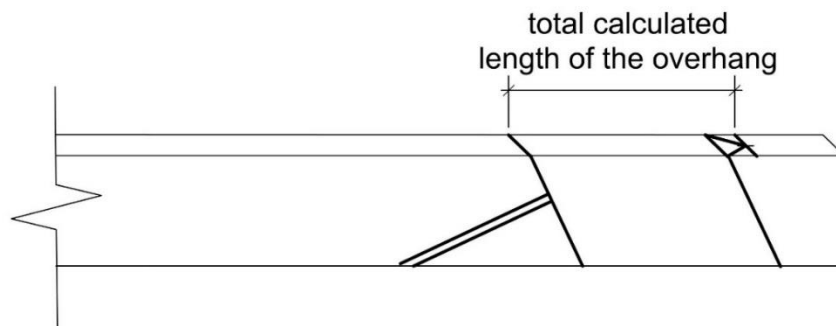
The same side cuts that were made at the top of the rafter will also be used to lay out the tail. The plumb line (unit rise & 17) will match those at the ridge and the building line. Before installing the hip, rip the tail down to 3 1/2" so that it will be the same as the common tails.

3 1/2"
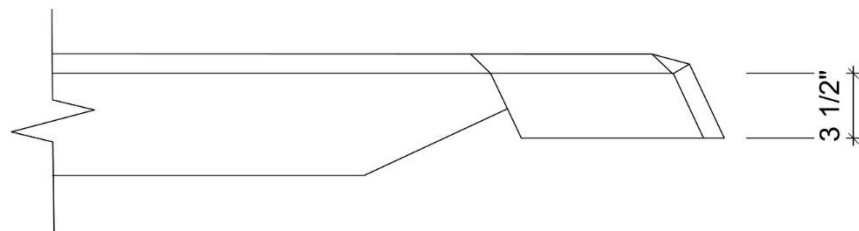
This completes the layout of the hip. Cut one hip and try it, if it fits well, then make another the same length. The hip should be placed so that the center of the hip is directly over the corner. When the hip is in place, the top edges should line up with the commons and the tip of the hip should be lower by the amount of the drop.

Lesson 4

An intersecting roof consists of two or more roof sections sloping in different directions. If the two sections of the roof are the same width, they are known as equal spans. If they are different widths, then they are known as unequal spans. Our projects have unequal spans, one at 6' and the other at 4'. A hip rafter goes from the ridge to an outside corner of the building, a valley goes from the ridge to an inside corner.


Valley at inside corner

Hip at outside corner
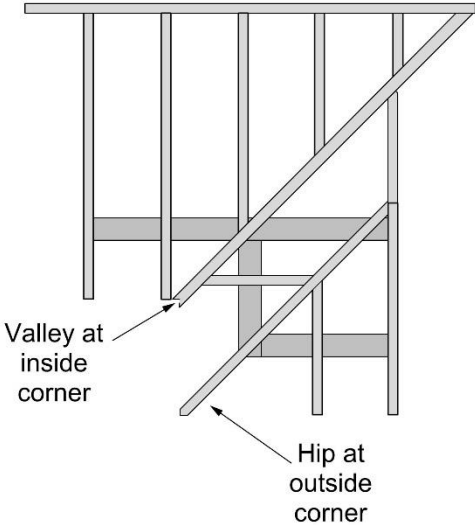
The transition between the two spans will involve using a supporting valley and a shortened valley.



Supporting valley

Shortened valley
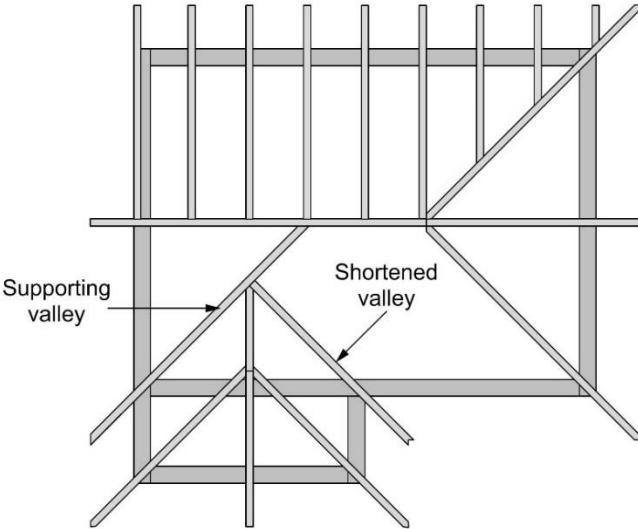
As can be seen, the supporting valley is a part of the major span, it is the same theoretical length as the previously cut hips. The second line on the framing tables it says "LENGTH HIP **OR VALLEY** PER FOOT OF RUN". Just like hips, valleys run at a 45° angle to the ridge. A valley, unlike a hip, does not need to be dropped or chamfered.

The placement of this valley is centered on the 6' mark on the project. The placement on the ridge is 3' from this corner. Where the valley intersects the ridge, a single cheek cut is required. Since the valley is running at a 45° angle, the amount to be shortened is 1 1/16".
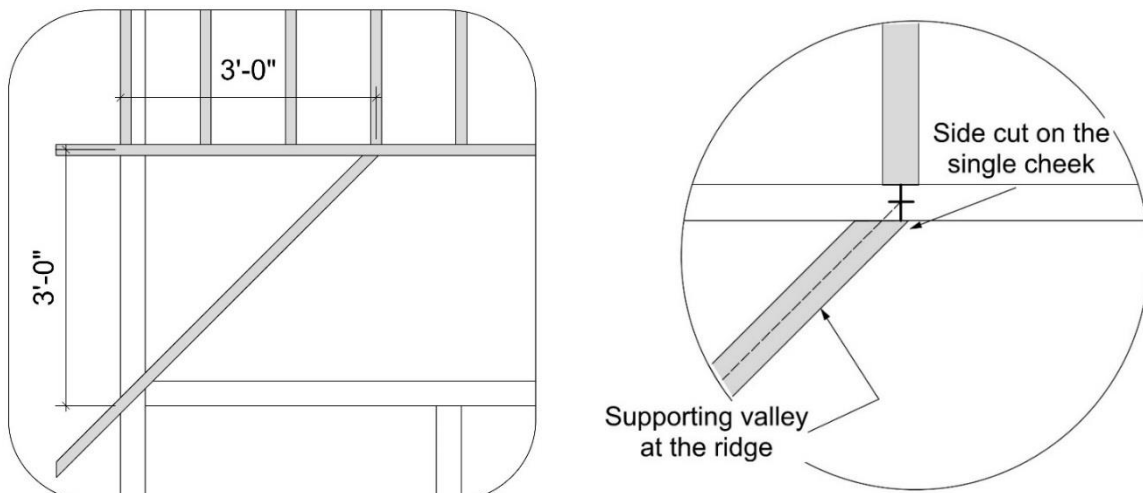

At the bottom of the rafter, mark the theoretical length, find the center and then mark a side cut across the center.
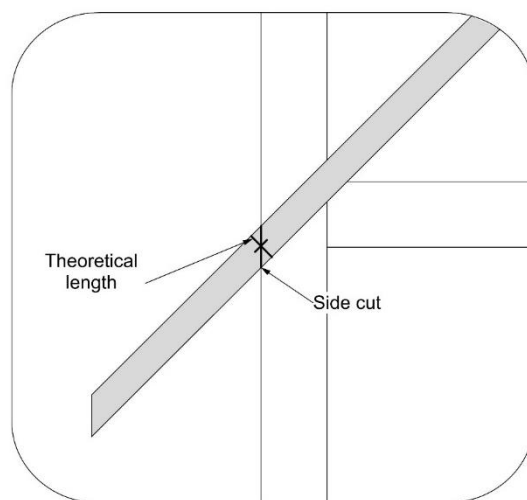
Remember that this is a valley, not a hip, therefore, it does not need to be dropped. Hips drop, valleys don't.

The shortened valley is a part of the minor span, so it needs to be calculated on the total run of that span rather than the major span. Again, to attain the total length, multiply the total run x the unit length of a hip or valley. The valley is called a shortened valley because it wants to run from the plate to the ridge. Instead, it intersects with the supporting valley at a 90°.
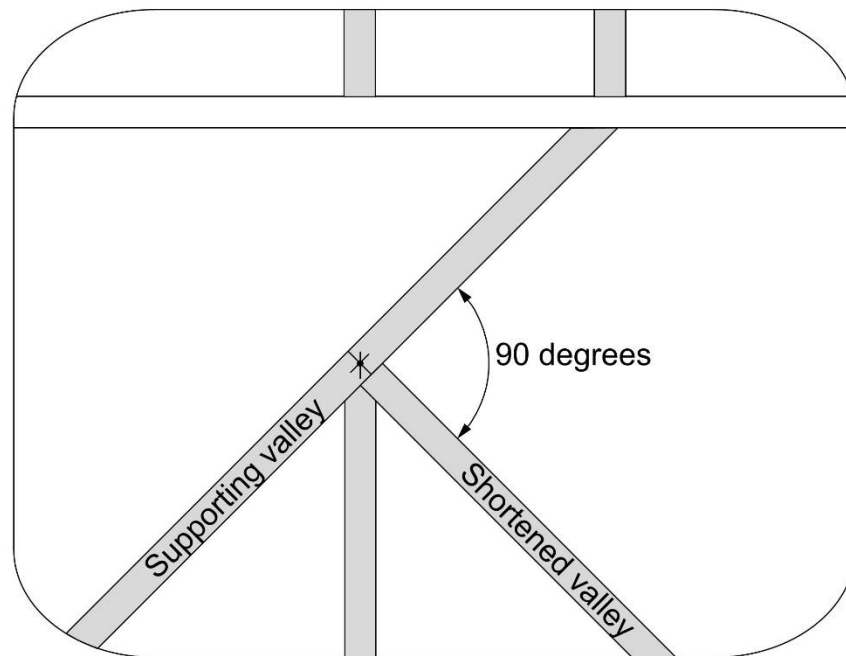
The seat cut of the shortened valley requires some precision to lay out and cut. The seat cut needs to come to a point and fit against both walls.
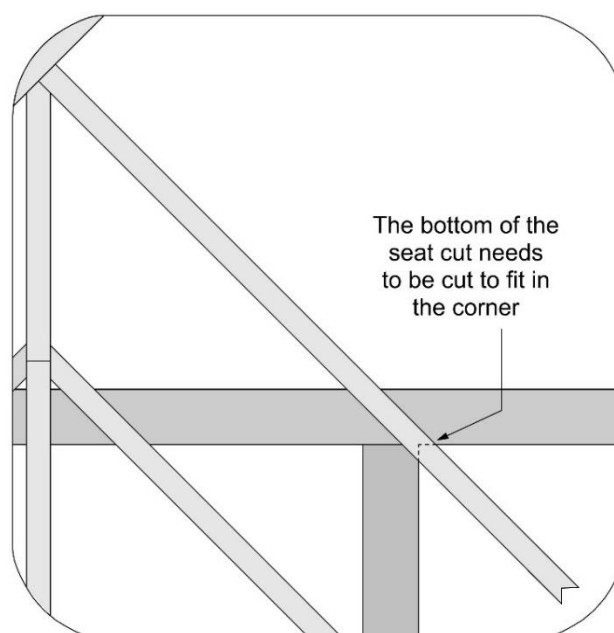
Step 1. Calculate the theoretical length and mark it on the 2 x 6.

Mark the theoretical
length and square
it across. Next, mark
the center of the
board
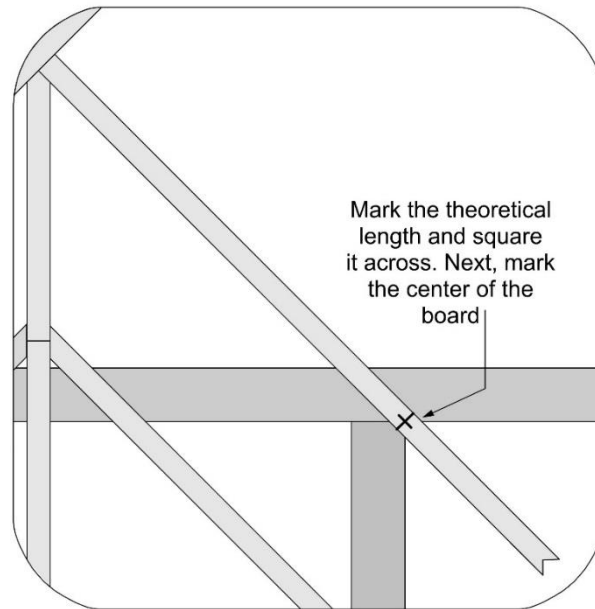
Step 2.   Using the side cut number given **and 12**, mark the side cuts out from the center
mark.

Mark the side cuts
and square across
the short point
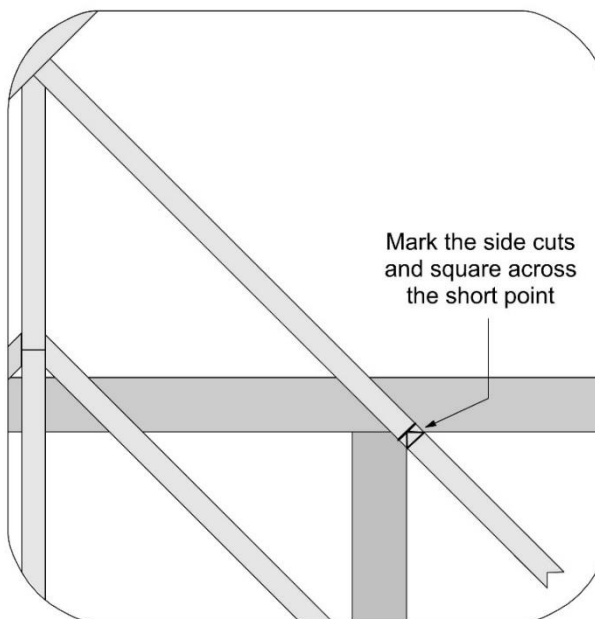
Step 3.   Working on the side of the valley, lay out the seat cut from the theoretical line. Measure down the 2 1/2" HAP and draw a level line using the unit rise and 17". Let the level line run past the plumb mark. Draw a plumb line from the short point of the side cut on both sides of the rafter.

2 1/2" HAP
Let the level line run
past the first plumb
line
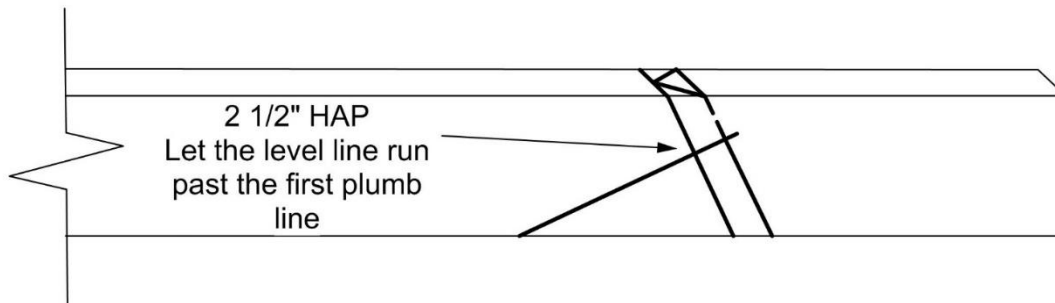
Step 4.   Cut the level line with the saw set at 90°. Cut the plumb line at 45°.

Cut the level
cut at 90 degrees

Cut the plumb
line at 45 degrees
to the level line.
Repeat on the
other side
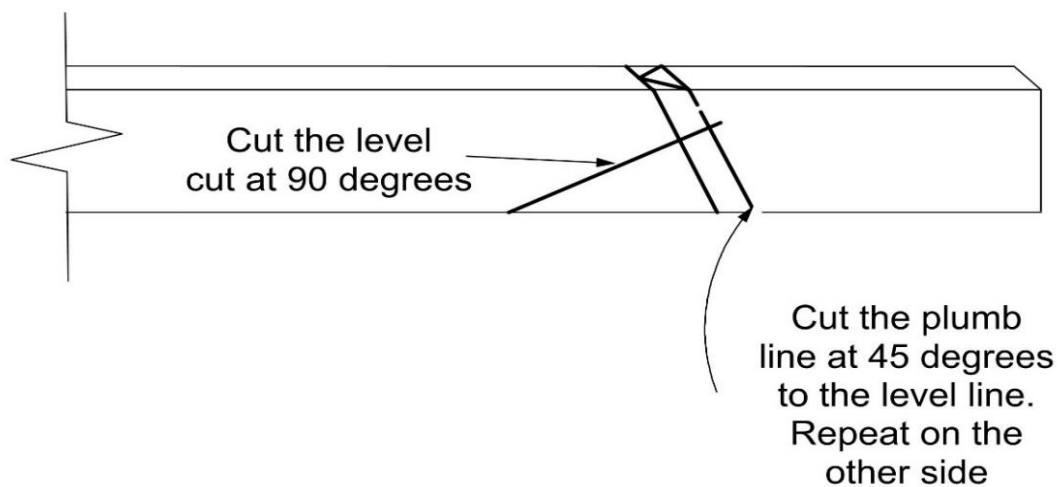
Step 5.   Lay out the tail with the same theoretical length as the tail on the hips.

Theoretical length
of overhang
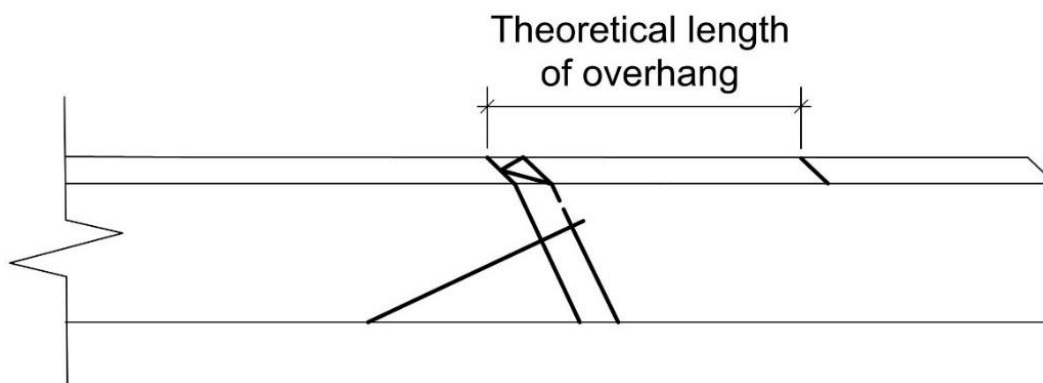
Step 6.	From there, lay out two side cuts from the center of the theoretical point.
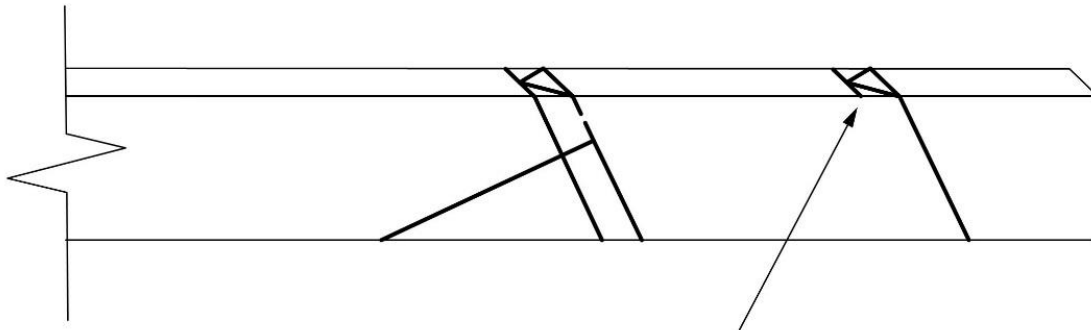
Side cut the tail down the rafter from the theoretical length

Step 7.	Cut the plumb lines at a 45° angle, being sure to set the blade at the proper depth so that the cut only goes halfway into the "vee". Rip the tail down to 3 1/2"

3 1/2"

Because the shortened valley meets the supporting valley at a 90° angle, the valley is shortened by 3/4" with a square cut at the top.

The placement of this rafter is important. As shown below, pull up the calculated length of the shortened valley from the theoretical length of the supporting valley. This will be where the center of the shortened valley goes.
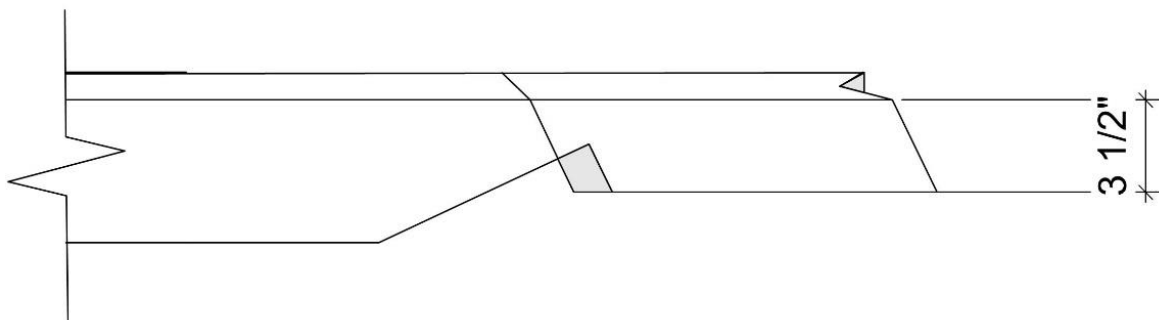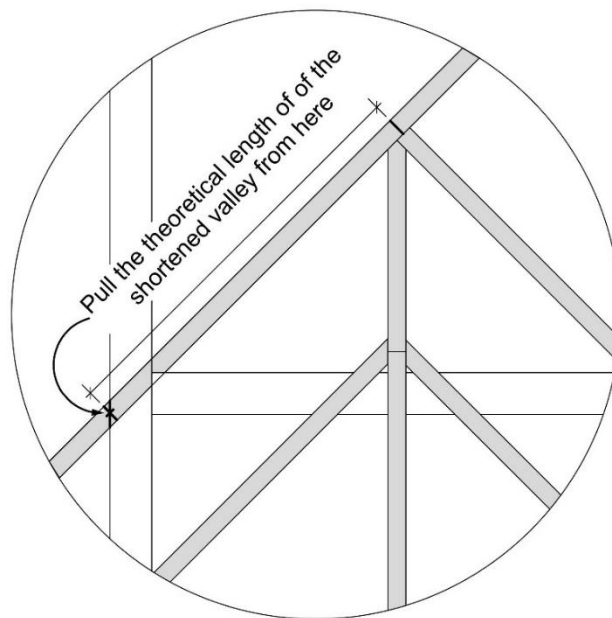

After the two valleys are cut and installed, you can focus on the other rafters of the minor span, specifically, two more hips and a king common. All of these rafters will be calculated using the total run of the minor span. The project will need only one commons. Remember when laying out the hips to include the drop.

The two spans are different which means that the ridges are at different elevations. The length of the minor ridge is equal to the amount of the pop-out section of framing.

Equal
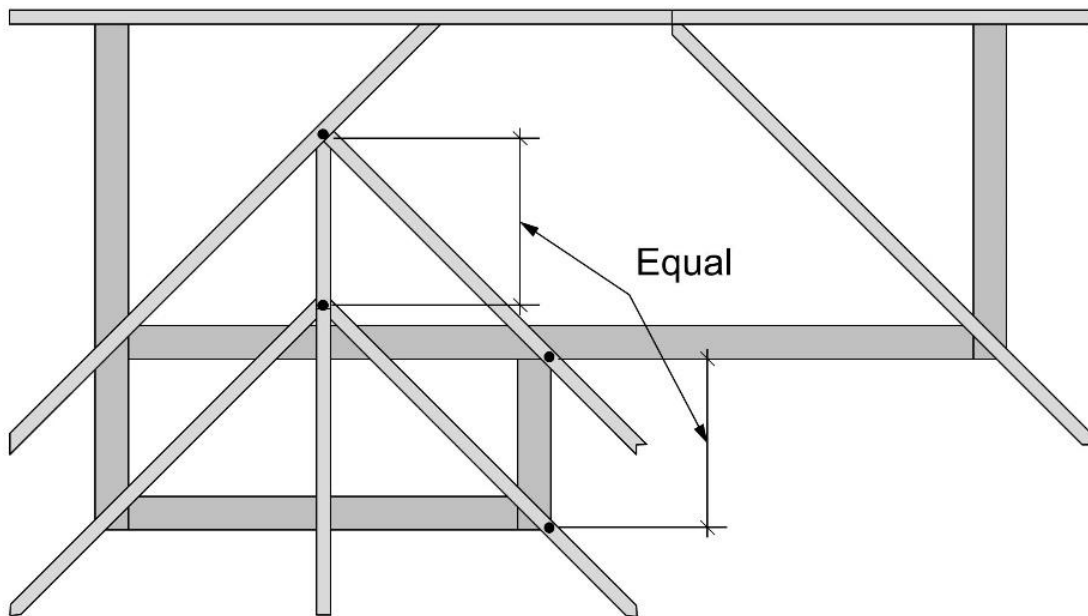
Since the king common has been shortened the ridge needs to be extended to reach the king common. At the other end, the ridge needs to be shortened 1/2 the width of the supporting valley at a 45° angle. Once the ridge is cut, the assembly of the minor span hips and common(s) can take place.

Once the hips, valleys and commons are in place, it is time to fill in the gaps with jack rafters. Think of jacks as interrupted commons. That is, they are laid out using the unit rise and a 12" unit run. The theoretical length of a jack can be found by several methods.

One way of calculating jack length is given on the framing square. As seen below, the third and fourth lines on the rafter tables read: "DIFFERENCE IN LENGTH OF JACKS 16 INCHES CENTERS" and "DIFFERENCE IN LENGTH OF JACKS 2 FEET CENTERS".

What is shown is the amount that is subtracted from the common rafter to calculate the length for each subsequent jack rafter. For example, if you have a 5 and 12 pitch and your common rafter is 11'- 4 1/2" with a spacing of 16" on center, the length of the first jack can be determined like this:

Follow the third line on the rafter table to the 5" mark.

The number 17.33" is the amount to be deducted from the common.

       .33 x 16 = 5.28/16ths, which rounds to 5/16"

       11'- 4 1/2" − 17 5/16" = 9'- 11 3/16"

Thus, the theoretical length of the first jack will be at 9'-11 3/16".

The next jack would then be 9'- 11 3/16" − 17 5/16" and so on.

Another method of calculating the jacks would be to take the run of the common and subtract the 16" spacing from the total run. This can then be multiplied by the unit common length.

In the example above, the total run is 10'- 6". Subtract the 16" at that leaves a run for the jack of 9'-2".

9.1666' x 13" (unit length for a 5" unit rise) = 9'- 11 3/16"

As can be seen, both methods give us the same answer.

Types of Jacks

The type of jack rafter is determined by what the jack intersects:

If the jack runs from the plate line to the hip, it is a hip jack.

If the jack runs from the ridge to the valley, it is a valley jack.

If the jack runs between the hip and the valley, it is a hip-valley cripple jack.

If the jack runs between one valley and another valley, it is a valley cripple jack.

Hip Jacks

Since hip jacks land on the outside plates, they lay out like any common. That is, their unit run is 12" and the HAP and the tail are the same as the full length commons. At the top end of the jack, a single cheek cut is needed where the jack meets the hip. Hip jacks are cut in pairs, both exactly the same with the long sides opposing each other.
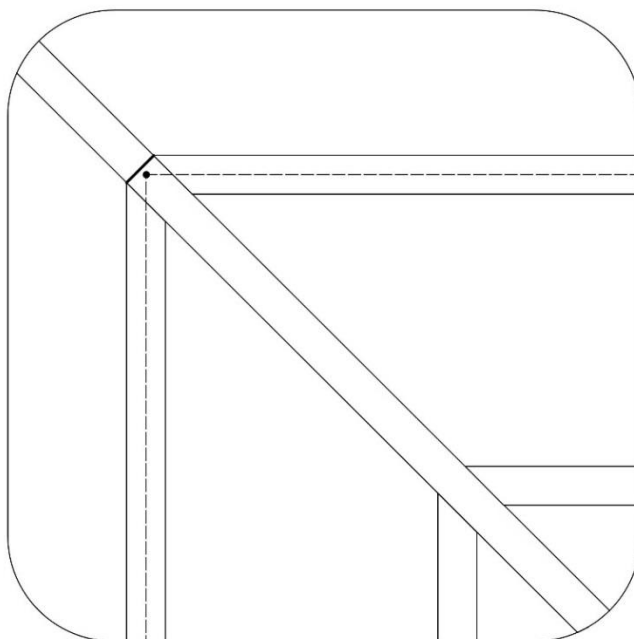
You can usually trace one hip onto the other and then cut the long point in the opposite direction. When the building is out of square or the hip is not at a true 45°, the jacks will not line up.

Another consideration when cutting hip jacks is the need for a side cut. For example, when laying out a hip jack, begin by pulling the theoretical length and marking the seat cut and the tail. Since the jack will be intersecting with the hip rafter at a 45° angle, it will need to be shortened by 1 1/16".
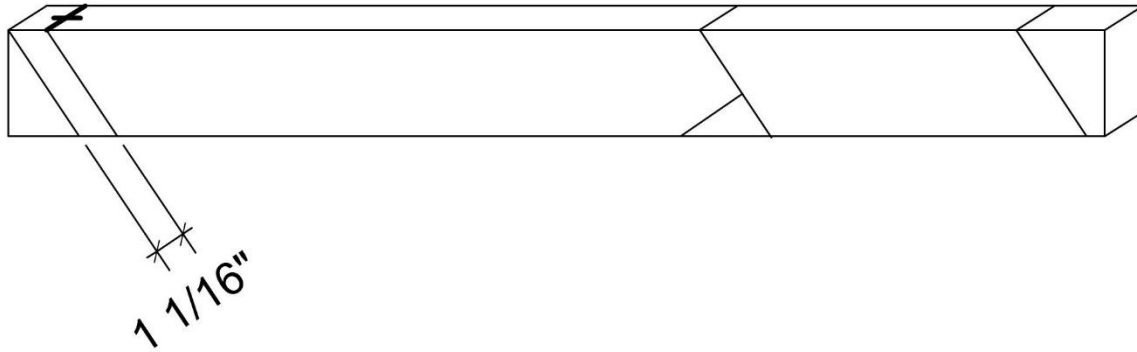
From the shortened mark, square across top and find the center of the hip jack. As with the hips and valleys, the jacks also use a side cut. However, the side cut for the jacks will use a different number than those of the hips and valleys. This is because the hip jack is running at an angle to the hip, which is also running at an angle. On the framing square rafter tables, the 5th line says "SIDE CUT OF JACKS USE"

The number shown is still combined with **12",** and this 12" is still the side that is marked. In the example below, which is an 8 and 12 pitch, the side cut numbers are 10" and 12".
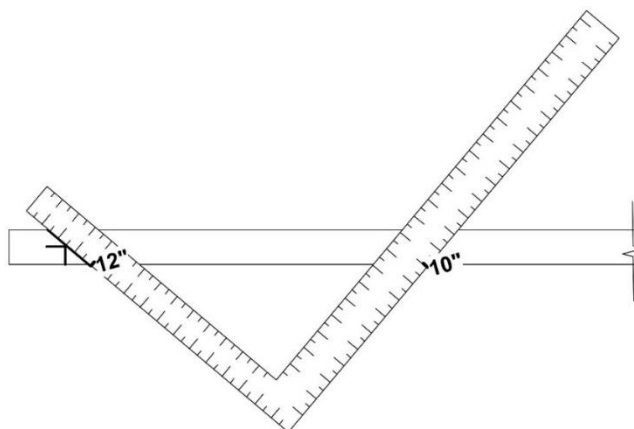
Once the side cut is marked, use the unit rise and 12" to layout a new plumb cut. Cut the line on a 45°. Remember, for hips jacks you need a pair for each length.
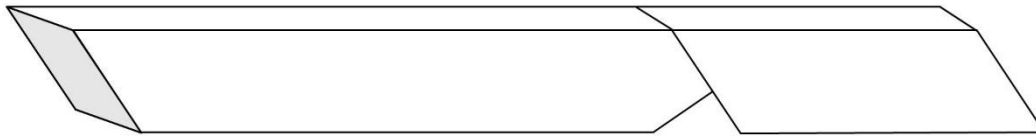
Valley Jacks

A valley jack also begins with calculating the length. Once the length is established, mark the theoretical length on the board. There is no tail or seat cut on valley jacks. Valley jacks need to be shortened at both ends.
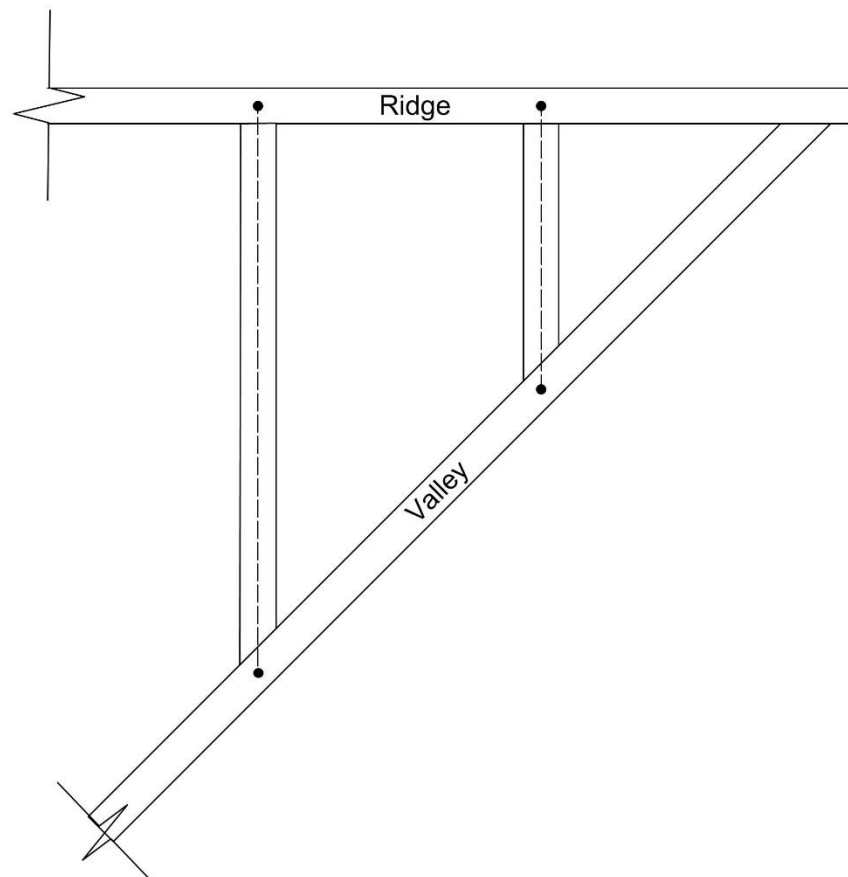
Where the valley jack intersects the ridge (90°), it must be shortened 3/4", and where it intersects the valley (45°), it must be shortened by 1 1/16".

When nailing the valley jack to the valley, hold the jack up enough so that the top of the jack planes into the center of the valley.
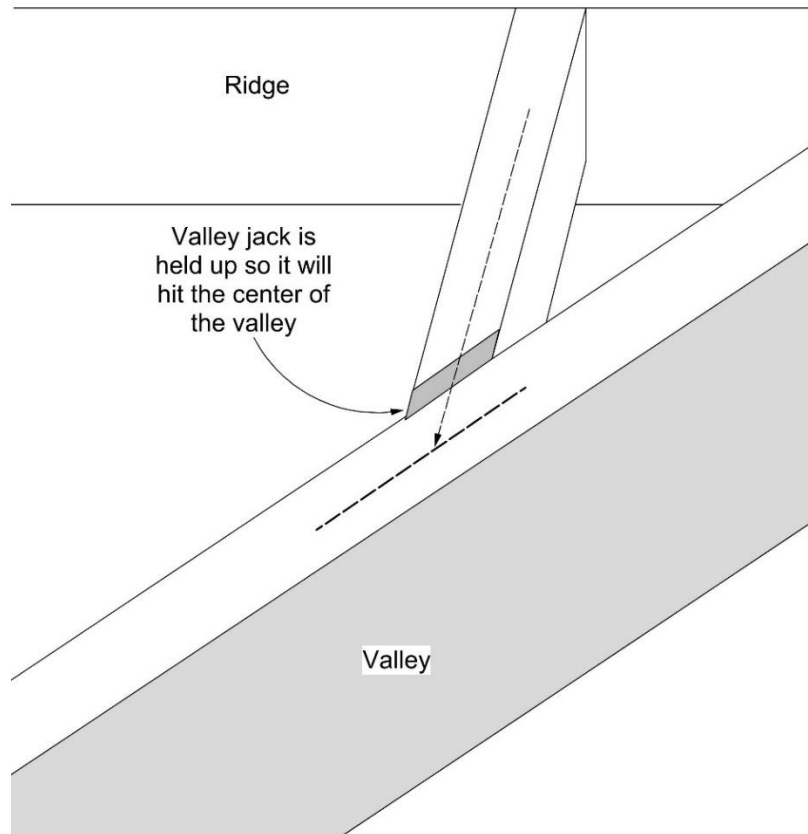
On our projects, the spacing of the commons is 12" o.c., so if you use the rafter table common difference, you must take the difference for 24" centers and cut that in half.

Once the full length rafters are installed, fill in all the jacks on your project.
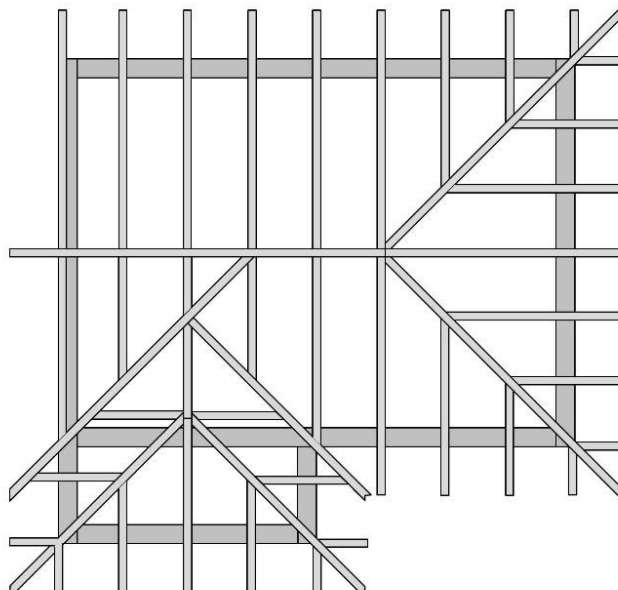
016 UBC CHAPTER 3

STUDY GUIDE

Identify the rafter part shown by writing the letter next to the correct term.
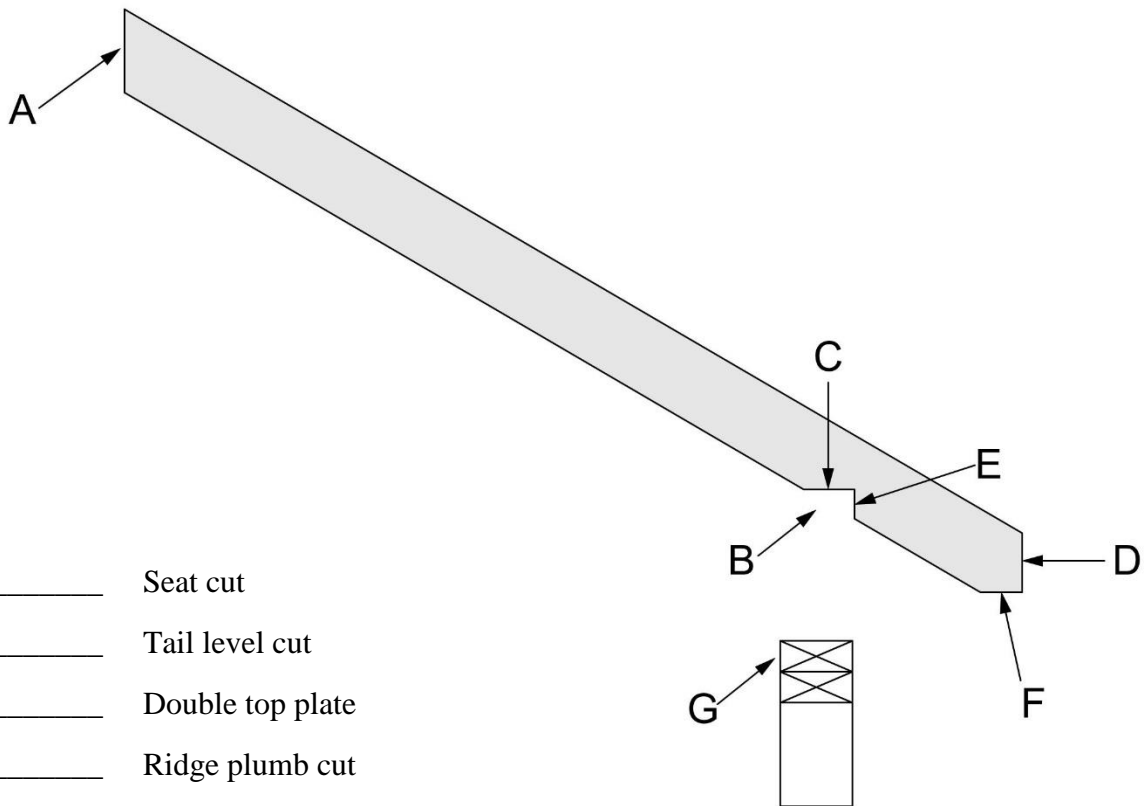
1. _____   Seat cut

2. _____   Tail level cut

3. _____   Double top plate

4. _____   Ridge plumb cut

5. _____   Heel plumb cut at building line

6. _____   Birdsmouth

7. _____   Tail plumb cut

8. The inches of rise per foot of run, is known as?

      a. Unit rise

      b. Total rise

      c. Line length

      d. Total run

9. The horizontal distance measured from outside of wall to outside of wall is:

      a. Total run

      b. Unit run

      c. Total rise

      d. Span

10. A view that shows an object or building as if it were cut vertically or horizontally is called?

      a. A floor plan

      b. An elevation

      c. A section

      d. A overhead view

11. This is the highest horizontal framing member that the rafters attach to.

      a. The plate

      b. The ridge

      c. The hip

      d. The common

Identify the rafter dimension shown by writing the letter next to the correct term.
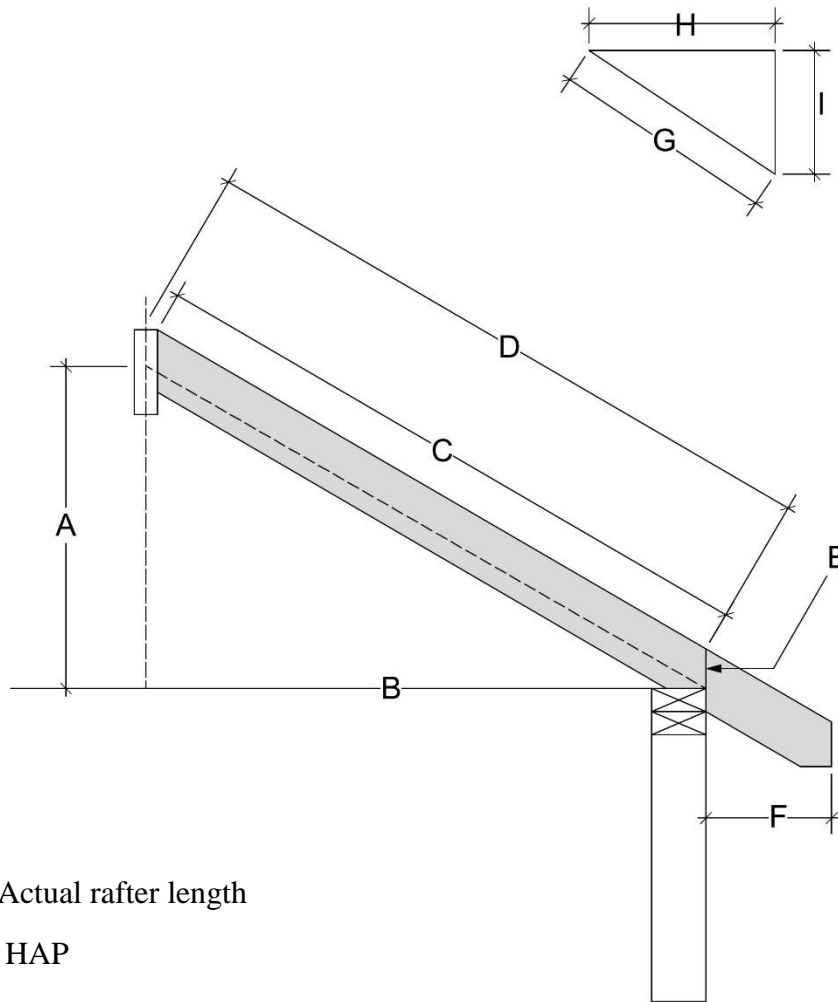
12. _____   Actual rafter length

13. _____   HAP

14. _____   Unit rafter length

15. _____   Total rise

16. _____   Line length (Theoretical length)

17. _____   Unit rise

18. _____   Projection

19. _____   Unit run

20. _____   Total run

NOTES:

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STUDY GUIDE

Identify the rafter part shown by writing the letter next to the correct term.
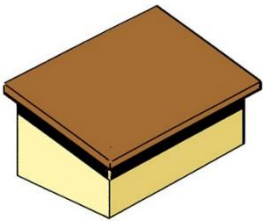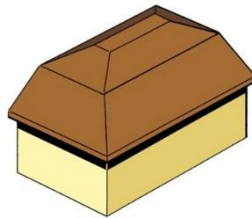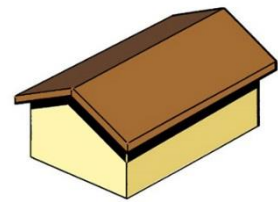
A   B   C
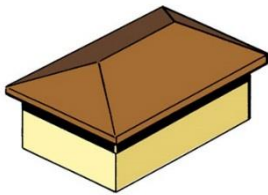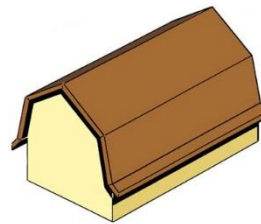
D   E

Identify the types of roof shown above by filling in the letter next to the type.

1. Gambrel   _____

2. Hip   _____

3. Shed   _____

4. Gable   _____

5. Mansard   _____

6. Extreme weather conditions may require the use of these to secure the roof to the frame.

    a. Metal connectors   b. Purlins

    c. Collar ties   d. All of above

7. What is the most common style of roof?

    a. Hip   b. Shed

    c. Gable   d. Gambrel

8. The weight and pressure of wind and snow are what kind of roof load?

    a. Dead load

    b. Axial load

    c. Tensile load

    d. Live load

9. What is the total rise of a roof with a span of 32' and a 6" unit rise?

    a. 8'- 0"   b. 16'- 0"

    c. 9'- 0"   d. 17'- 0"

10. A horizontal member placed beneath and perpendicular to the rafters to provide support is called:

    a. Collar tie   b. Purlin

    c. Gable stud   d. Outrigger

11. Which of the following roofs is the strongest type?

    a. Hip   b. Shed

    c. Gable   d. Gambrel

016 UBC CHAPTER 4

STUDY GUIDE

1. This is the length of the rafter per foot of run?

     a. Unit rise   b. Unit run

     c. Unit rafter length   d. Slope

2. This measurement is one half of the span.

     a. Total run   b. Unit run

     c. Total rise   d. Unit rise

3. This is the mathematical length of the rafter from the center of the ridge to the building line?

     a. Total rafter length   b. Actual rafter length

     c. Line length   d. None of the above

4. This is the distance from the center of the ridge to the end of the rafter tail.

     a. Line length   b. Total rafter length

     c. Unit rafter length   d. The stock length

5. The tongue of the framing square is used mark which part of the rafter?

     a. The unit rise   b. The unit run

     c. The unit length   d. The level cuts

6. The blade of the framing square is used mark which part of the rafter?

     a. The unit rise   b. The unit run

     c. The unit length   d. The plumb cuts

7. The ridge board is usually:

    a. One size smaller that the commons   b. The same size as the common rafters

    c. One size larger than the common rafters   d. It does not matter
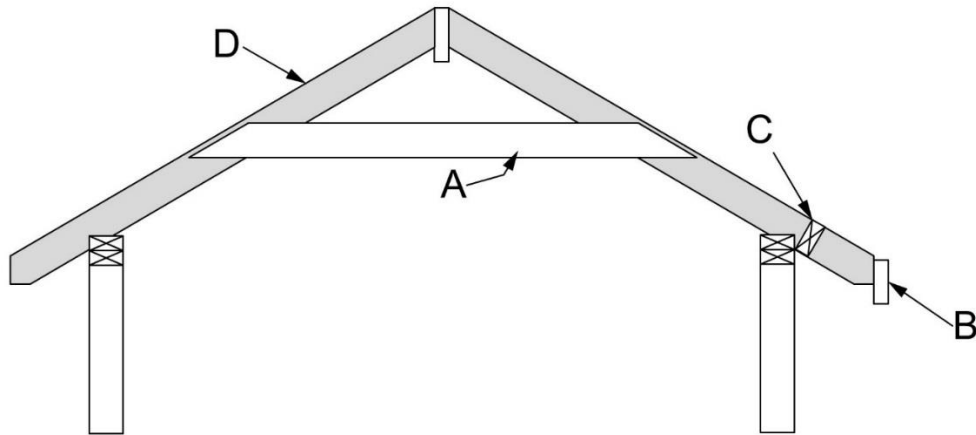
8. In the drawing above, the letter A is pointing to what part of the roof?

    a. Common rafter   b. Fascia

    c. Collar tie   d. Freize block

9. In the drawing above, the letter B is pointing to what part of the roof?

    a. Common rafter   b. Fascia

    c. Collar tie   d. Freize block

10. In the drawing above, the letter C is pointing to what part of the roof?

    a. Common rafter   b. Fascia

    c. Collar tie   d. Freize block

11. In the drawing above, the letter D is pointing to what part of the roof?

    a. Common rafter   b. Fascia

    c. Collar tie   d. Freize block

12. When installing roof sheathing, which of the following is called for?

      a. Stagger the end joints of the sheathing

      b. Leave a 1/8" gap between panels

      c. Use panel edge clips for support of the long edges of the sheathing

      d. All of the above

13. The ridge plumb cut must be shortened (adjusted) an amount equal to what thickness of the ridge material?

      a. 3/4

      b. The whole thickness

      c. 1/2

      d. 2/3

NOTES:

016 KOEL UNIT 47

STUDY GUIDE

1. The most common spacing for the placing of roof rafters is:

   a. 16" o.c.   b. 24" o.c.

   c. 12" o.c.   d. 18" o.c.

2. Layout for the rafter should be done on:

   a. The ridge board

   b. The top plate

   c. The top plate and the ridge board

   d. None of the above

3. The run of a shed roof is:

   a. The total span of the building

   b. The total span of the building minus two wall thicknesses

   c. The total span of the building minus one wall thickness

   d. The total span plus one wall thickness

4. What should be used to frame the gable end of a roof?

   a. Sheathing

   b. Purlins

   c. Jacks

   d. Gable studs

5. To mark the plumb cut of a common rafter with the steel square, the carpenter should combine the unit rise with:

      a. 12 inches and mark on the 12 inch side

      b. 24 inches and mark on the unit rise

      c. 12 inches and mark on the unit rise

      d. 17 inches and mark on the unit rise

6. Deducting half of the thickness of the ridge board from the theoretical length is called:

      a. Trimming the rafter

      b. Lengthening the rafter

      c. Shortening the rafter

      d. Adjusting the rafter

7. What method of calculating a common rafter involves marking each foot of rafter length progressively along the rafter?

      a. The framing square rafter table method

      b. The rafter book method

      c. The step-off method

      d. Mathematically

8. What is the term to describe the amount of material remaining above the seat cut?

      a. HPA   b. Rise

      c. HAP   d. Leftover

9. What is the length of a common rafter for a building with a span of 28'- 6" and a unit rafter length of 13.89" (7" unit rise)?

      a. 16'- 5 15/16"   b. 32'- 11 7/8"

      c. 14' -3"   d. 16'- 8 1/8"

10. How is ridge height determined?

    a. Total run x unit rise in inches

    b. Total rise + HAP

    c. Total rise – HAP

    d. Total rise + HAP – drop at ridge

11. How should common rafters be checked for accuracy before others are cut?

    a. Put one in place and see how it looks

    b. Put an opposing pair of rafters up with a piece of wood the size of the ridge   between

    c. Measure the rafter a second time to check yourself

    d. Ask someone else to check it
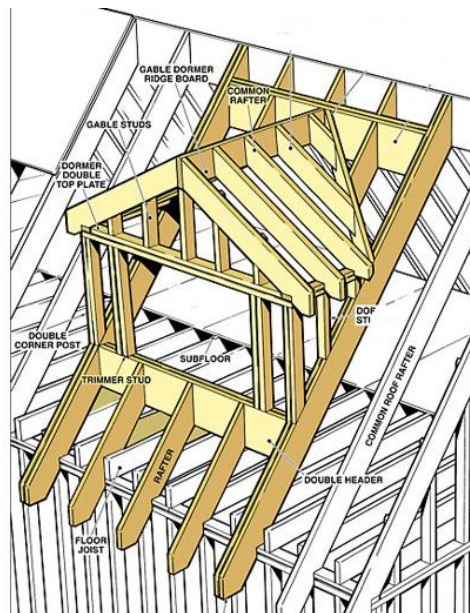
12. What is shown in the above illustration?

    a. Dormer   b. Hip

    c. Pop-out   d. Gambrel

13. To mark the level cut of a common rafter with the steel square, the carpenter should combine the unit rise with:

    a. 12 inches and mark on the 12 inch

    b. 24 inches and mark on the unit rise

    c. 12 inches and mark on the unit rise

    d. 17 inches and mark on the 17 inch

14. What is the length of a common rafter for a building with a span of 33'- 3" and a unit rafter length of 14.42" (8" unit rise)?

    a. 39'- 11 7/16"

    b. 19'- 11 3/4"

    c. 20'- 2"

    d. 19'- 4 3/8"

016 UBC CHAPTER 5

STUDY GUIDE

1. A hip rafter runs at what angle to the outside of the building?

    a. 90°

    b. 45°

    c. 30°

    d. 22.5°

2. To assure that the hip rafter planes in with the common rafters, the hip must be:

    a. Dropped

    b. Backed (chamfered)

    c. Either dropped or backed

    d. Neither dropped nor back

3. What is the unit of run for a hip rafter?

    a. 12"

    b. 16.97"

    c. 16"

    d. 13"

4. The theoretical length of a hip roof ridge is found by taking:

    a. The length of the building minus the span of the building

    b. The span of the building minus the length of the building

    c. The span of the building plus the length of the building

    d. The length of the building plus the span of the building

Identify the rafters to the right.
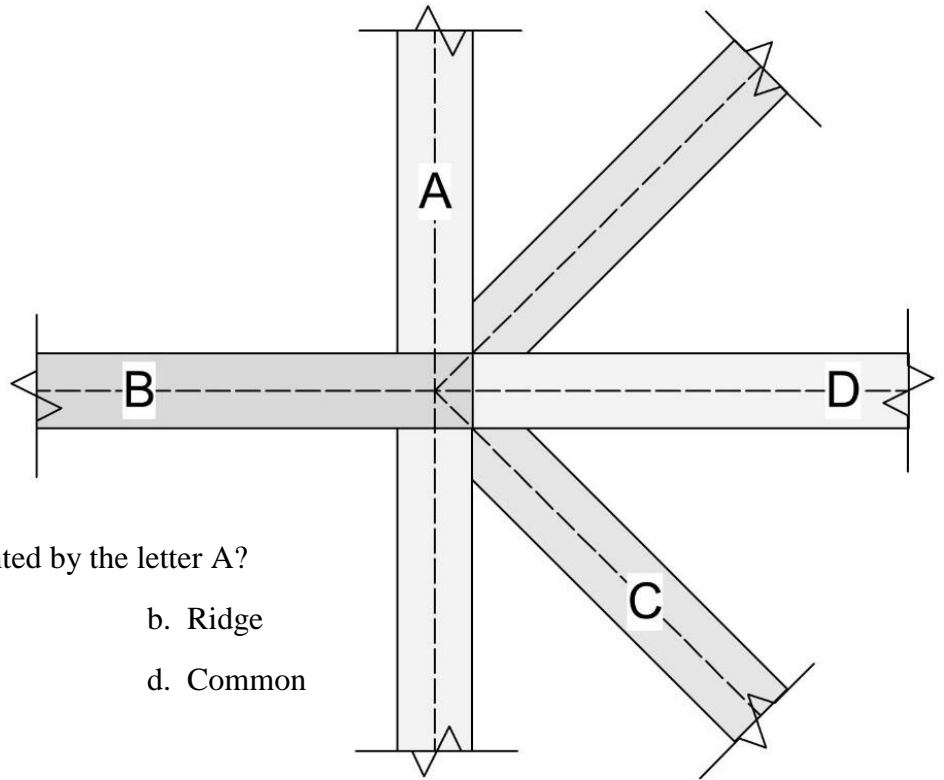
5. What kind of rafter is represented by the letter A?

    a. Hip   b. Ridge

    c. King common   d. Common

6. What kind of rafter is represented by the letter B?

    a. Hip   b. Ridge

    c. King common   d. Common

7. What kind of rafter is represented by the letter C?

    a. Hip   b. Ridge

    c. King common   d. Common

8. What kind of rafter is represented by the letter D?

    a. Hip   b. Ridge

    c. King common   d. Common

9. In the drawing above, what type of cut is needed on the top of the hip?

    a. Square cut   b. Single cheek cut

    c. Double cheek cut   d. Nub cut
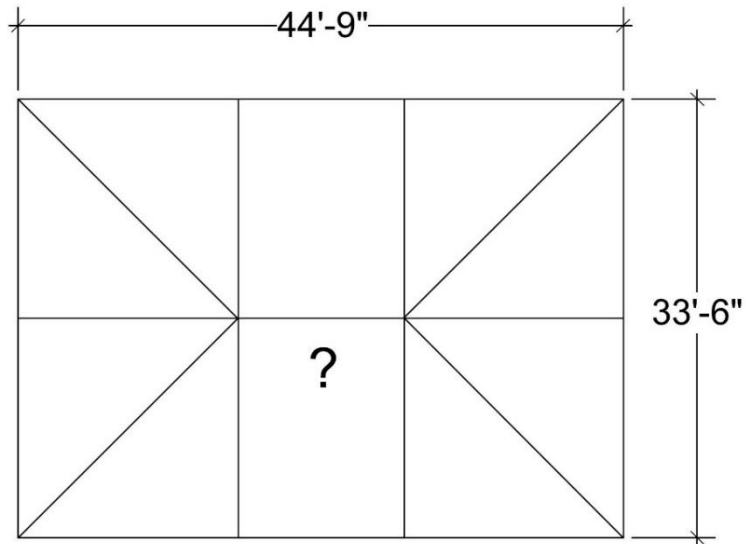
10. What is the theoretical length of the ridge in the above hip roof?

    a. 26' -0"   b. 44'- 9"

    c. 11'- 3"   d. 22'- 6"

11. What is the actual length of the ridge in the hip roof shown below? (the king commons are both 2x material)

    a. 11'- 1 1/2"   b. 11'- 4 1/2"

    c. 11'- 3"   d. 11'- 5 1/2"
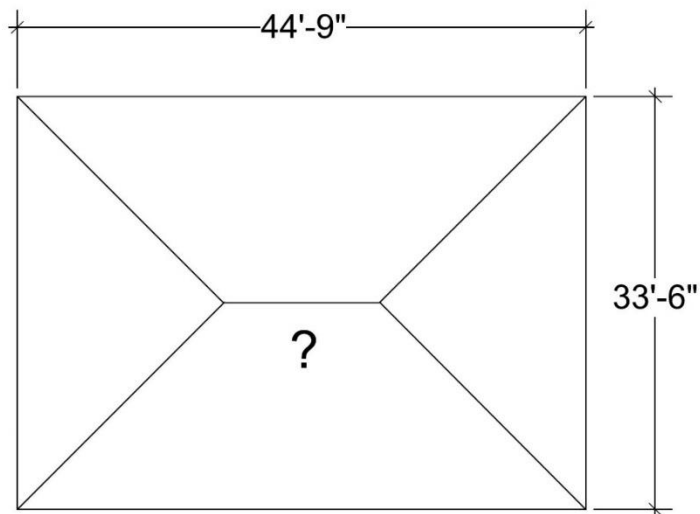
NOTES:

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STUDY GUIDE

1. Which line on the framing square rafter table shows the *length of hip or valley per foot run*?

    a. First line   b. Second line

    c. Third line   d. Last line

2. How does the length of the hip rafter seat cut compare with the length of the seat cut of the common?

    a. It is the same as the common

    b. It is less than the common

    c. It is greater than the common

    d. It depends on the pitch of the roof

3. To layout the hip side cut, use the number shown on the framing square and what other number?

    a. 17   b. 8

    c. 12   d. 16

4. This rafter extends from the end of the ridge board to the top plate.

    a. Hip

    b. Common

    c. Hip jack

    d. King common

5. The first step in laying out a hip rafter is:

    a. Calculate the length

    b. Figure the shortening

    c. Laying out the drop

    d. Laying out the side cuts

6. A hip jack is:

    a. An interrupted hip rafter

    b. An interrupted common rafter

    c. An interrupted valley rafter

    d. None of the above

7. Hip jacks frame the space between:

    a. The hip and the ridge

    b. The hip and the valley

    c. The hip and the wall plates

    d. None of the above

8. When shortening the hip rafter, the amount to be shortened is one-half of the diagonal thickness of the ridge. If the ridge is 1 1/2" thick, the amount to be shortened is:

    a. 1 3/16"   b. 2 1/8"

    c. 3/4"   d. 1 1/16"

9. Chamfering the top edges of a hip rafter, is called?

    a. Backing

    b. Dropping

    c. Planing

    d. Fixing

10. What line of the framing square is used to calculate the length of jacks?

    a. Length of common rafters per foot of run

    b. Length of hip or valley rafter per foot of run

    c. Side cut of jacks

    d. Difference in length of jacks
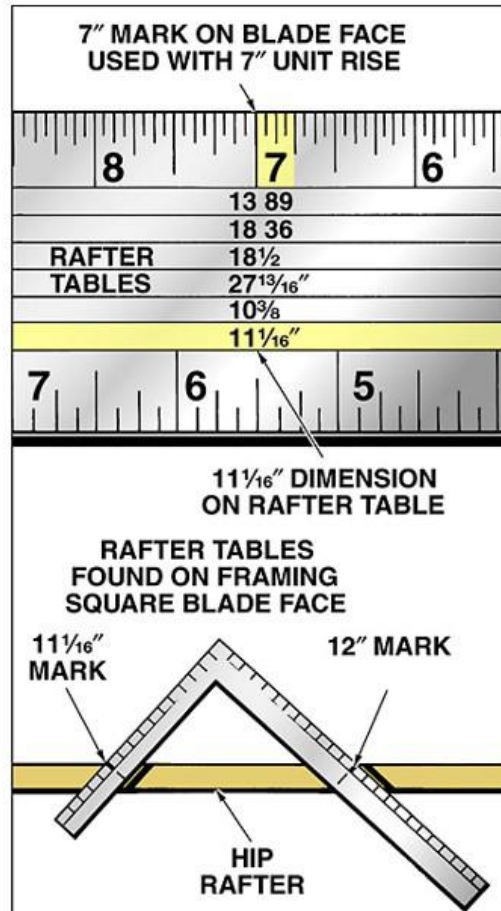
11. The illustration above shows how to lay out what?

    a. Hip plumb cut

    b. Side cut of hips or valleys

    c. Level cut of a hip

    d. Side cut of a common

NOTES:

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STUDY GUIDE
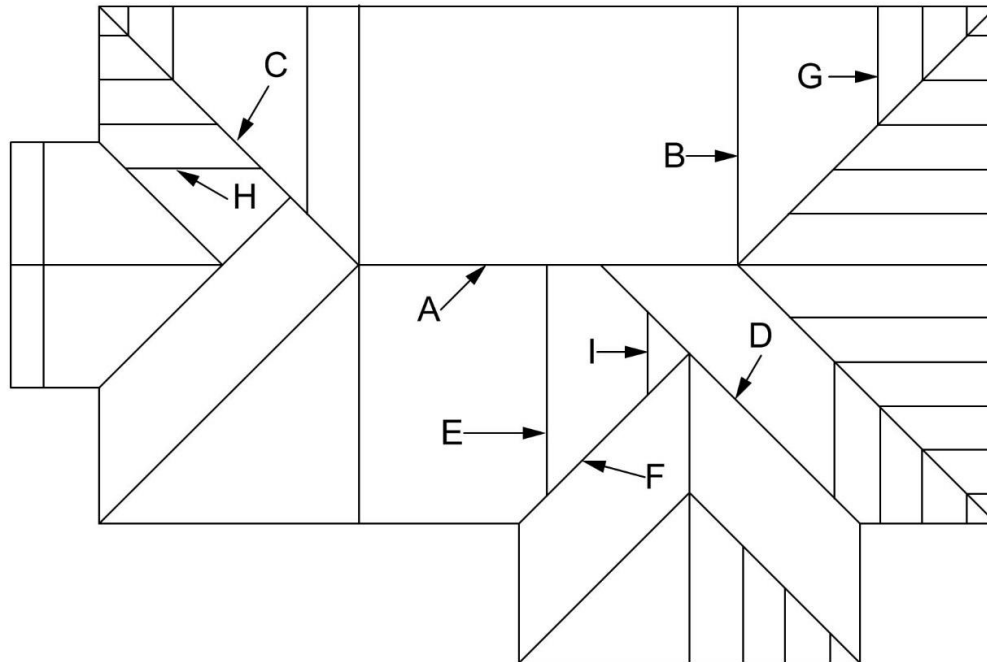
Identify the rafters shown by writing the letter next to the correct rafter.

1. Supporting valley   _____

2. Hip jack   _____

3. Common   _____

4. Valley jack   _____

5. Hip   _____

6. Valley cripple jack   _____

7. Ridge   _____

8. Shortened valley   _____

9. Hip-valley cripple jack   _____

10. Which of the following is formed where two slopes meet at an inside corner?

    a. Hip   b. Ridge

    c. Valley   d. Intersection

11. What type of rafter runs from the ridge to the valley rafter?

    a. Valley rafter   b. Hip-valley jack rafter

    c. Valley cripple jack rafter   d. Valley jack

12. With an intersecting roof that has equal spans, the ridge heights are:

    a. Different for each ridge

    b. The same for each ridge

    c. Based on the number of floors in the building

    d. Based on the length of the valley rafter

13. An intersecting roof includes what kind of ridges?

    a. Major   b. Minor

    c. Sloped   d. Major and minor

14. A shortened valley rafter runs at a _____degree angle to the supporting valley rafter.

    a. 22 1/2   b. 45

    c. 60   d. 90

15. What kind of tail cut is used for a shortened valley rafter?

    a. Double cheek cut   b. Single cheek cut

    c. Inverted double cheek cut   d. Inverted single cheek cut

016 KOEL UNIT 49

STUDY GUIDE

1. The two sections of a(n)_____roof may be the same or different widths

    a. Intersecting   b. Gable

    c. Gambrel   d. None of the above

2. In a roof with equal spans, the _____is the same for each ridge.

    a. Total run

    b. Total rise

    c. Unit rise

    d. Unit run

3. Valleys rafters always run at what angle to the outside walls of a building?

    a. 22 1/2°   b. 45°

    c. 60°   d. 90°

4. Valley rafters always run _____to hip rafters?

    a. Parallel

    b. Diagonal

    c. Perpendicular

    d. None of the above

5. Valley jack rafters _____in length as they near the top of the roof?

    a. Increase   b. Decrease

    c. May increase of decrease   d. Remain the same

6. The space between hip and valley rafters, which are placed close together, is framed with _____ rafters.

    a. Common   b. Gable

    c. Hip-valley cripple jack   d. Hip

7. A hip-valley cripple jack requires :

    a. A plumb cut at one end and a side cut at the other end

    b. A side cut at one end and a side cut at the other end

    c. Plumb and side cuts at each end

    d. None of the above

8. A _____ valley rafter extends from the wall plate to the main ridge board and has a single side cut where it fits against the ridge board.

    a. Shortened   b. Hip

    c. Cripple   d. Supporting

9. A method of building intersecting roofs without valley rafters is called?

    a. Blind valley construction

    b. Deep valley construction

    c. Dropped valley construction

    d. Any of the above

10. When laying out the plumb cut of jacks, use the unit rise of the roof and:

    a. 17"   b. 16.97"

    c. 16"   d. 12"