It is my intent to share Information with you on the Art of Roof Framing.

I will do my best to explain each Procedure in simple terms.

It’s much easier than you think!

Please Visit my Web Site:
http://www.theroofframer.com
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<th>Page</th>
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Tools Needed:
1. An open Mind
2. An inexpensive Scientific Calculator
3. Framing Square
4. Sharp Pencil

Trig. Functions:

**Sine**: Ratio of Rise to Rafter Length
\[ \frac{5}{13} = 0.384615385 \]
Push INV or 2ndF and Sine Key. 22.619 deg. should be on Display.

**Cosine**: Ratio of Run to Rafter Length
\[ \frac{12}{13} = 0.923076923 \]
Push INV or 2ndF and Cosine Key. 22.619 deg. should be on Display.

**Tangent**: Ratio of Rise to Run
\[ \frac{5}{12} = 0.416666667 \]
Push the INV or 2ndF and Tangent Key. 22.619 deg. should be on Display.

Note: These are the Trig. Functions of the Angle Off the Horizontal. 22.619865º
Similar Triangles

Two Triangles are Similar if the three Angles of One Triangle are equal, respectively, to the three Angles of the other Triangle.

Any Triangle can be Enlarged or Reduced in Size By Multiplying or Dividing every Leg of the Triangle by the Same Number.

This will not change any of the Angles.

I can see lots of Triangles in the Polygons below.

You can lay-out Rafters for them easily by Adding some dimensions for the Sides and a Pitch for the Roof.
Formulas:

To Find Sum of Angles In an Enclosure:
Number of Sides or Corners Minus 2 times 180 Degrees equals the sum of the Interior Angles.

Calculating Bevel of Hip or Valley Rafters:
Sine of Hip Slope Divided by Tangent of Corner Angle Equals the Tangent of the Saw Setting.
Push Inv. Or 2nd F and Tangent Key.
The Degrees will be on Display if your Calculator Is in Degree Mode.

The Corner Angles are the Angles on each side of The Hip.
If you have a single pitch, the Corner Angles will Be the same.
Corner Angles will be different, if you have a Different Pitch on each side of the Hip.

Examples:

Calculating Length of Common and Hip Rafters:
(Span of Building minus the thickness of the Ridge Board) Divided by the Span of the Scale Equals a Multiplier.

The Multiplier times any Dimension on your Scale Will give you the Actual Dimension on the Building.
# Cosine Chart

<table>
<thead>
<tr>
<th>Rise per 12 Units of Common Run &amp; 16.97056275 units of Hip Run</th>
<th>Common Cosine</th>
<th>Hip Cosine</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.99654758</td>
<td>.998268397</td>
</tr>
<tr>
<td>2</td>
<td>.986393924</td>
<td>.993127066</td>
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<tr>
<td>3</td>
<td>.9701425</td>
<td>.984731928</td>
</tr>
<tr>
<td>4</td>
<td>.948683298</td>
<td>.973328527</td>
</tr>
<tr>
<td>5</td>
<td>.923076923</td>
<td>.95923292</td>
</tr>
<tr>
<td>6</td>
<td>.89442719</td>
<td>.942809042</td>
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<td>7</td>
<td>.863778901</td>
<td>.924445459</td>
</tr>
<tr>
<td>8</td>
<td>.832050294</td>
<td>.90453034</td>
</tr>
<tr>
<td>9</td>
<td>.80</td>
<td>.883452209</td>
</tr>
<tr>
<td>10</td>
<td>.76822128</td>
<td>.86154979</td>
</tr>
<tr>
<td>11</td>
<td>.73715414</td>
<td>.839140322</td>
</tr>
<tr>
<td>12</td>
<td>.707106781</td>
<td>.816496581</td>
</tr>
<tr>
<td>13</td>
<td>.678280103</td>
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<tr>
<td>16</td>
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<td>18</td>
<td>.554700196</td>
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<tr>
<td>19</td>
<td>.533992991</td>
<td>.666152858</td>
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<tr>
<td>20</td>
<td>.514495755</td>
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<td>21</td>
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<td>22</td>
<td>.478852131</td>
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<tr>
<td>23</td>
<td>.462566007</td>
<td>.593724835</td>
</tr>
<tr>
<td>24</td>
<td>.447213596</td>
<td>.577350269</td>
</tr>
</tbody>
</table>

Note: The number of Hip Run Units will change if working with Multiple Pitches and the Hip Cosine will change.

<table>
<thead>
<tr>
<th>Run of the Common Rafter to the Ridge Board divided by the Cosine in this Column equals Length of the Common Rafter</th>
<th>Run of the Hip Rafter to the Ridge Board divided by the Cosine in this Column equals the Length of the Hip Rafter</th>
</tr>
</thead>
</table>

This is a Handy Chart.
Please
Double Check the Calculations.
Note: Carry out Your Decimals at least 5 Places When You are Calculating for your Scale.

Be Sure to Check your Calculations:
Cosine x Rafter Length = Run to the Ridge
Sine x Rafter Length = The Rise

If Calculations don’t add up--It is likely due to the Decimal not being carried out Far enough.
Gable Roof

The Run on each Pitch to Ridge Plus Ridge Thickness must = Span of Building.

(288" - 1½" Ridge) = 286.5" ÷ Span of Scale 2.08333" =
137.52022 The Multiplier

137.52022 x 1.25 = 171.90" Length of Rafter 16/12 Pitch

137.52022 x 1.66667 = 229.20" Length of Rafter 9/12 Pitch
Gable Roof

9/12 & 16/12 Pitch

22" Difference in Plate Elevation
Gable Roof

Add H.A.P. To 123.44" to Calculate Rise to Top Of Ridge Board.

\[ \text{H.A.P.} \]

\[ 36.869^\circ \]

\[ 36.66^\circ + 205.7336'' = \text{Rafter} \ 242.3936'' \]

\[ 257.17 \div 2.08333 = 123.44179 \text{ Multiplier Also the Rise} \]

\[ 288'' - 29.33 = 258.67'' \]

\[ 258.67 - (\text{Ridge Board}) \ 1.5 = 257.17 \text{ Span to Proportion} \]

\[ 257.17 \div 2.08333 = 123.44179 \text{ Multiplier Also the Rise} \]

The Run on each Pitch to Ridge Plus Ridge Thickness must = Span of Building.

\[ 29.33'' + 164.5886'' + 1 \frac{1}{2} '' + 92.58'' = 287.9986'' \text{ Span} \]

\[ .9986 \times 16 = 15.997/16'' \text{ That’s pretty close} \]

To a 288" Total Span.
You can calculate all the Numbers on your Framing Square with a little understanding of The Three Trig Functions that I have told you about.

The Framing Square is a very handy Tool for Marking your Rafter and Laying out Stair Stringers.

Always work with one edge of the Framing Square at a time (Inside or Outside). If you don’t, your Angles will be off.
The Framing Square

Plumb Cut

Measurement Line

Pitch 6 9/16":12" (6.5625"

Rafter

Seat Cut

Example: 5½” Wall Run ÷ 12” Run = 0.4583333 Multiplier X 6.5625” = 3.0078”

Hold 5½” & 3” to Mark Birdsmouth

I always mark a parallel Line
About ¼ " in from the edge and this
Is where I Hold my Run & Rise

You need a Sharp Edge to Hold
Your Framing Square to.

Stair Stringer

Rise

Run

Please don’t forget to cut
The thickness of the Tread
Off bottom Riser

5½”
You can use either Span for the Divisor. It Depends which way you want the Ridge to Run.

Corner Angles change
When working with Multiple Pitches.

Note: Carry out Your Decimals at least 5 Places or more. Large Multipliers can produce Discrepancies. Always Double Check your Calculations using Trig. Functions.
**Hip Roof**

Length 384"

Length of Building 384" - 126.66" - 71.25" = 186.08" Ridge

**Formula:**
Span of the Building Minus the Ridge Divided by Span of the Scale Equals a Multiplier. The Multiplier Times Any Measurement on the Scale Equals that Measurement On the Building.

\[(144 - 1.5) ÷ 1.5 = 95\text{ The Multiplier}\]

**Measurements on Building**

95 x 1.66666 = **158.3327 Common Rafter**  

95 x 1.82763 = **173.62485 Hip Rafters**  

95 x 1.33333 = **126.66635 Common Run**

95 x 1.45773 = **138.4851075 Hip Rafters**  

95 x .75 = **71.25 Common Run**

95 x 1.0 = **95" Rise**
Bevel of Hips

Common Rafter 1.66666
Common Run 1.33333
Hip Rafter 1.82763
Hip Run 1.52979

Rise 1.0 ÷ Hip Rafter
1.82763 = .5471567
Sine of Hip Slope On West Side of Building.

Length of Building 384" - 126.66" - 71.25" = 186.08" Ridge

Rise 1.0 ÷ Hip Rafter
1.82763 = .5471567
Sine of Hip Slope On West Side of Building.

Sine Hip Slope .5471567 ÷ Tangent 1.77777
=.30775699.
Push Inv. & Tangent Key.
17.107° Bevel of Hip.

.Tangent 29.36° Corner Angle
.Sine Hip Slope .5471567 ÷ Tangent .562501406
= 972720591.
Push Inv. & Tangent Key
44.2° Bevel of Hip
Bevel of Hips

\[ \frac{.75}{.75} = 1.0 \]
Tangent of 45° Corner Angle

Rise 1.0 ÷ Hip Rafter
1.457737 = 0.685994799
Sine of Hip Slope On East Side of Building.

Push Inv. & Tangent Key.
.685994799 ÷ 1 = .685994799
34.449 Degrees should be on Display. Bevel of Hip on Each Side
**Legend**

Measurement Lines
On Scale

<table>
<thead>
<tr>
<th>Common Rafter 1.66666</th>
<th>Common Rafter 1.25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Run 1.33333</td>
<td>Common Run .75</td>
</tr>
<tr>
<td>Hip Rafter 1.82763</td>
<td>Hip Rafter 1.457737</td>
</tr>
<tr>
<td>Hip Run 1.52979</td>
<td>Hip Run 1.06066</td>
</tr>
</tbody>
</table>

**Saw Settings**

- **60.64° Side Cut of Jacks**
  - At the Green Hips
- **45° Side Cut of Jacks**
  - At the Purple Hips
- **60.64° Side Cut of Green Hips**
  - At the Ridge
- **45° Side Cut of Purple Hips**
  - At the Ridge
- **29.36° Side Cut of Jacks**
  - At the Green Hips

**Note: Hold the Rise & Run on your Framing Square.**

**Mark the Rise for your Plumb Cut.**
**Mark the Run for Your Seat Cut.**
You can use either Span for the Divisor. It Depends which way you want the Ridge to Run.

Difference in Length of Jacks @ 16" on Center Cut against the Green Hips on the West End

\[ 16" \div .75 \times 1.6666 = 35.55" \]

Difference in Length of Jacks @ 16" on Center Cut against the Green Hips on the South and North End.

\[ 16" \div 1.33333 \times 1.25 = 15" \]
### Polygon Chart

<table>
<thead>
<tr>
<th>No. Of Sides</th>
<th>Saw Settings in Degrees for Side cuts of Hips &amp; Jacks</th>
<th>No. Of Units on Center per 12 Units of Run per Common Rafter</th>
<th>Hip or Valley Run per 12 Units of Common Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>45</td>
<td>12</td>
<td>16.97056275</td>
</tr>
<tr>
<td>5</td>
<td>36</td>
<td>8.71851033</td>
<td>14.8328157</td>
</tr>
<tr>
<td>6</td>
<td>30</td>
<td>6.9282032</td>
<td>13.85640646</td>
</tr>
<tr>
<td>7</td>
<td>25.7142857</td>
<td>5.7788954</td>
<td>13.31899517</td>
</tr>
<tr>
<td>8</td>
<td>22.5</td>
<td>4.970562748</td>
<td>12.988706040</td>
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<tr>
<td>9</td>
<td>20</td>
<td>4.3676428</td>
<td>12.770133269</td>
</tr>
<tr>
<td>10</td>
<td>18</td>
<td>3.899036</td>
<td>12.61754669</td>
</tr>
<tr>
<td>11</td>
<td>16.363636</td>
<td>3.5235178</td>
<td>12.5066054</td>
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<tr>
<td>12</td>
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<td>3.2153903</td>
<td>12.423314</td>
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<td>13</td>
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<td>2.957734</td>
<td>12.3591339</td>
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<td>14</td>
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<td>2.738921</td>
<td>12.3086022</td>
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<tr>
<td>15</td>
<td>12</td>
<td>2.5506787</td>
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<tr>
<td>16</td>
<td>11.25</td>
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<td>2.2431887</td>
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<td>10</td>
<td>2.1159237</td>
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<td>19</td>
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<tr>
<td>20</td>
<td>9</td>
<td>1.90061328</td>
<td>12.14958</td>
</tr>
<tr>
<td>36</td>
<td>5</td>
<td>1.0498639</td>
<td>12.045838</td>
</tr>
</tbody>
</table>

**Note:** At the Point of Contact of Hips & Jacks, Make Plumb Cut First & Hold Bed of Portable Saw on Cut Edge.

180 degrees divided by the number of sides = Saw Settings.
At the Eaves, Hold Bed of Saw On Wide part of Material for Hips.

Tangent of saw settings x 12 = these numbers used for Plate layout.

1.90061328 squared + 12 squared = 147.6123308. Square Root of 147.6123308 = 12.14958.
Octagon

This is a Scale for an Octagon with a 9/12 Pitch

Install Hip Rafters First.

Use of Saw Setting in Polygon Chart
At the Point of Contact of Hips & Jacks, Make the Plumb Cut First & Hold Bed of Portable Saw on the Cut Edge.

The Hip Rafter Tail can be cut with the Bed of Saw on the Wide part of the Rafter Material.
Octagon

Length of Side + (2 x 4.97) ÷ 9.941 = the Multiplier.
The Multiplier x 15.802 = the Length of Hips.

16.75 minus .8117 = 15.938. 15.938 divided by 4.97056275 times 15 = 48.098". Length of 1st. Jack to long side of Cut.

3rd. Jack 48.098 + 48.28 + 48.28 etc.
This includes the Over Hang so you have to step back 12 inches on the Level with your Framing Square to Mark the Birds Mouth.
Octagon

The Measurement Line for Commons & Hips is the Point where the Rafter makes contact with the Outer Edge of the Plate and is Parallel with the Rafter and runs the Full Length.

The H.A.P. (Height Above the Plate) must be the Same at the Point of Contact at the Plate for Hips and Jacks.

You should be able to stretch a String Parallel with the Sides on the Backs of two Hip Rafters without a bend in the String.

H.B.P. Is important If you are going to Have a Cathedral Ceiling!
Octagon

$48 \div 15 = 3.2$
$3.2 \times 4.97 = 15.9058$
Ellipse

Roof: 9/12 Pitch
\[
90^\circ \div 4 = 22 \frac{1}{2}^\circ
\]

22.5° Cosine
\[.923879 \times 12.0 = 11.086"
\]

[Diagram showing calculations and angles with values labeled accordingly.]
Round Pipe going through the Roof is a good example of an Ellipse.
Hip Roof Problem:

Common Rafter Tails cut square

Compound Angle for Hip Rafter Tails?
Plumb Cut 12.1875 In  
Minus 10.73 in. 
= H.B.P. 1.457

Flip Upside Down
Make a sketch to use for Calculating the Slope of the Hip to Match the 67.38 deg. Slope of the Commons and Jacks. The Commons and Jacks are cut square on the end.


\[
2.39999 \times 1.00 = 2.3999 \text{ Rise}
\]

\[
1 \text{ squared} + 2.3999 \text{ squared} = 6.75952.
\]

Square root of 6.75952 is 2.599.

Common Length

\[
1.4142 \text{ squared} + 2.3999 \text{ squared} = 7.75948.
\]

Square Root of 7.75948 is 2.785.

Hip Length

The Tangent of 45 deg. Corner Angle is 1.00.

Use this Formula: Sine of Hip Slope divided by Tangent of Corner Angle = the Tangent of saw setting for Angle of Cut.

With Tangent on Display, push Inv. Or 2ndF and Tangent Key.

40.74 Deg. Should be on Display if your Calculator is in Degree Mode. This is the Saw setting for this Problem.


Push Tangent Key.

0.251182638 should be on Display.

\[
0.251182638 \times 12 = 3.014191662.
\]

\[
0.014191662 \times 16 = 0.2/16
\]

Using your Framing Square, Hold 12 & 3 on a line parallel with your Rafter.

Mark 3 and you will have the layout for your Hip Rafter Tail.
This is the END of the Hip Rafter Tail. You are looking at it Upside Down.

The Hip & Common Run Lines are on The Level. This Hip has been Beveled.
17.69
Hip/Valley

16.97056275
Hip Run

10.73 in.
H.A.P.

.996 in.
H.B.P

11.73 in.
Plumb Cut

59.49 deg.
Measurement Line

16.97 in. O.H. On 45 degree angle from the wall
Gives you a 12 in. O.H. Perpendicular to the wall.

Flip Upside Down

16.97 in. O.H. On 45 degree angle from the wall
Gives you a 12 in. O.H. Perpendicular to the wall.
Bow Window
Roof Framing

7 Panel
Tip: (Number of Corners in any Enclosure - 2) x 180 degrees = the Sum of the Interior Angles.
Example: Visualize a Bow Window as being a Portion of a Gazebo with 36 Sides.
(36 - 2) x 180 Degrees = 6120 Degrees (Sum of Interior Angles)
6120 Divides by 36 = 170 Degrees (Sum of Interior Angles at each Corner.)

These are the Saw Settings for Side Cuts of Jacks Against their Respective Ledgers.

The Length of the Leg Opposite any Angle in a Triangle Divided by the Sine of that Angle will give you a Multiplier.

The Multiplier Times the Sine of each of the other Angles will give you the Length of the Leg Opposite each Angle.

This Works on any Triangle.
16 ÷ 28.44102 = .554706123 (Sine of Ledger Slope) off The Horizontal.
Push the 2nd F & Sine Key and 33.69047 degrees will Be on Display.
Bevel of Ledger: Sine ( .554706123 ) divided Tangent of Corner Angle (30 Deg. (.577350269) ) = .960779188. With .960779188 on Display, Push 2nd F & Tangent Key. 43.854 Degrees is the Saw Setting for the Bevel of this Ledger.

Use Framing Square: Mark 16 for Plumb & 24 for Seat Cut.
Use these Saw Settings to Join the Ledgers together after Plumb Cut is Marked using Framing Square. Hold 20.35 & 9.28. Mark 9.28 Inches.
5° is Saw Setting on this End of this Ledger.

Bevel Ledger: Sine of Ledger Slope (.225684211) divided by 10 deg. Tangent (.176326981) = 1.27991876) Push 2ndF & Tan. Key (51.99° should be on display. Use 38° & cut on Edge.

15° is Saw Setting on this End of this Ledger.

15° is also the Saw Setting for Side Cut At the Ledger for this Hip.

Bevel Ledger: Sine of Ledger Slope (.225684211) divided by 10 deg. Tangent (.176326981) = 1.27991876) Push 2ndF & Tan. Key (51.99° should be on display. Use 38° & cut on Edge.

5° Sine x Hip Run 19.03362189 = 1.6588 Inches on Center

25.28 Rise

15° is Saw Setting on this End of this Ledger.

5° Cosine x Hip Run = Common Run 22.1765

Total Hip Run 22.26129

5° Sine x Hip Run 22.26129 = 1.940 Inches on Center

17.954

4th. Panel

Ledger 17.954

5° is Saw Setting On each End of This Ledger.

Bevel Ledger: 16/12 = 1.33. Push Inv. Tangent

53.13° will be on Display. The Saw Setting for Bevel Of this Ledger if Bed of Saw is placed on Wide Part Of Ledger.

36.87° Can Be used if you Run your Saw on the Narrow Edge of the Material.

21.8344 Panel

21.8344 Panel
Framing
Stair Winders
A 10" Pathway 12" from interior wall is a good starting point.
Outside Stringer:
55.96 X 18 deg. Tangent = 18.18 in.

55.96 X 36 deg. Tangent = 40.65 in. Minus
18.18 = 22.47 in.

55.96 minus 40.65 = 15.31 in.
2 x 12 stringers
You can use your biscuit joiner to add enough material so you can Layout Risers and Tread cut-out.

Cut Off thickness of Tread from bottom of Stringer.
45 deg. Cut Optional. This is a 90 deg. Corner & can be cut Square. Remember to deduct the thickness of the material from one side.

I would recommend using a third Stringer in the Middle.

Starting at the Central Point, The Tangent of 18 deg. X the Distance to either side of the Stringer will give you the Cut-out for Tread.

The Tangent of 36 deg. X that Same Distance minus the preceding Tread will give you the Cut-out for the next Tread.

The Tangent of 45 deg. X that Same Distance will give you the Point where the Two Stringers meet.
Multiple Pitch Roofs

Always Remember The Measurement Line for Commons, Hips & Valleys

You can put Multiple Pitches together by Reducing the Rise to One Unit.

Divide Each Leg of each Pitch by it’s own Rise.
Multiple Pitch
16/12 House
9/12 Dormer

Common Run 12/9 = 1.333
Rise 9/9 = 1.0
Rafter 15/9 = 1.666

Common Run 12/16 =
1.0
Rafter 20/16 = 1.25

Common Run 12/16 =
Rise 16/16 = 1.0
Rafter 1.25

Common Run 1.333
.Rise 1.0
Rafter 1.666

Common Run 1.333
.Rise 1.0
Rafter 1.25

Common Run .75
.Rise 1.0
Rafter 1.25

Rise 1.0
Rafter 1.25
33.17º
1.8276 Rafter
1.529 Run

Run of Major Valley Rafter To Ridge Board Of the House
Actual Run to Ridge Board 143.25 inches

Run 1.5297
Rise 1.0
Dormer Run 1.333
Dormer Run 1.333
Common Run 1.25
Common Run .75

Dormer Run 1.333
Scale
Dormer Span 2.666

Measurement Line
H.A.P.
H.B.P.
You should now be able to see that for every 2.666 Units of Dormer Span, You will Use Up .75 Units of House Run and 1.529 Units of the Major Valley Run.

The Actual Dormer Span Minus the Ridge Board divided by (Span 2.666) of the Scale = The Multiplier.

The Multiplier x any of the Red Numbers will give you the Actual Measurements on the Building.

The Major Valley and the House Commons have to be Calculated Separately.
Run of House to the Ridge Board \( (143.25 \div .75) = (191) \) Multiplier
\[ 191 \times 1.8276 = 349.07" \] Length of Major Valley Rafter.

Difference in Length of Jacks @ 16" o.c. For 16/12 Pitch:
\[ 16 \div 1.33 = 12.03 \text{ The Multiplier.} \]
\[ 12.03 \times 1.25 = 15.03" \]

Difference in Length of Jacks @ 16" o.c. For 9/12 Pitch:
\[ 16 \div .75 = 21.33 \text{ The Multiplier.} \]
\[ 21.33 \times 1.66 = 35.55" \]

**Note:** These Calculations are not on your Framing Square.
Concave Roof Framing

16/12 Pitch

Rise 48''

Run: 36''

Common Rafter 2 x 12

18.75 Plumb cut Common Rafter

H.A.P.
11.42 inches

5 ½ inch seat cut

H.B.P.
7.33 inches

Adjust to the size of Fascia.
Concave Roof Framing

Hip Rafters
2 x 12

23.323" Run 50.91" Rise 48" H.A.P.

Calculate the Length of All the Rafters & Mark
The Measurement Line on all of them.
Then Lay Out the Curve.

The Red Vertical Lines
From the Measurement Line on all the Rafters
Must be the Same
So The Backs of the Rafters will be at the Same
Elevation for a given Point.