While this manual outlines generally accepted practices in the industry, Stair Technologies, LLC cannot be held responsible for the installation of specific staircases. Users of this manual are urged to follow building code requirements to ensure the structural integrity of all stair projects.

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Introduction

Stair building is one of the most specialized components of construction. Building a staircase requires advanced planning, meticulous attention to detail, and good quality stair parts. Stairs can be built in a variety of forms ranging from the simple straight stair to the complex U-shaped stair. Regardless of the type of stair you wish to build, consideration must be taken with regards to comfort, building code requirements and cost.

Using This Manual

The Stair Installation Instruction Manual was written in conjunction with training provided by Stair Technologies, LLC. The manual was designed as a teaching tool for Stair Technology's Stair School. The goal of this manual is to explain the general principles of basic stair building, specifically focusing on the construction of the straight stair and the L-shaped stair. Due to the broad range of technical description this manual assumes a basic knowledge of carpentry in its depictions. If you are interested in the construction of more complex types of stairs, you should contact Stair Technologies for custom courses or advanced training.

As you use the text, you will notice sample boxes that have been provided for you to work the needed calculations associated with stair building. For your convenience, these calculations have also been placed at the end of the manual for you to use as you see fit. The calculations are marked with a large blue box to simplify the process and show you where a calculation is needed.

Recommended Tools

As with any major construction project, the stair builder is aided by the use of high quality tools. This manual provides a list of tools, some of which are designed specifically for stair building that will make the installation more efficient and effective. The following tools are recommended for stair construction:

- Drill
- Circular saw
- Belt sander
- Finish sander
- Jig saw

- Sliding compound miter saw
- Hammer
- Rubber mallet (white is preferred)
- Nail set
- 24” level
- 48” level
- Torpedo level
- Framing square, carpenter’s square
- Combination Square UI
- Sliding T bevel
- Rail bolt wrench**
- Rail bolt driver**
- Drill bits 1”, 3/4”, 5/8”, 1/2”, 1/4”**
- Pneumatic brad nailer (1-inch brad)
- Pneumatic finish nailer (2-inch finish nail)
- Socket set-3/8-inch drive
- Chalk line
- Back saw
- Ruler
- Plumb bob
- Wood chisels
- Vise grips
- Pinch clamps
- Bar clamps
- Utility knife
- Saw horses
- Block plane
- Screwdrivers (Phillips and straight head)
- Eye and ear protection

**Can be obtained when purchasing stair parts

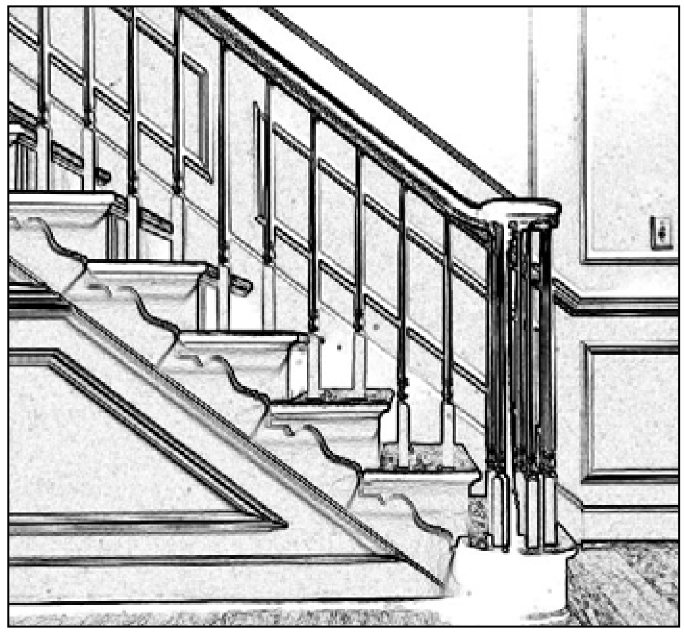
Stair Building and Safety

During the construction of a staircase, as with any form of construction, the builder always assumes a certain degree of risk. The Stair Installation Instruction Manual was designed to take personal safety into account. In order to minimize the risk of personal injury, we suggest the following basic safety precautions:

- The use of eye and ear protection
- The use of a dust mask
- The correct use of power tools (as recommended by the manufacturer)

Chapter 1
Laying out the Staircase

In this chapter:



Designing the Staircase

The critical design characteristic of any staircase is based on the fundamental calculation of total rise and total run. Total rise refers to the vertical distance a stair must climb from finished floor on the lower level to finished floor on the upper level. Total run, formerly referred to as “the going” of a stair, refers to the horizontal distance a stair must cover from the beginning of the first tread to the end of the last tread. Neither term should be confused with the rise and run, or unit rise and unit run, which are layout terms generally used to refer to the dimensions of each individual step.

Building codes dictate the rise and run of a staircase. *(Please note that local building codes must be determined before the design process is undertaken.) The dimension of each rise and run must be almost identical over the complete stair. Rise is the most important part of the calculation. Most building codes require that the variance between the highest and lowest risers not exceed 3/8-inch.

This chapter outlines the principles of rise and run and the fundamentals of laying out the main supporting structure of the staircase.

The Rise and Run of a Staircase

Calculating the Total Rise

The total rise must be calculated from finish floor to finish floor.

1. First, attain the rough floor-to-floor measurement. This measurement is taken by running a measuring tape down from the second floor to the first floor. The measurement should be as close to plumb – or exactly vertical – as possible.
2. From this measurement, add the thickness of the upper finished floor and subtract the thickness of the lower finished floor. (This will factor for flooring added after the installation of the staircase.) The following calculation provides the total rise of the stair finish floor to finish floor:

Total Rise

__________	Total distance from rough floor to rough floor
__________	+ Thickness of upper finished floor
__________	- Thickness of lower finished floor
__________	= Thickness rise (Finished floor to floor)

Figure 1-1 illustrates this concept.

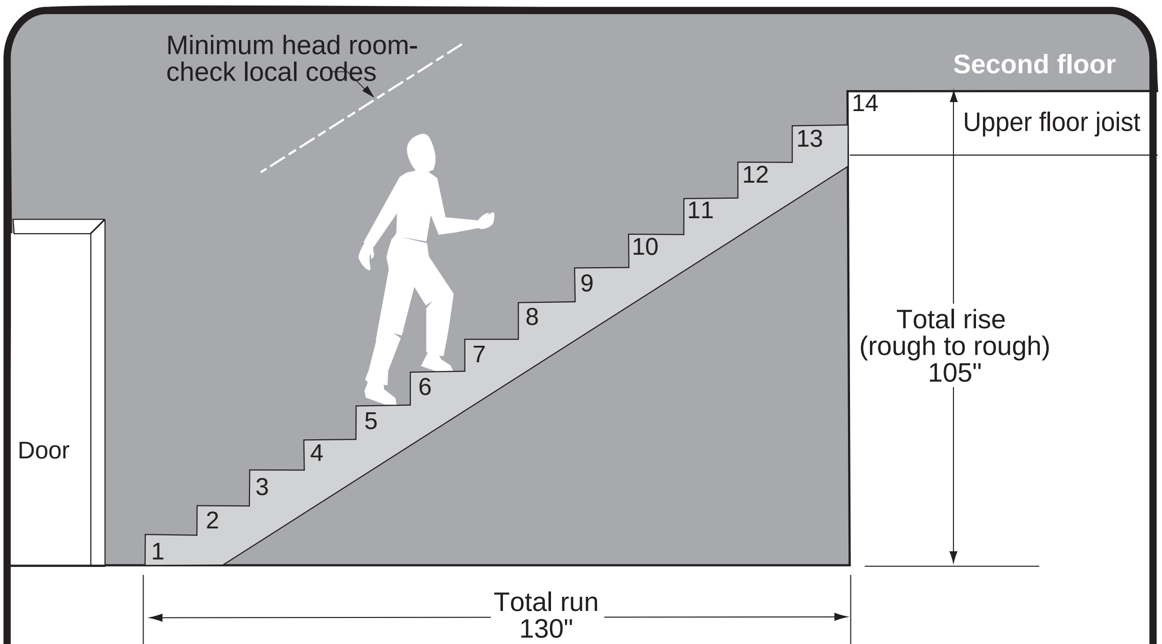


Fig. 1-1 *Calculating the total rise and total run of a straight staircase.*

Calculating the Total Run

Now you must determine the total horizontal distance that the stair must travel.

1. Plumb down from the upper floor joist to the lower floor and make a mark.
2. Place a mark on the floor where you would like the stair to end.

3. Measure the distance between the two marks. This distance is the total run. When calculating the total run, pay close attention to any obstructions such as walls, doors, or openings that may impede the design of the staircase. Make sure you have enough room for the desired total run and that the minimum headroom requirements are met. This is illustrated in figure 1-1.

Calculating the Unit Rise

The unit rise is the calculation of the height of each individual rise in the stair. Please note Fig. 1-2

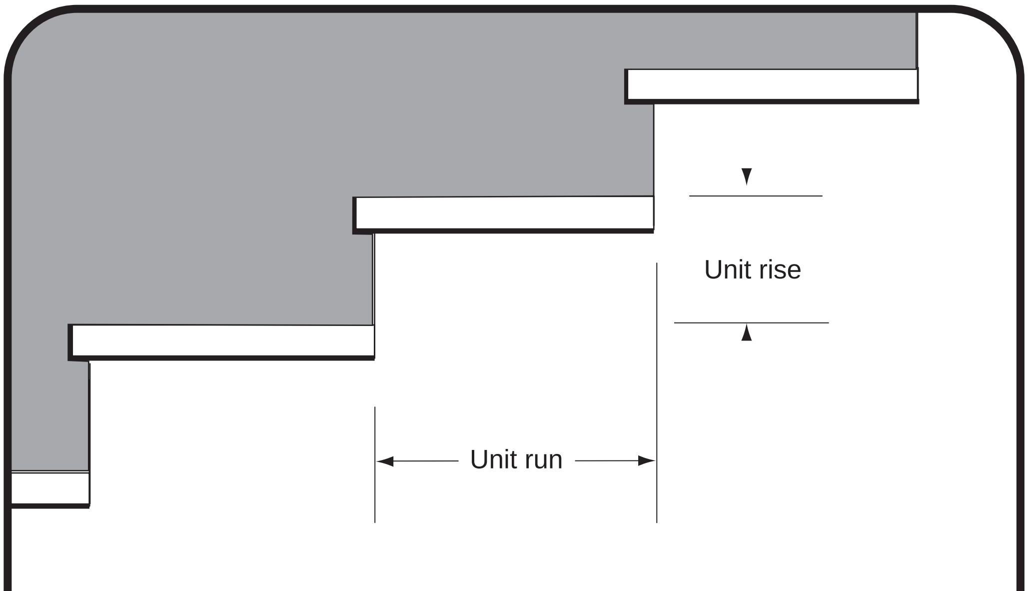


Fig. 1-2 *Unit rise and unit run of a staircase.*

** (Please note that local building codes can restrict maximum rise. In most areas this maximum distance is 7-3/4-inches.)*

1. To determine the minimum number of risers, divide the total rise of the stair by the maximum unit rise allowed. For instance, if the total rise of the stair was 105-inches and the maximum allowable unit rise was 7-3/4-inches, you would divide 105 by 7-3/4. This would give 13.54 rises. Since it is not possible to have a portion of a rise, you should round off to the next highest whole number. This would yield for a 14-rise staircase. The calculation is provided below.

Number of Risers

________	Total rise (Finished floor to floor)
________	÷ Maximum unit rise
________	= Number of risers
	(Rounded to the next highest whole number)

Example: Total Finished Rise (105) / Maximum Unit Rise (7-3/4) = (13.54) or 14 Risers

2. Divide the total finished rise by the minimum number of risers to determine the height of each individual rise.

Unit Rise

________	Total rise (Finished floor to floor)
________	÷ Number of risers
________	= Unit rise

Example: Total Finished Rise (105) / Number of Risers (14) = Unit Rise (7-1/2)

In this example the maximum rise would be 7-1/2-inches. It is important to note that this is the maximum unit rise of this particular stair. More risers may be added to create a stair with a more gradual rake (slope). Keep in mind that the addition of risers can take a considerable amount of floor space. Strive to keep the individual riser height to above 6-inches because too low of a rise may be considered awkward and unsafe. *(Statistics indicate that accidents are just as likely to occur on stairs with a 7-inch rise as those with an 8-inch rise: a stair with a 7-1/2-inch rise is considered the safest.) Carson Et Al, 1978 Study.

The numbers used in the last example were sample figures provided by Stair Technologies, LLC. They are in no way representative of all staircases.

Calculating the Unit Run

The unit run of a stair is the horizontal distance from the face of one riser to the face of the next. (Please note above Figure 1-2) It is once again important to check local building codes, because some areas restrict the run to be no less than 10-inches. The number of treads is determined by taking the total number of risers and subtracting one. The stair will have one less tread than it has risers since the stair starts and finishes with a riser.

Number of Treads

__________ Number of risers

__________ - One

__________ = Number of treads

Use the following formula to calculate unit run:

1. Multiply the number of treads by the minimum allowable unit run to get the minimum distance the stair must travel. In the example, this would be 13 multiplied by 10-inches or 130-inches of total run.

Minimum Total Run

__________ Number of treads

__________ (x) Maximum unit run

__________ = Maximum total run

Ex: Number of Treads (13) x Minimum Unit Run (10”) = Minimum Total Run (130”)

2. If you wish to increase the total run of the stair and there are no doors or obstacles, you must recalculate the actual run of the stair. To do this, divide the total desired run by the number of treads to determine the exact unit run. For instance, if the desired run in the example above was 136-1/2-inches, you should divide that by 13 to get a unit run of 10-1/2-inches.

Unit Run

__________ Desired total run

__________ 4 Number of treads

__________ = Unit Run

Note: While there are no limits to the maximum length of the unit run, be careful not to create a situation that requires the user to take a "half step" when climbing or descending the stair. This will happen if the unit run is too long.

Installing Stringers for Straight Stairs

The stringers, also known as carriages, are the supporting pieces of lumber that run the length of the staircase and support the treads, risers, and balustrade. Stringers are generally built from good quality lumber, usually 2 x 12's, preferably with a minimal crown. Always make sure to use appropriate-sized, as well as an adequate amount of lumber. Proper building materials will ensure the structural soundness of the staircase. ******(Staircases must meet load requirements of local building codes.)*

Calculating Stringer Length and Marking the Stringer

When building stringers, the first thing to determine is the length of the material that will be required. The two primary methods for determining stringer length are:

- The use of the Pythagorean Theorem
- The use of a framing square

The next two sections provide the methods for determining stringer length.

Note: It is important to remember that lumber is sold in even lengths. You are always suggested to "round up" to the next even number. It is better to have too much material than not enough.

Calculating Stringer Length Using the Pythagorean Theorem

The first way to calculate the rough stringer length is to use the Pythagorean theorem:

$$a^2 + b^2 = c^2$$

or, in this case, the run^2 plus the rise^2 equals the rake^2.

$$(Run)^2 + (Rise)^2 = (Rake)^2$$

Use a calculator to determine the square root of the sum of the run squared, and the sum of the rise squared. An understanding of this formula for right triangles is very helpful as all stair design is based on this relationship.

Stringer Lengths - Pythagorean theorem

$$(\text{Run})^2 + (\text{Rise})^2 = (\text{Rake})^2$$

$$(\_\_\_\_\_)^2 + (\_\_\_\_\_)^2 = (\_\_\_\_\_)^2$$

$$(\text{Rake})^2 = \_\_\_\_\_$$

$$(\quad)^2 = \_\_\_\_\_$$

$$\_\_\_\_\_ \div 12'' = \_\_\_\_\_$$

- or the length of the stringer. Round this to the next highest "even" number. The rounded number will give you the necessary 2 x 12-inch length you will need.

Calculating Stringer Length Using a Framing Square

Another way to determine the stringer length is to use a framing square and ruler.

1. On the blade of the square, mark the unit run; on the opposite side (or tongue) mark the unit rise.

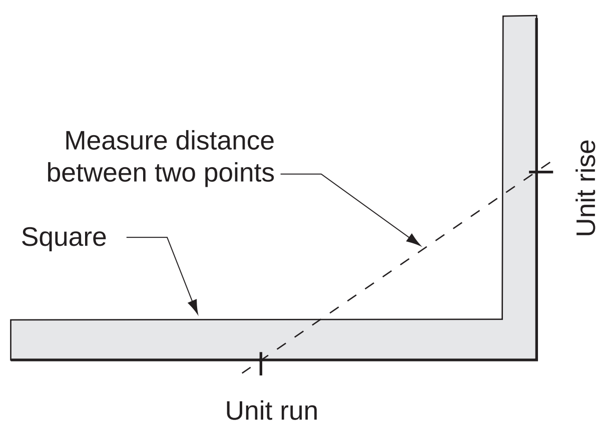


***Fig. 1-3** Using framing square and ruler to determine stringer length.*

2. Next, use a ruler to measure the distance between the two marks. Please note Fig. 1-3 here.
3. Multiply this distance by the number of treads in the stair to determine stringer length.

Marking the Stringers Using a Framing Square

A framing square is also used to mark the stringer for cutting.

1. Mark the blade at a point that is equal to the unit run of the stair, and then mark the tongue at a point equal to the unit rise of the stair. Make sure both marks are on the outside edge of the square.
2. Now, clamp a straight edge to the square on the outside of those marks. You are now ready to mark your stringer. This can also be done using small clamps called stair gauges that are made strictly for marking rise and run. Please note Fig. 1-4 here.

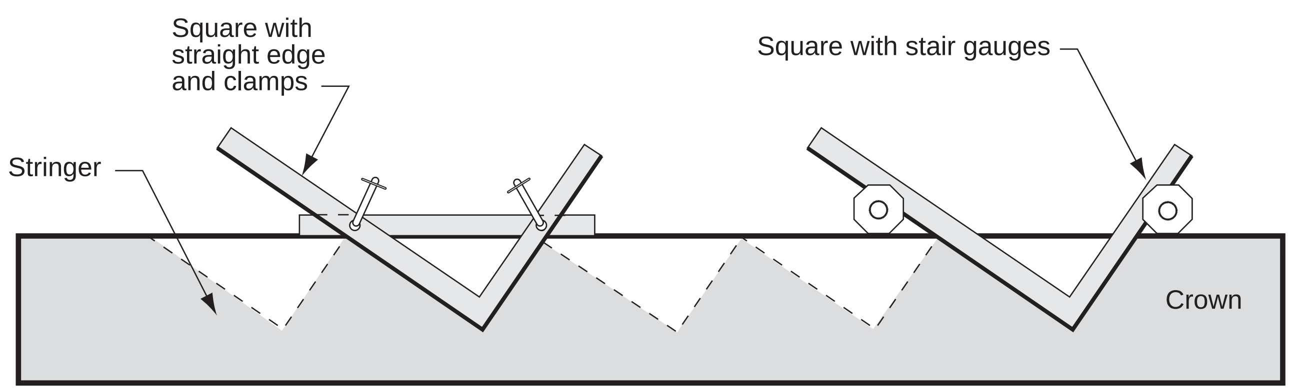


Fig. 1-4 *Using framing square and ruler to mark stringer*

3. Next, sight down the piece of lumber to determine whether it is straight or has a slight crown or bow to it. Usually boards are slightly arched in the middle.
4. Lay out the stringers so that the crowned edge is up, thus the crown is pointing opposite the load.
5. With the stringer lying flat, place the square so that its corner points are away from the wood's crowned edge.
6. Mark a line along the outside edges of the square, and then slide it down so it aligns exactly with the previous mark.
7. Mark the next cut.
8. Repeat this process until the proper number of risers has been marked. *You are suggested to number each riser as you go.*

Cutting the First and Last Riser on the Stringer

When cutting the stringer, it is essential to accommodate for the thickness of the tread material. The first (or bottom riser) of the stringer needs to be lowered by an amount equal to the thickness of the tread material. This provides the correct vertical height of the stringer. The following steps illustrate the process:

1. Subtract the thickness of the tread material and add the thickness of finished floor from the height of the unit rise. *(Remember that the rise is the vertical cut on a stair and the run is the horizontal cut.)*

Calculating First Riser Heights

__________ First unit rise

__________ - Tread thickness

__________ + Finished floor thickness

__________ = First Riser height

Note: If you are installing a rough tread now and covering it later with another material, add both thicknesses' together.

2. Measure down a distance equal to the first riser height (calculated above) on the stringer and draw a line square with the riser. This is the line for the bottom level cut of the stair. Please note figure 1-5.
3. Make a cut along the scribed line.

Cutting the Top of the Stringer

1. At a point even with the back of the last run, scribe a line perpendicular to the run.
2. Cut top end of stringer.

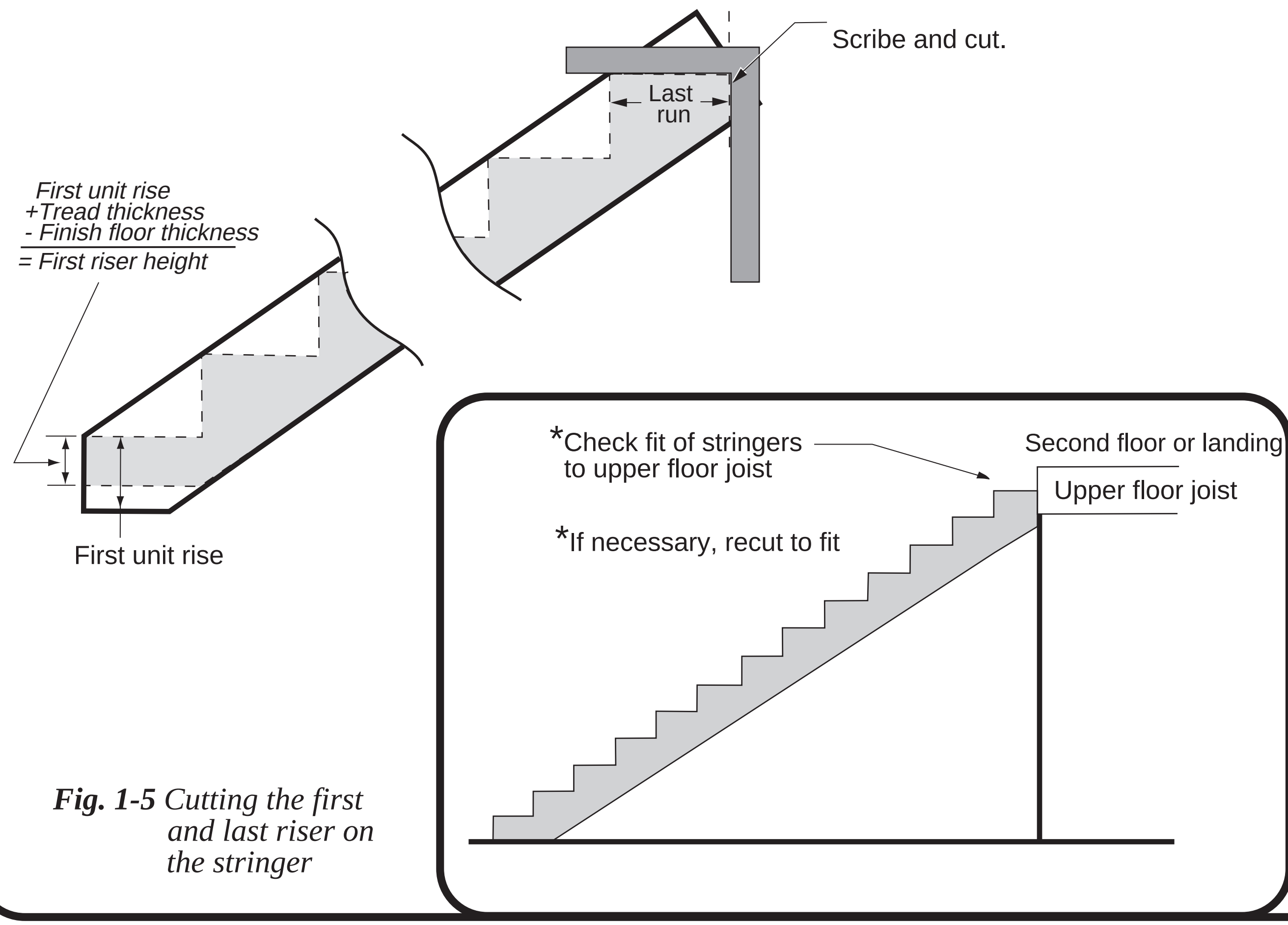


Fig. 1-5 *Cutting the first and last riser on the stringer*

Cutting the First Stringer

1. Clamp the stringer to two sawhorses and begin cutting the rise and run. Cut along the previously scribed lines.

   Caution: Be careful not to cut beyond the point where the rise and run lines meet, as this will weaken the stringer. For the best result, finish each cut with a handsaw or jigsaw.
2. Cut one stringer at a time.

Checking the Fit of Stringers

1. Place the top of the stringer in the wellhole so that from the rough second floor framing, the distance is equal to: one unit rise plus one tread thickness minus the finished floor thickness of the second floor or landing. Please note Fig. 1-6 here.

Checking the Fit of the Stringer

__________ Unit Rise Height

__________ + Tread thickness

__________ - Finished floor thickness

__________ = Distance of the stringer below rough cut

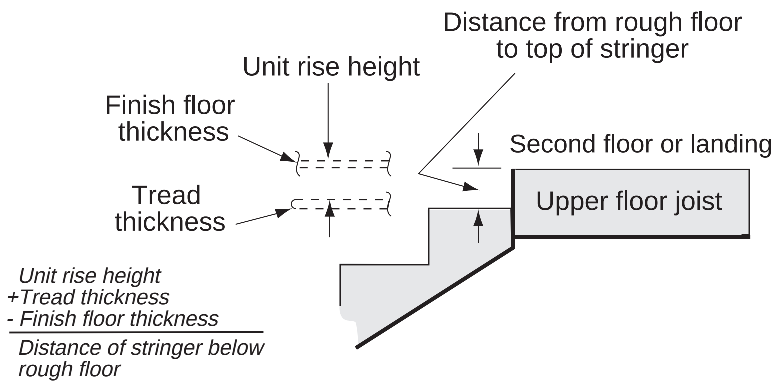


Fig. 1-6 *Checking the fit of stringers.*

2. Next, take a two-foot level and check that the runs of the stringer are as close to level as possible.
3. Check to make sure there is adequate room at the bottom of the stair as well as headroom clearance down the stair. Minor adjustments may be necessary.

Note: If too many adjustments are required, it may be necessary to start over and recalculate the rise and run.

Cutting the Other Stringers

1. Lay the first stringer on top of the other stringers with the crown up.
2. Using the completed stringer as a template, mark and then cut the other stringers. When cutting, make sure to cut out the width of a pencil line to ensure a tight fit.

Installing the Stringers

1. Nail a 2 x 4, (called the kicker plate or thrust block), equal to the width of the staircase, to the floor at the point where the staircase will end. Please note Fig. 1-7 here.

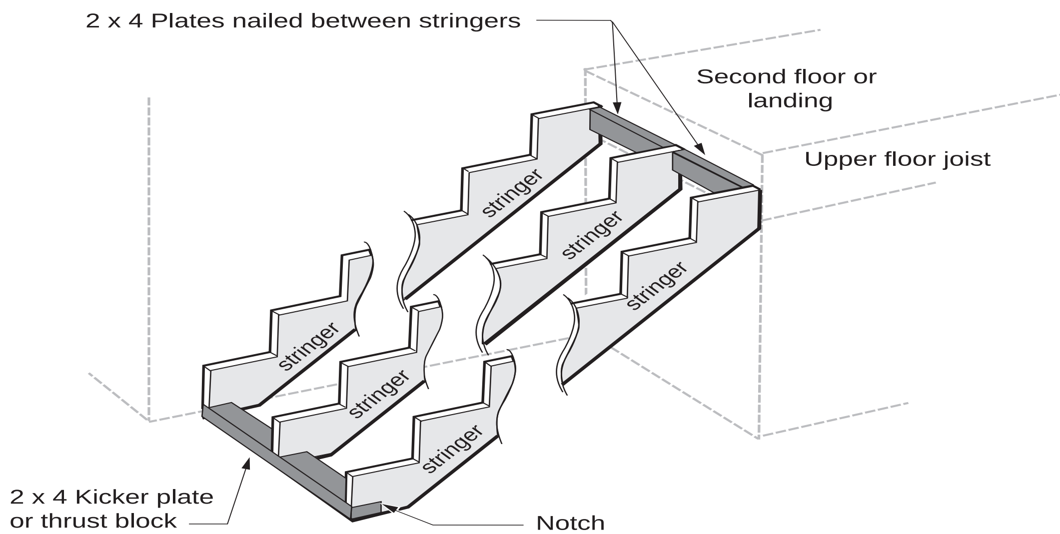


Fig. 1-7 *Installing the stringers with use of a 2x4 plate and securing the stringers against the upper floor.*

2. Notch the bottom of the stringers to accept the 2 x 4 plate.
3. Stand the stringers up in the wellhole with the bottom of the stringer resting on the 2 x 4 plate, and the top of the stringer resting against the upper floor joist.
4. Nail 2 x 4 plates horizontally against the upper floor joist between the stringers to support the back of the last tread.

Note: Because the framing of a structure may be out of square, plumb, or level, make sure to check the alignment of the stringers before attaching them.

5. Properly attach stringers to upper floor joist to ensure they comply with local building codes

Note: Sometimes the inside stringer is placed 1-1/2-inches from the wall so that the skirt and the sheet rock can easily be slipped behind the stringer. Please note Fig. 1-8 here.

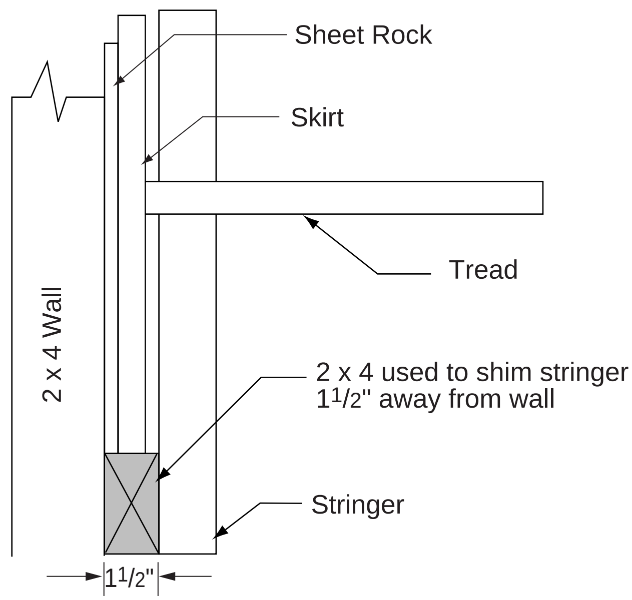


Fig. 1-8 *Shimming inside stringer*

Laying out the L-shaped Staircases

The L-shaped staircase differs from the straight staircase with regards to its level of complexity. The design, which is quite versatile, consists of two straight stair sections separated by a landing. The landing is nothing more than a large tread that divides a single flight into two separate straight runs. This provides an added degree of safety in the event of a fall. **(Most building codes dictate that no flight of stairs should have a vertical rise of more than 12 feet.)*

The process of designing and laying out the L-shaped staircase is similar to that of the straight staircase. See instructions under the straight stair section to calculate the total rise and unit rise.

Calculating Landing Height

***(Please note that the following numbers are for sample purposes only.)**
When the total rise (105”) and unit rise (7-1/2”) are determined, you must next determine the landing size. The landing should be at least the width of the stair in each direction.

1. Plumb down from the face of the second floor to the first floor to have a reference point for landing measurements. Please note Fig. 1-9 here.

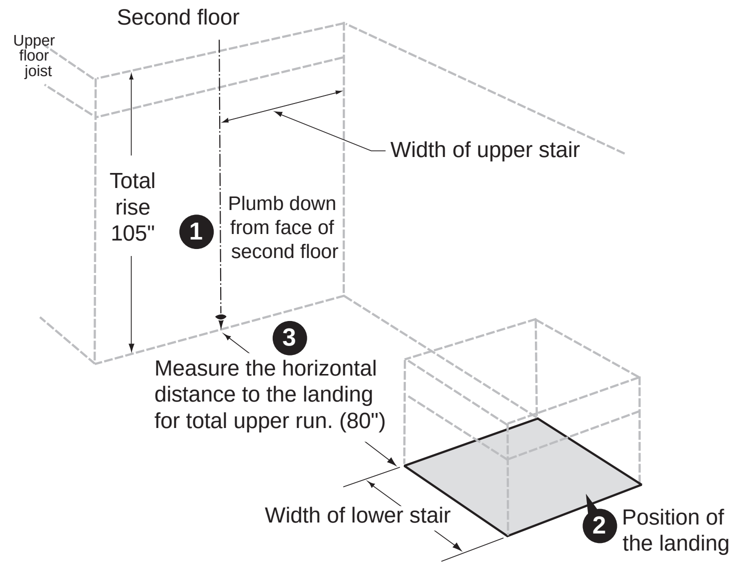


Fig. 1-9 *Determining position of landing and measuring total upper run*

2. Determine position of landing and then draw the landing out on the first floor.
3. Measure the horizontal distance between the landing and the upper floor reference point (80").
4. Divide this number (80") by the size of minimum allowable unit run (10") and round this number down to the nearest whole number (8). This will give the total number of treads (8) possible on the upper section of the L-shaped stair. Please note Fig. 1-10 here.

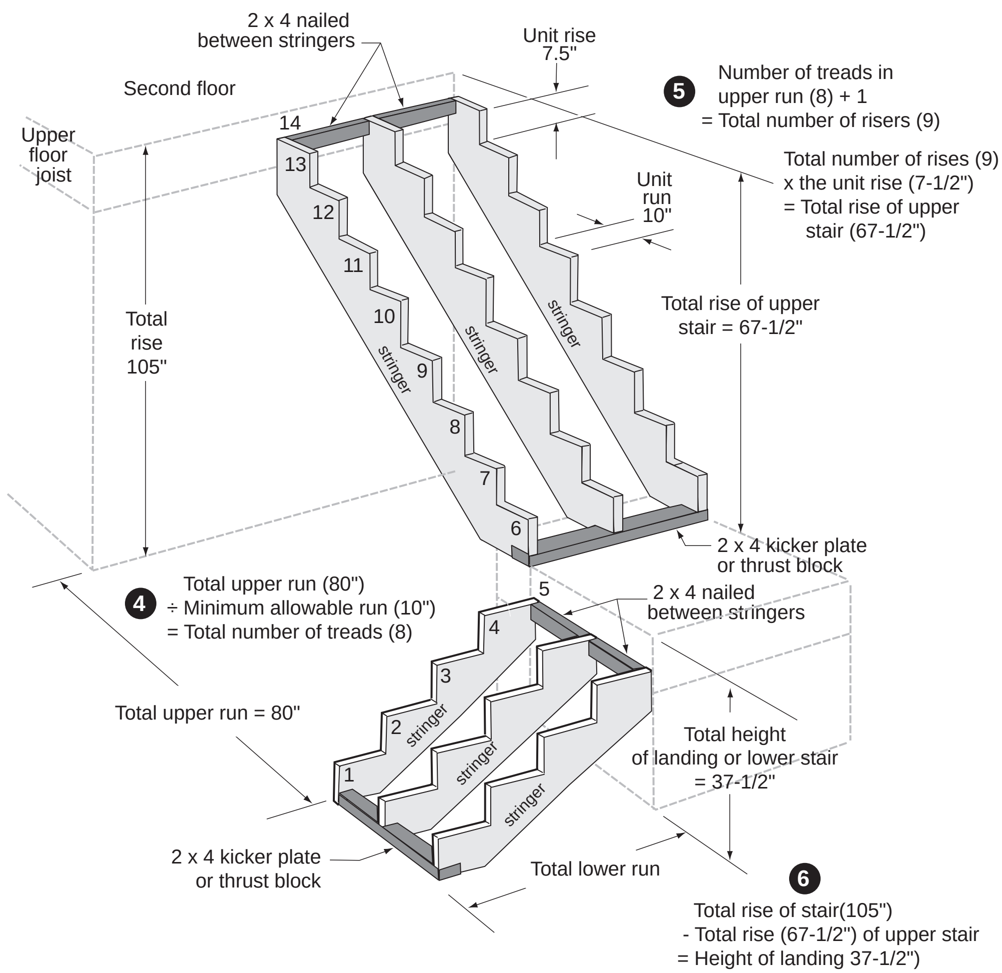


Fig. 1-10 *Calculating the total rise of upper stair and landing height.*

5. The L-shaped stair, like any other staircase, will start with a rise and end with a rise. Add one to the number of treads (8+1) determined for the upper stair and multiply this by the unit rise (7-1/2") to determine the total rise for the upper stair.
6. Subtract the total rise of the upper stair from the total rise (67-1/2") of the entire stair (105"). This will give the height of the landing (37-1/2").

Once again, the numbers used in the last example were sample figures provided by Stair Technologies, LLC. They are in no way representative of all staircases.

Building the Landing Platform

The landing platform, as stated before, should be at least the same width as the stair in each direction. Since the upper stringers will need to sit on the landing platform, it should extend out the distance of one unit run toward the upper staircase. The landing platform should be treated like any other floor in the structure and framed accordingly.

Installing the Stringers

Now that a landing is in place, complete the stair as if it were two separate straight stairs. The only difference is that the unit run on both the upper and lower stairs should be equal.

Chapter 1: Things to Remember

1. Always consult local building codes before constructing or installing a staircase.
2. Bond all connecting surfaces with a quality wood glue or construction adhesive.
3. Add backing or blocking to all areas where newels will be attached.
4. Make sure to make the necessary adjustments to the first and last rise in order to allow for finished floor and tread thickness.
5. Make sure that the stringer material is the proper size so that it will meet the required structural standards.