Unit 6
Finish Carpentry

In this Unit:

Hands-On Math Project Preview

Presenting a Professional Estimate

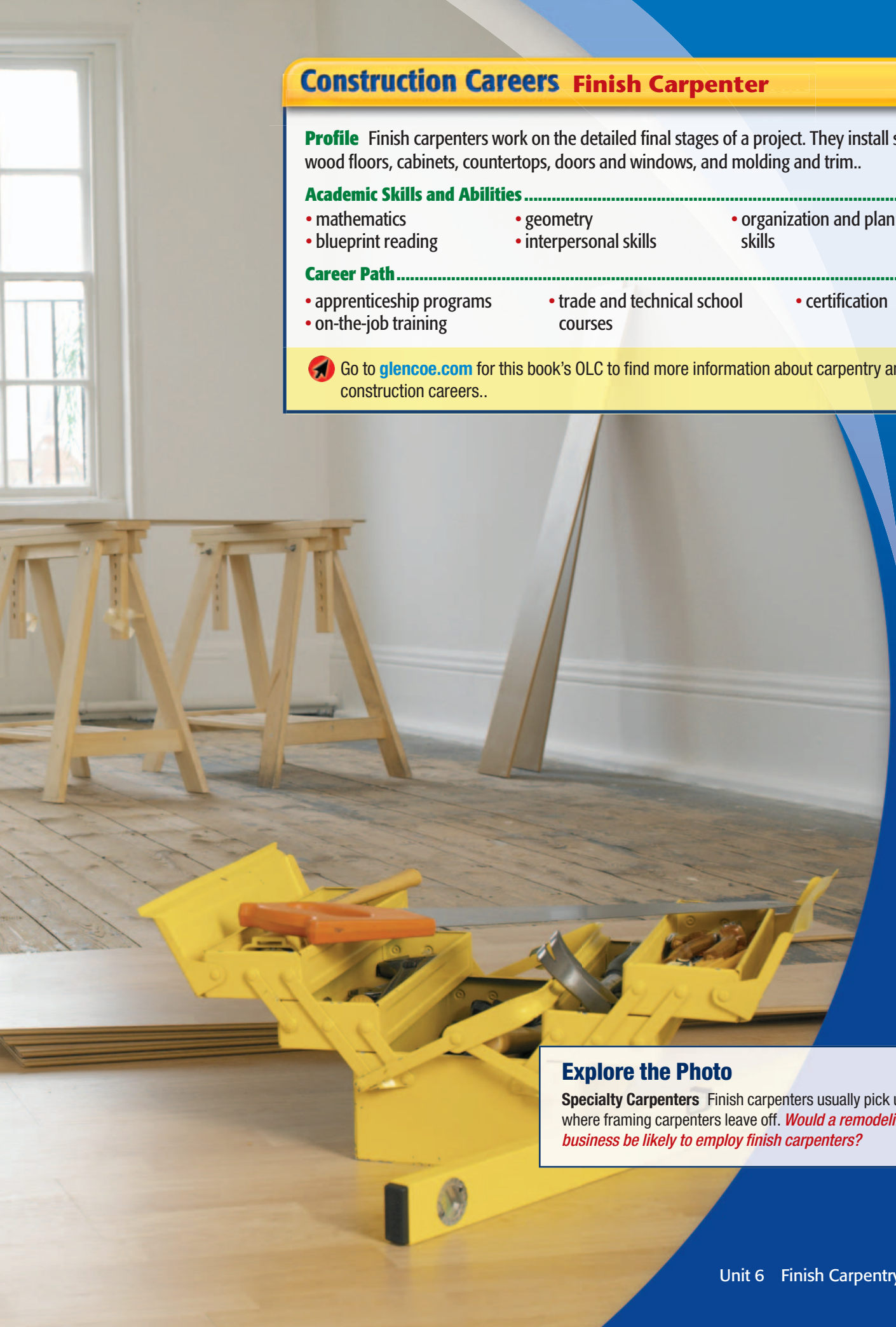
After completing this unit, you will you will create an estimate for remodeling a kitchen. You will also draw up and present a bid sheet.

Project Checklist

As you read the chapters in this unit, use this checklist to prepare go the unit project.

- ✓ Identify the methods for estimating materials, labor, and cost of a remodeling project.
- ✓ Research materials and appliances
- ✓ Calculate costs and check estimates.

Go to glencoe.com for this book's OLC. Find the WebQuest activity for Unit 6 called Estimating.



Construction Careers Finish Carpenter

Profile Finish carpenters work on the detailed final stages of a project. They install stairs, wood floors, cabinets, countertops, doors and windows, and molding and trim..

Academic Skills and Abilities

- mathematics
- blueprint reading
- geometry
- interpersonal skills
- organization and planning skills

Career Path

- apprenticeship programs
- on-the-job training
- trade and technical school courses
- certification

Go to **glencoe.com** for this book's OLC to find more information about carpentry and construction careers..

Explore the Photo

Specialty Carpenters Finish carpenters usually pick up where framing carpenters leave off. *Would a remodeling business be likely to employ finish carpenters?*

CHAPTER 25

Stairways

Chapter Objectives

After completing this chapter, you will be able to:

- **Identify** the method of construction used on any stairway.
- **Identify** the different parts of a stairway and the purposes of each part.
- **Understand** the building code requirements that apply to stairs.
- **Summarize** the steps of stair construction.
- **Explain** how to lay out a cut-stringer stairway.
- **Explain** how to install a cleat-stringer stairway.

Discuss the Photo

Interior Stair Each step consists of a tread and a riser. *Can you find the tread and the riser of each step in this photo?*

Writing Activity: Writing a Letter

Stairways are made up of a combination of structural lumber and millwork items such as treads, balusters, and trim. Write a one-page letter to a millwork company asking which types of wood are used for these common stairway items.

Chapter 25 Reading Guide

Before You Read Preview

Wood stairway construction is often considered the hallmark of fine finish carpentry. The work is entrusted to experienced carpenters because stairways must be durable and safe as well as attractive. Choose a content vocabulary or academic vocabulary word that is new to you. When you find it in the text, write down the definition.

Content Vocabulary

- stairwell
- treads
- stringer
- step
- risers
- stairway
- balusters
- flight
- winders
- headroom
- skirtboard
- rabbet
- kick plate

Academic Vocabulary

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

- involves
- process
- parallel

Graphic Organizer

As you read, use a chart like the one shown to organize information about content vocabulary words and their definitions, adding rows as needed.

Content Vocabulary	Definition
stairwell	the vertical shaft inside of which a stairway is built; sometimes called well opening

Go to glencoe.com for this book's OLC for a downloadable version of this graphic organizer.

Academic Standards

Mathematics

Geometry: Use visualization, spatial reasoning, and geometric modeling to solve problems (NCTM)

Algebra: Understand patterns, relations, and functions (NCTM)

Number and Operations: Compute fluently and make reasonable estimates (NCTM)

Problem Solving: Solve problems that arise in mathematics and other contexts (NCTM)

English Language Arts

Use written language to communicate effectively (NCTE 4)

Use different writing process elements to communicate effectively (NCTE 5)

Science

Physical Science: Motions and forces (NSES)

Science and Technology: Abilities of technological design (NSES)

Industry Standards

Stair Construction, Installation, and Finishing

NCTE National Council of Teachers of English
NCTM National Council of Teachers of Mathematics
NSES National Science Education Standards

Section 25.1

Stair Basics

Understanding Stairways

What features of a house might make stairway placement difficult for a designer?

Falls on stairs can result in many injuries. This is why building codes tightly regulate the design of stairways. To reduce the possibility of injury by people using a stairway, the carpenter must understand the local building codes for stair design and construction. In addition, the carpenter must work carefully, because even small differences in step height can make the stairs unsafe.

Stairways are typically built by carpenters on site. They use a combination of structural lumber and millwork items such as treads, balusters, and trim. However, stairs are sometimes assembled in a cabinet shop and delivered to the site for installation. This is particularly true of curved stairways.

This chapter covers primarily the construction of interior stairways. Many houses also have exterior stairways that lead to decks. Those are discussed both in this chapter and in Chapter 35.

Stairway Location

Determining the location of a stairway is one of the first and most important decisions made during the design of a house. There are several reasons for this. In addition to being a functional element of the house, a stairway can be a very important architectural feature. This is due in part to the size of the stairway. It is also due to the fact that a stairway is typically the only portion of a house that contains walls two or more stories high.

The stairway location also has an impact on the size and location of rooms on both floors. In fact, many architects start their floorplan sketches by determining the location of the stairway. The stairway is usually centrally located. This makes it equally accessible from various rooms.

Finally, the location of a stairway has an impact on the structure of the house. Because the stairwell interrupts the spacing of floor joists, structural reinforcement is required to channel loads to the foundation. A **stairwell** is the vertical shaft inside of which a stairway is built. It is sometimes called a *well opening*. Carpenters must provide framing details that are strong and unlikely to squeak as the stair is used.

Parts of a Stairway

Some houses have two interior stairways. The stairway that connects the main levels is called a *main stairway, primary stairway,* or *finish stairway*. A main stairway, such as the one in **Figure 25-1**, often provides a dramatic

Figure 25-1 A Main Stairway
Focal Point Stairs can be custom built or assembled from a collection of stock parts.

Courtesy of Designed Stairs

Science: Simple Machines

Inclined Planes In physics, *work* is the amount of force required to move an object over a distance (work = force × distance). A *simple machine* is a tool that makes work easier through the application of a force. However, a simple machine does not reduce the amount of work done. Any decrease in force is accompanied by a reciprocal increase in distance.

A stairway is an example of a simple machine called an inclined plane. An *inclined plane* makes it easier to raise or lower objects over a vertical height. It allows you to overcome the force of gravity by applying a smaller amount of force over a longer distance than the distance that the load is to be raised. Why is it easier to carry a 10 pound weight up a stairway than up a ladder?

Starting Hint Find a stairway and lean a ladder against it. Compare the length of the stairway to the length of the ladder.

focal point for an entry hall. The stairway that leads to the basement is called a *service stairway*. Either type of stairway may be built completely by hand or assembled from prefabricated parts purchased as stock millwork items.

The framing of the stairwell, shown in **Figure 25-2**, is explained in Chapter 15. Most stairways are built within framed walls that form a stairwell. Sometimes it completely encloses the stair from one floor to another. In other cases, it may be open on one or more sides. When the stair builder begins to work, carpenters should already have completed the framing for the floor opening and the stairwell. In some cases, temporary stairs may also be in place.

Though stairways vary in their construction, all stairways have three common elements. The **treads** are the parts of the stair upon which you step. The stringers support

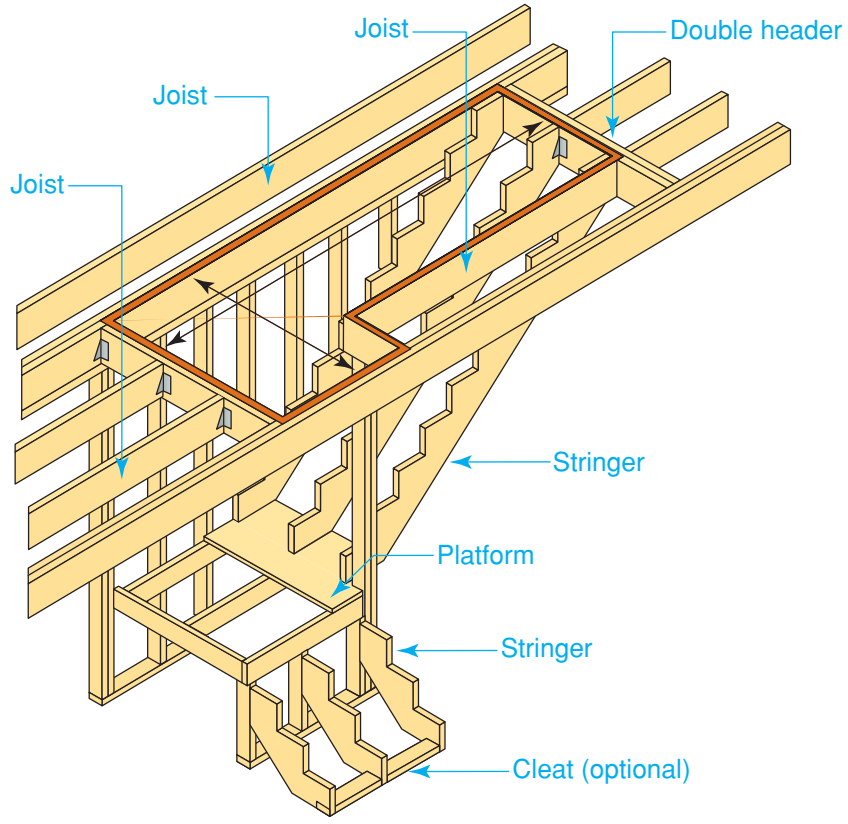


Figure 25-2 Basic Stair Framing
Stairwell and Stairway Framing for a stairwell and stairway. The top of the stairwell is outlined in red.

the treads, and a *handrail* is required for safety. A **stringer** is a long piece of 2× lumber that supports a stair. On some stairways, the spaces between treads are enclosed by vertical boards called **risers**.

In this book, the term **step** refers to a tread and a riser. The term **stairway** refers to a series of steps along with all the related elements, including structural elements such as stringers and finish elements such as handrails and balusters. **Balusters** are the slender vertical members that support the handrail.

Explain *What can a carpenter do to reduce the possibility of injury on stairways?*

Types of Stair Construction

There are three common types of stair construction. Each type is based on how the stringers are installed.

Cleat-Stringer Stairway The simplest stair construction has two stringers and a series of treads made from wood planks, as shown in **Figure 25-3**. It is called a *cleat-stringer stairway* because the treads are supported by small pieces of wood called *cleats* that are attached to the sides of each stringer. Metal brackets are also available to take the place of wooden cleats. Cleat-stringer stairways are fairly easy to build and are usually made of inexpensive materials. They are sometimes used as service stairways. Note that the stringers are not notched to accept treads or risers.

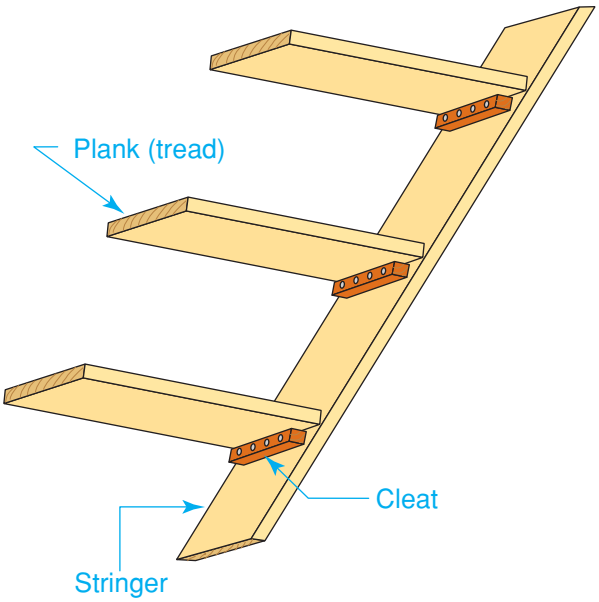


Figure 25-3 Cleat-Stringer Stairway
Quickly Built Cleat-stringer stairways are sometimes used as service stairways because they are inexpensive and easy to build.

Cut-Stringer Stairway A *cut-stringer stairway* is the most common type of stairway found in houses. The treads and risers are attached to notches sawn into the upper edge of each stringer, as shown in **Figure 25-4**. A cut-stringer stairway may have two or more stringers. Three stringers are common on main stairways, but unusually wide stairs may have four stringers.

Housed-Stringer Stairway *Housed stringers,* sometimes called *closed stringers* or boxed stair construction, have recesses in the sides. The treads and risers fit into the recesses and are held in place with wood wedges. This type of stair construction, shown in **Figure 25-5**, is often found in prefabricated stair systems.

Handrails and Balusters

In order to be used safely, all stairways require some type of handrailing. In some cases, the handrailing can be attached to the inside surfaces of the stairwell using special handrail brackets. With open stairs, which

Builder's Tip

FIRE SAFETY The space beneath a stair is often enclosed to provide storage. Building codes require that drywall ½" or thicker be installed on the inside of all walls. Drywall should also be attached to the underside of the stair stringers. The drywall provides a measure of fire protection in these spaces. This requirement should be taken into account when framing the platform walls.

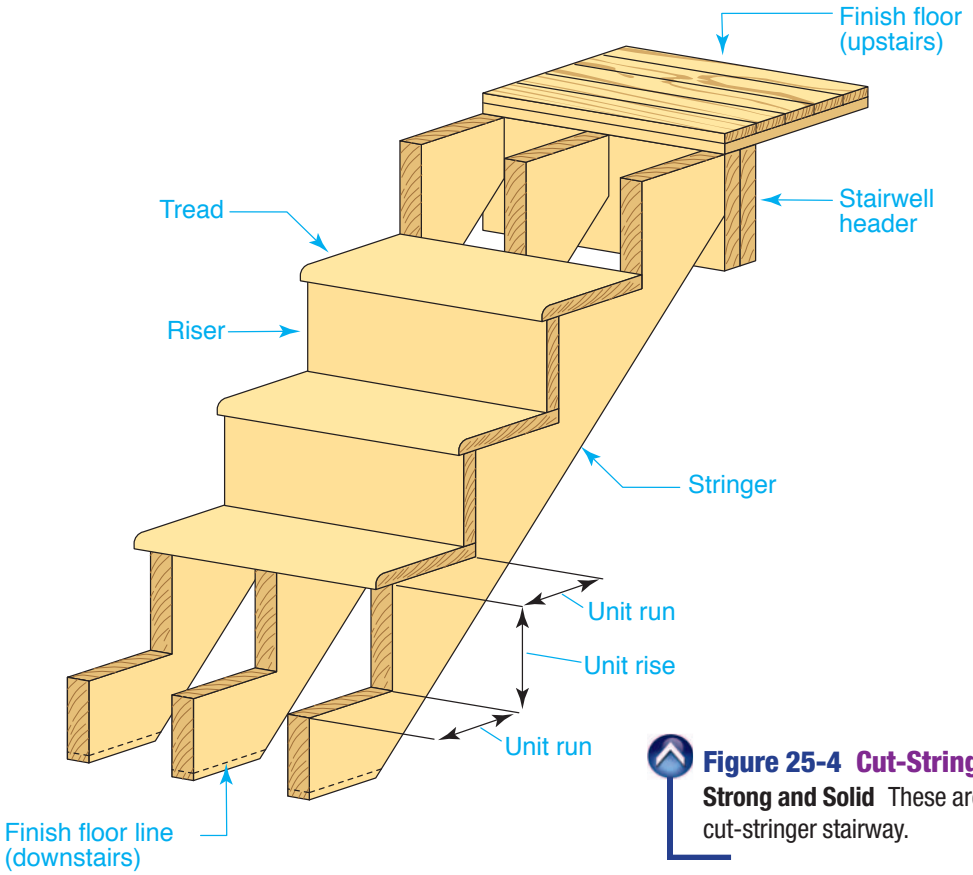


Figure 25-4 Cut-Stringer Stairway
Strong and Solid These are the basic elements of a cut-stringer stairway.

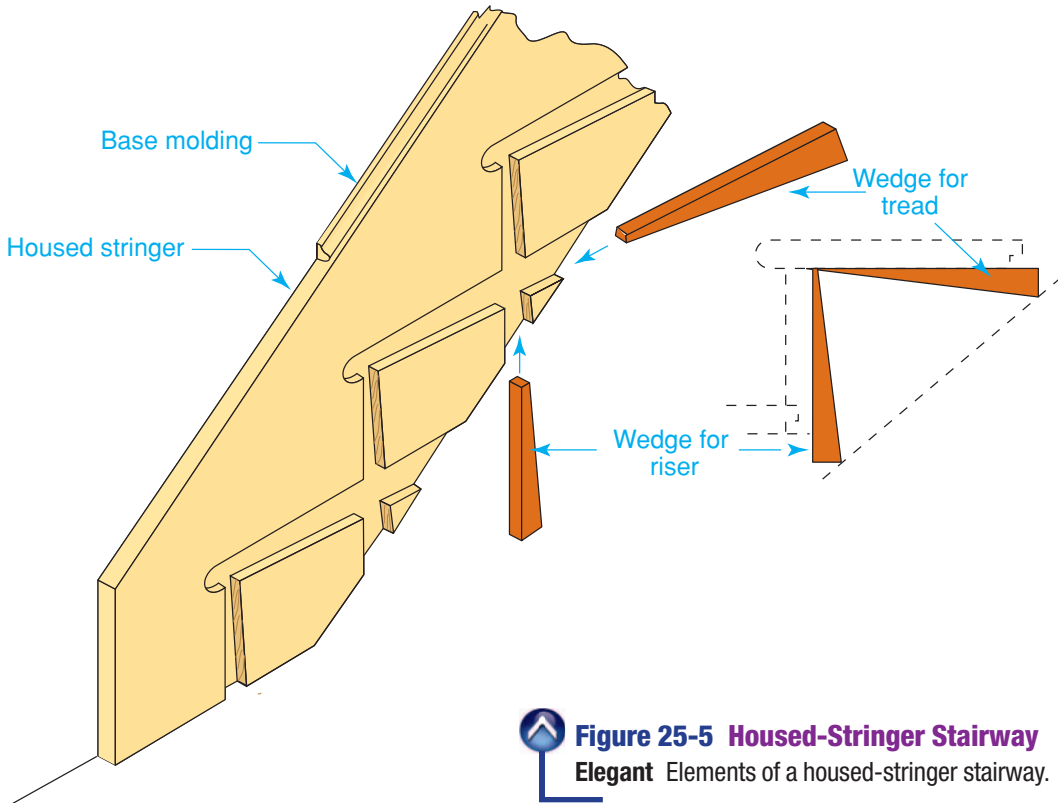


Figure 25-5 Housed-Stringer Stairway
Elegant Elements of a housed-stringer stairway.

are not enclosed in a stairwell, the handrail must be supported by balusters. Newel posts support each end of the handrail. The entire system of balusters, handrails, and related support pieces is sometimes called a *balustrade*.

The various parts of an open stairway are shown in **Figure 25-6**.

Baluster A vertical member that supports the handrail on open stairs.

Gooseneck The curved piece between the main handrail and a newel post.

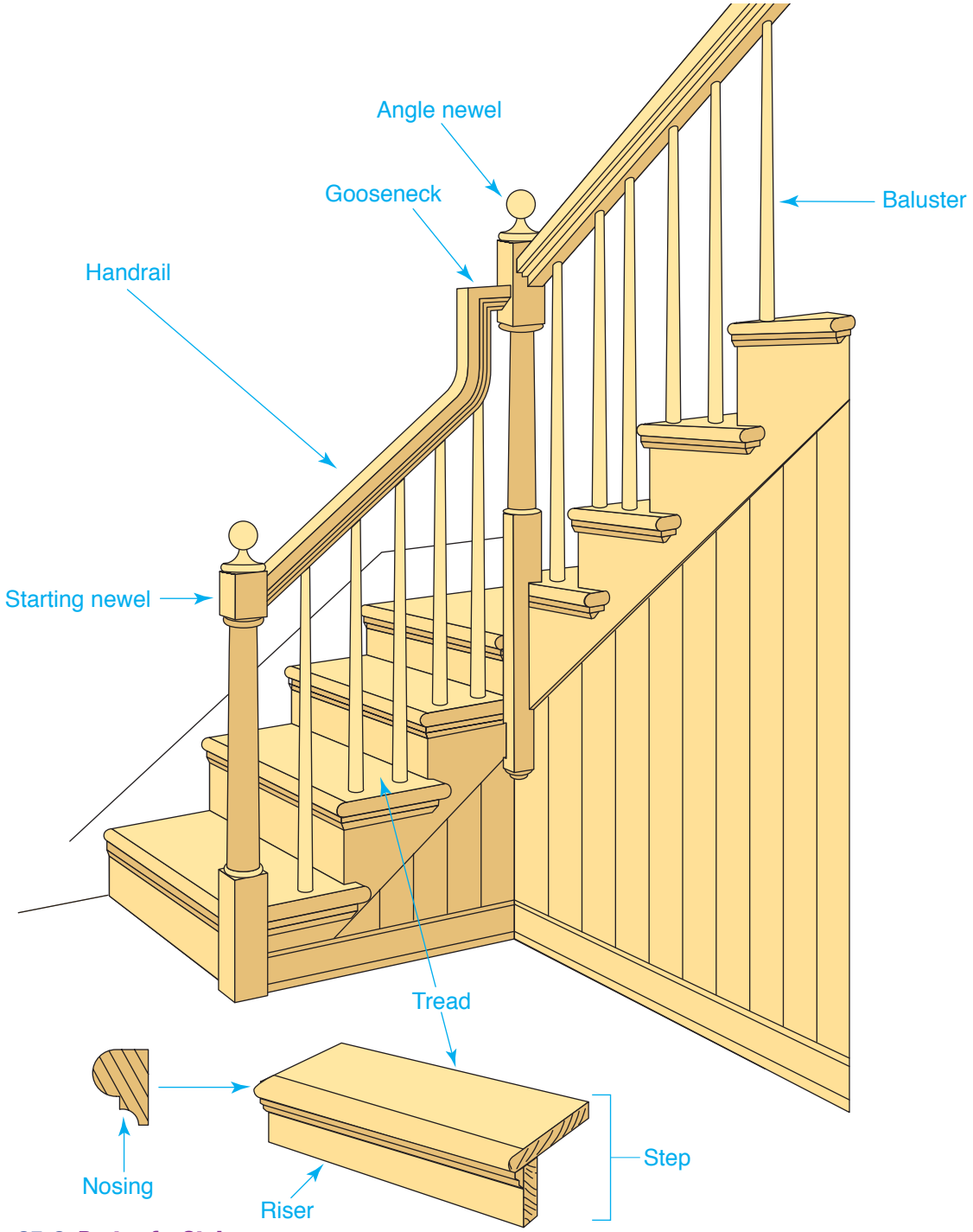


Figure 25-6 Parts of a Stairway
Finished Stair These parts can be found on many types of stairs.

Handrail The portion of the stair that is grasped when going up or down. It sometimes continues past the stairway to form a balcony handrail.

Newel A newel is a post that supports the handrail at the top and bottom. A *landing newel*, also called a *starting newel*, is located at the bottom of a stair. It is often more elaborate than other newels and can serve as an architectural feature. An *angle newel* supports the handrail at landings, particulary where the stair changes direction.

Nosing The part of a tread that projects beyond the face of the riser.

Riser The vertical portion of a step.

Step One tread or a tread and riser. The first step of a stair is often called the *starting step*. If the starting step is lengthened and rounded at one or both ends, it is referred to as a bullnose starting step.

Tread The horizontal portion of a step.

Riser The vertical portion of a step.

Stringer The piece of lumber that supports the treads and risers. A stringer may also be called a *string*, a *carriage*, or a *horse*.

Metal Stair Parts Most stairs are built entirely of wood products, but some include parts made of metal as well. This is often the case with balusters and handrails. For example, an ornate balustrade might be made of wrought iron. It could support a handrail made of wood or metal. It would also include wrought iron newel posts. Metal stair parts must be ordered well in advance of stair construction. They are sometimes shipped as a collection of pieces that must be installed according to the manufacturer's instructions. In other cases, portions of the railing system may be shipped as complete sections that can then be linked together and attached to the stair.

Explain *What type of stairway is sometimes used as a service stairway?*

Stairway Planning

How is headroom measured?

In most houses, a stairway makes a straight, continuous run. A straight run of stairs is called a **flight**. A flight goes from one landing to another. The *landing* is the floor area where a flight ends or begins, as shown in **Figure 25-7**. However, a stairway may make a turn to conserve space. Stairways that turn usually include a platform. This platform can also be considered a landing because it is the start of one flight and the end of another. The platform or landing must be at least as wide as the stairway itself.

The stair shown below is an example of an L-shaped stair. It contains two flights arranged at 90° to each other and separated by a platform. The platform is built with short joists covered by floor sheathing and

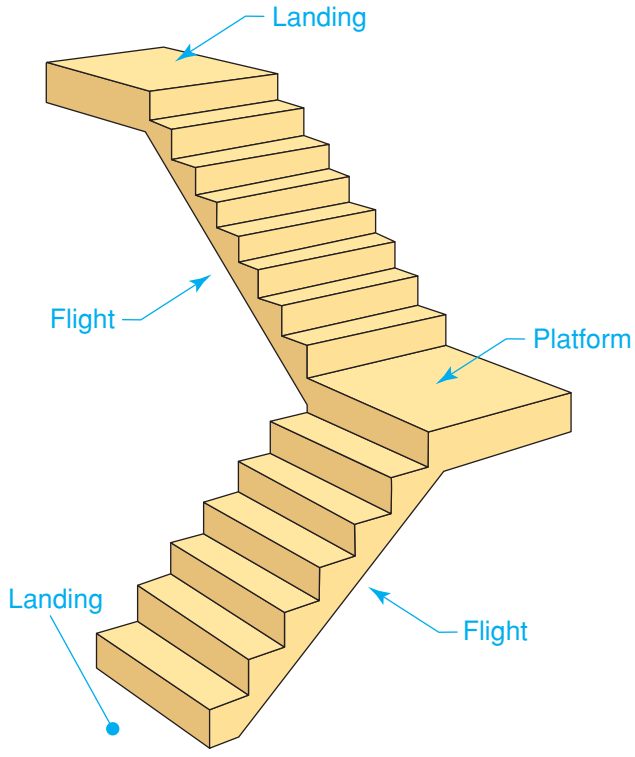


Figure 25-7 Flights and Landings
Stair Layout The arrangement of a stair is a combination of flights leading to landings (and sometimes to platforms).

is supported by framed walls. The enclosed sides of a platform may be nailed into one or more existing walls. Flights may also be arranged at 180° to each other, with a platform between. This arrangement is visible in Figure 25-2 on page 725.

Radiating treads called **winders** can be used instead of a platform when a stairway must change directions. Winders such as those shown in **Figure 25-8** are often found in older houses, but they are not as safe as standard treads. This is because a winder is wedge-shaped and a portion of the tread is too narrow for safe use. Current building codes now restrict how narrow the point of the winder can be.

Stair Codes

The following factors are important to consider when designing and building a stair. The code dimensions found in this chapter are from the 2006 IRC. Before designing a stair, be sure to find out what building codes have been adopted in your area. The codes noted here apply to stairways with straight flights. Codes for spiral stairways and curved stairways are somewhat different. Temporary access stairs used during construction should conform to OSHA guidelines.

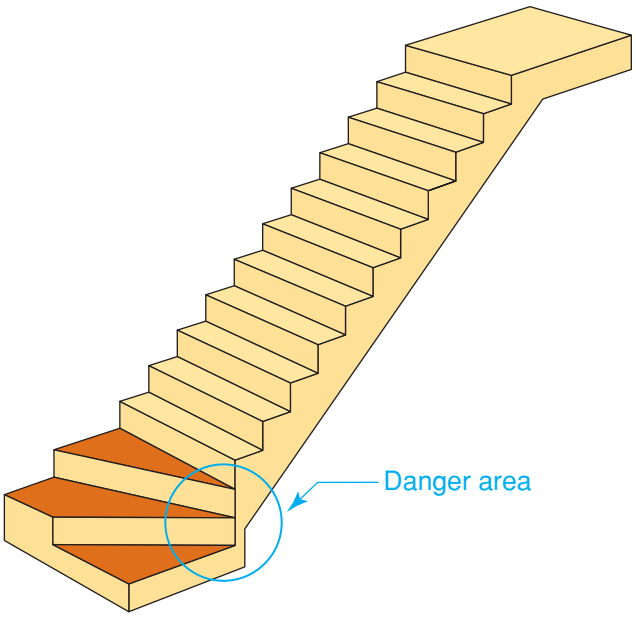


Figure 25-8 Unsafe Winders
Difficult to Use The winders are the shaded steps at the bottom of this stair. Building codes now prohibit winders that come to a point as shown here.

Headroom The clearance directly above a step is called **headroom**. Headroom is measured from the outermost edge of the nosing to the ceiling surface directly overhead. If a beam projects below the ceiling surface, headroom is measured to the underside of the beam. Headroom on a landing is measured from the floor surface to the ceiling. Although the minimum headroom required by code on stairs and landings is 6'-8", main stairways generally have between 7'-4" and 7'-7" of headroom. Sometimes two or more flights of stairs are arranged one above the other in the same stairwell. An example would be a basement stairway under the main stairway. Headroom on the lower stair must be carefully calculated because support beams for the first floor can make it difficult to provide suitable headroom.

Calculating headroom is critical in framing stages because the header height must be positioned to provide the minimum headroom for the finished stairway.

Stairway Width A stairway must be wide enough to allow two people to pass comfortably and to permit furniture to be carried up and down. The minimum width for a stairway is 36", measured between the finished walls of the stairwell. However, a width of 42" makes moving furniture easier. The *minimum clear width* of a stair is the distance between the handrails. If a stairway has two handrails, the minimum distance allowed between them is 25". If there is only one handrail, the minimum clear width is measured to the opposite wall surface and is 31½". There is also a minimum distance between balusters.

Risers and Treads The height of the riser and the depth of the tread determine the ease with which the stairs are used. If the

Figure 25-9 Stair Comfort

Too Steep A stairway should be built with the proper height of risers and treads. On this stairway, the tread is too shallow and the riser is too high.

risers are too high, climbing the steps can be difficult, as shown in **Figure 25-9**. If the treads are too shallow, toes will bump the riser at each step. The building code allows a maximum riser height of 7¾" and a minimum tread depth of 10". Safety research indicates that the ideal riser is 7" high and the ideal tread is 11" deep. Winders such as those in Figure 25-8 are no longer allowed. Codes now specify that all winders must be at least 10" wide at a point measured 12" away from the wall. In addition, no part of a winder can be less than 6" wide. The general rule of thumb for stair design is that the riser and tread should add up to between 17 and 18 inches. In addition, the wider the tread, the lower the riser should be. This is both for safety and comfort when accessing the stairs.

Whatever dimensions are chosen for steps, the height and depth of each step must be uniform. Perfect uniformity is difficult, but the code allows a variation of no more than ⅜" between maximum and minimum riser heights. Likewise, the difference between the deepest and the shallowest tread must be no more than ⅜". Variations that are greater can cause someone to trip when using the stairs. Warped or poorly secured treads reduce uniformity. As a result, they are a tripping hazard.

Treads should have a slip-resistant surface. Materials such as polished stone and glazed tile can be dangerous on a stair and should be avoided.

Handrails One of the most important features of good stair design is the handrail. A solid, easily grasped handrail can prevent falls and serious injuries. A continuous handrail must be provided on at least one side of every flight that has four or more risers.

You should be able to curl your fingers around a handrail with ease. Handrails are easiest to grasp when they are made from metal tubing or solid wood shaped into a cylinder. The diameter of such handrails should be between 1½" and 2". Handrails with a larger diameter are more difficult to hold. Other shapes of handrails are permitted, but their shape and size is regulated by code in great detail. In general, however, the edges of the handrail must have a minimum radius of ⅛" for comfort. They should be rounded over and have no sharp edges. There should be at least 1½" of space between the handrail and the wall on which it is mounted.

A handrail should be 34" to 38" high. This distance is measured vertically from the upper edge of the nosing to the top of the handrail.

Balusters The purpose of balusters is to prevent anyone, particularly children, from slipping under the handrail and falling. Balusters should be spaced so that a sphere 4" in diameter cannot pass between them. One exception is at the triangular opening sometimes formed between adjacent steps. In that case, a sphere 6" in diameter should not be able to pass through.

Section 25.1 Assessment

After You Read: Self-Check

1. What is a stairwell?
2. What are risers?
3. Name the three basic types of stair construction.
4. What role do the dimensions of risers and treads play in the ease with which a stair can be used?

Academic Integration: English Language Arts

5. **Write a Description** Research online and print sources for photos or illustrations of open stairways. Select one. Write a description of how the stair in Figure 25-6 on page 728 compares to the stairway you have selected. In your description, use the following terms: platform, nosing, risers, railing, and open and closed stringers.

Go to glencoe.com for this book's OLC to check your answers.

Section 25.2

Stair Construction

Basic Calculations

What are unit rise and unit run?

The construction of any stairway calls for detailed calculations to ensure that it meets building codes. The calculations for a basic stairway can be easily done with pencil and paper. However, some builders use a construction calculator instead. The handheld calculator can display results in fractions of an inch and is programmed to solve stair problems.

The basic calculations determine the dimensions of details, such as those shown in **Figure 25-10**. Use this illustration to study and familiarize yourself with the basic terminology needed to understand stairway calculations.

- ***Stairwell Header*** The doubled framing that forms the ends of the stairwell opening. It supports the floor joists that were cut to create the stairwell opening.
- ***Total Rise*** The vertical distance from the finished surface of one floor to the finished surface of the next floor.
- ***Total Run*** The horizontal length of the stairs.
- ***Unit Rise*** The vertical distance from the top of one tread to the top of the next highest tread.
- ***Unit Run*** The horizontal distance between the face of one riser and the face of the adjacent riser.

Unit Rise and Unit Run

The first task in stairway layout is to determine the unit rise and unit run per step. These terms are illustrated in **Figure 25-11**. The unit rise is the height of one riser. It is based on the total rise of the stairway and the fact that the unit rise for stairs should be about 7". The unit run is the distance

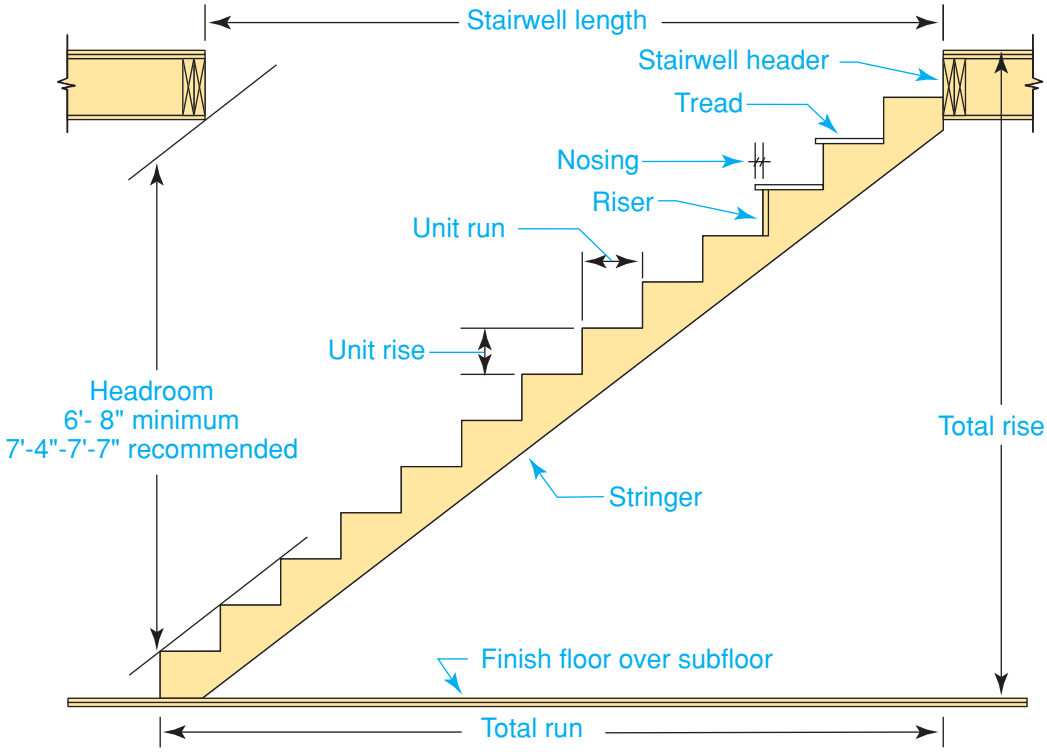


Figure 25-10 Basic Layout of a Stairway
Critical Dimensions This illustration identifies the elements of a stair that must be calculated.

from the face of one riser to the face of the next riser, or the depth of a tread. It does not include the nosing. The total rise is the vertical distance between the surface of the finish floor on one level and the surface of the finish floor on the next level. It is shown on the plans in elevations and wall sections.

It is important to actually measure the total rise before stair construction starts. It may vary slightly from the distance specified on the plans. For example, suppose that you are building a service stairway from the basement, and the concrete basement floor is already finished. You must then add the thickness of the upper floor's finish flooring to your total rise measurement in order for it to match the measurement on the plans.

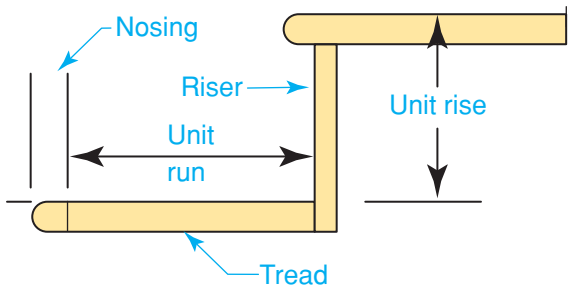


Figure 25-11 Unit Rise and Unit Run
Step Details The unit run is the distance from the face of one riser to the face of the next riser and does not include the nosing. The unit rise is the distance from the top of one tread to the top of the next tread.

Builder's Tip

TIGHT JOINTS Careful construction techniques improve the safety and durability of a stair. Be sure to make all cuts square and even. This will result in tight joints and will also prevent stair parts from wobbling or squeaking over time. Securing key parts with woodworking glue or construction adhesive helps to reduce wood movement that can result in squeaks.

Step-by-Step Application

Calculating Unit Rise and Unit Run Here is an example of how to calculate unit rise and unit run. Assume that the total rise for this stairway is 8'-11".

Step 1 Convert the total rise to inches. That number is 107" (12 × 8 = 96; 96 + 11 = 107).

Step 2 Divide 107" by 7", the ideal riser height. The result is 15.28 (107 ÷ 7 = 15.28).

Step 3 Round 15.28 to the nearest whole number, which is 15. This gives you the total number of risers in the stairway.

Step 4 To find the unit rise, divide the total rise (107) by the number of risers (15) for a result of 7⅛" (107 ÷ 15 = 7.13, or 7⅛").

Step 5 As a general rule, the sum of one riser and one tread should be between 17" and 18". If you subtract the unit rise from this sum, you can find the unit run. For example, if the sum of one riser and one tread is 17½" and the unit rise is 7⅛", the unit run will be 10⅜" (17½" − 7⅛" = 10⅜").

Go to **glencoe.com** for this book's OLC for additional step-by-step procedures, applications, and certification practice.

Once you know the total rise for a stair, you can calculate the unit rise and unit run. For an example of how to do this, see the Step-by-Step Application on this page.

Calculating Total Run The *total run* is a measurement equal to the unit run times the number of treads in the stairway. The total number of treads depends on the manner in which the upper end of the stairway is anchored to the upper landing. Two common methods are shown in **Figure 25-12**.

A complete tread at the top of the stairway is shown in Figure 25-12A. This tread requires a larger stairwell opening, yet it allows the stringer to bear solidly against the header. This means that the number

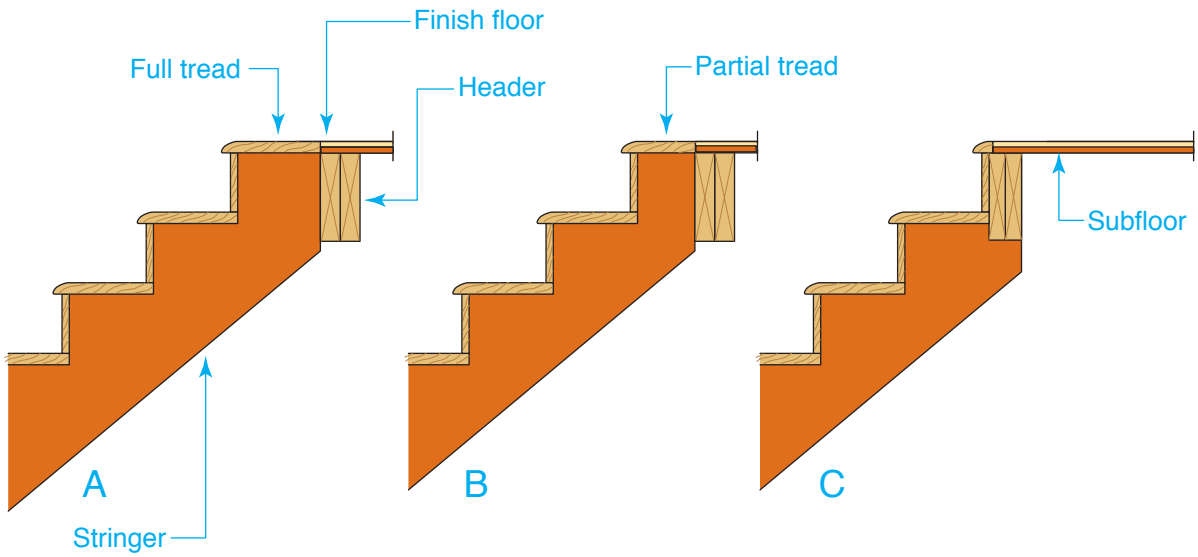


Figure 25-12 Anchoring the Stringers
Three Methods In **A.**, the top of the stringer forms a full tread. In **B**, it forms a partial tread. In **C**, it stops short of the upstairs finish floor.

of treads in the stairway is the same as the number of risers. If there are 15 treads and the unit run is 10⅜", the total run of the stairway is 12'-11⅝" (15 × 10⅜" = 155⅝", or 12'-11⅝").

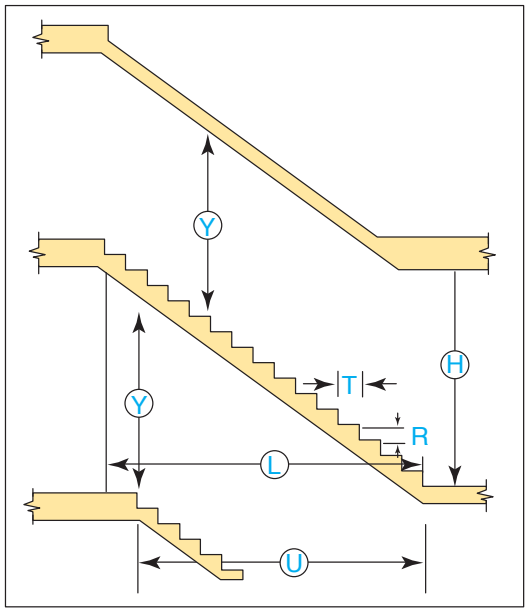
Only part of a tread at the top of the stairway is shown in Figure 25-12B. In this case, the number of complete treads is one less than the number of risers. Using the earlier example, that would mean 14 treads. The total run of the stairway would then be 14 × 10⅜", plus the run of the partial tread at the top. This partial tread may be dimensioned in detail on the plans. If not, you will have to estimate it as closely as possible. If we assume that it is about 7", the total run is 12'-8¼" (14 × 10⅜" = 145¼"; 145¼" + 7" = 152¼", or 12'-8¼").

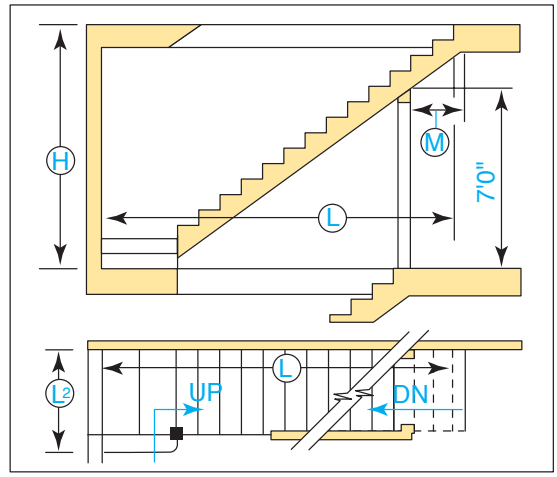
In Figure 25-12C, the upper finish flooring serves as the top tread. In this case the number of treads is one less than the number of risers. Using our example, the total run would be 12'-1¼" (14 × 10⅜" × 145¼", or 12'-1¼").

After you have figured the total run of the stairway, drop a plumb bob from the stairwell header to the floor below. Measure off along the floor the total run, starting at the plumb bob. This locates the anchoring point for the lower end of the stairway. Some standard stair layouts can be seen in **Figure 25-13**.

Sometimes there may not be enough room for a straight run. In this case, a landing and two or more sections of stairway would be needed.

Height Floor to Floor H	Number of Risers	Height of Risers R	Width of Tread T	Run		Run	
				Number of Risers	L	Number of Risers	L2
8'0"	13	7 3/8" +	10"	11	8'4" + W	2	0'10" + W
8'6"	14	7 5/16" -	10"	12	9'2" + W	2	0'10" + W
9'0"	15	7 3/16" +	10"	13	10'0" + W	2	0'10" + W
9'6"	16	7 1/8" -	10"	14	10'10" + W	2	0'10" + W





Height Floor to Floor H	Number of Risers	Height of Risers R	Width of Treads T	Total Run L	Minimum Head Rm. Y
8'0"	12	7 3/8" +	9"	8'3"	6'8"
	13	7 3/8" +	9 1/2"	9'6"	6'8"
	13	7 3/8" +	10"	10'0"	6'8"
8'6"	13	7 3/8" +	9"	9'0"	6'8"
	14	7 3/8" +	9 1/2"	10'3 1/2"	6'8"
	14	7 3/8" +	10"	10'10"	6'8"
9'0"	14	7 3/8" +	9"	9'9"	6'8"
	15	7 3/8" +	9 1/2"	11'1"	6'8"
	15	7 3/8" +	10"	11'8"	6'8"
9'6"	15	7 3/8" +	9"	10'6"	6'8"
	16	7 3/8" +	9 1/2"	11'10 1/2"	6'8"
	16	7 3/8" +	10"	12'6"	6'8"

Figure 25-13 Sample Stair Layout Dimensions
Various Possibilities Layout dimensions for some standard stairways.

Cut-Stringer Stairways

What factors might weaken a stringer?

A cut-stringer stairway is very versatile. It can be built of expensive materials or common lumber. It can have treads and risers, or just treads. (If it has no risers, it is called an *open-riser stairway*.) It can be a permanent part of the house or be used only during the construction phase. All of these variations rely on the same basic concepts.

The building of a stair **involves** a series of operations. These operations must be done carefully and accurately.

Laying Out the Stringers

The treads and risers are supported by two stringers that are solidly fastened in place. When the treads are less than 1⅛" thick, or if the stairs are more than 2'-6" wide, a third stringer should be installed in the middle of the stairs.

Cut stringers for main stairways are usually made from 2×12 stock. To lay out the stringer, you must first determine how long a piece of stock you will need. We will use the same figures used in the calculation examples. Assume that the method of anchoring the stair is the one shown in Figure 25-12C on page 734. The total rise is 8'-11". The total run is 12'-1¼".

1. On the framing square twelfth scale, measure the distance between a little over 12$^{1}/_{12}$" on the blade and 8$^{11}/_{12}$" on the tongue. You will find that it comes to just about 15". Therefore, you will need a piece of stock at least 15' long. You should allow extra stock for waste (about 3' more in this case).
2. Select or cut a piece about 18' long. Lay out the stringer from the lower end.
3. Set the framing square to the unit run and unit rise as shown in **Figure 25-14**. Draw line $\overline{AB}$ along the blade and line $\overline{BC}$ along the tongue. $\overline{AB}$ indicates the first tread, $\overline{BC}$ the second riser.
4. Reverse the square and starting at A, draw line $\overline{AD}$ perpendicular to $\overline{AB}$. It should be equal in length to the unit rise. Line $\overline{AD}$ indicates the first riser.

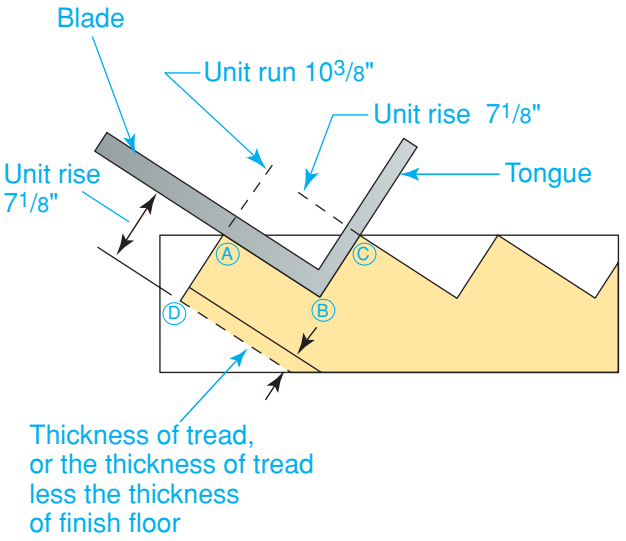


Figure 25-14 Starting the Layout
Riser and Tread Laying out the lower end of a cut stringer.

5. The first riser has to be shortened, a **process** that is called *dropping the stringer,* as shown in **Figure 25-15**. In the completed stair, the unit rise is measured from the top of one tread to the top of the next. Assume that the bottom of the stairway is to be anchored to a finished floor, such as a concrete basement floor. If $\overline{AD}$ were cut equal to the unit rise, the first step would be too high when the first tread was put on. Its height would equal that of the unit rise plus the thickness of the tread. To make the height of the first step equal to just the unit rise, shorten $\overline{AD}$ by the thickness of a tread. If the bottom of the stringer is to be anchored on a subfloor to which finish flooring will be applied, shorten $\overline{AD}$ by the thickness of a tread minus the thickness of the finish flooring.
6. When you have shortened $\overline{AD}$ as required, proceed to step off the unit run and unit rise as many times as the stairway has treads. In our example, that would be 14. To maintain the square

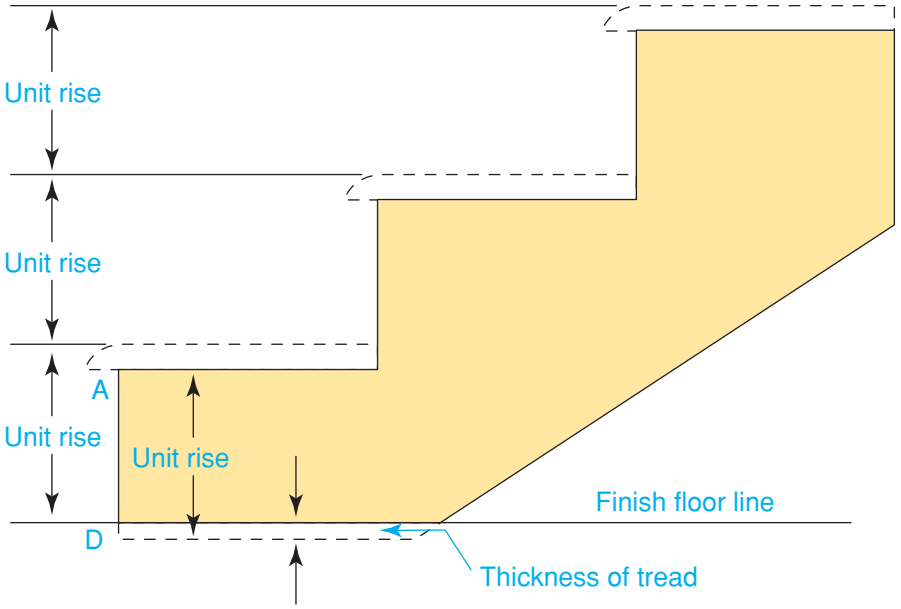


Figure 25-15 Dropping the Stringer

Crucial Detail Dropping the stringer to compensate for the thickness of the first tread keeps the unit rise uniform throughout.

in the same position as you slide it along the rafter, attach stair gauges to the framing square as shown in **Figure 25-16**. They ride along the edge of the stock to prevent the square from slipping out of position.

7. Finish the layout at the upper end as shown in **Figure 25-17** on page 738. Remember, we are going to anchor the upper end by the method shown in Figure 25-12C. First lay out line $\overline{AB}$, which represents the last of the treads.
8. Lay out dotted line $\overline{BC}$, which indicates the face of the header.
9. Extend $\overline{BC}$ down to D, so that $\overline{BC}$ plus $\overline{BD}$ will equal the depth of the header.
10. To make the stringer fit close under the lower edge of the header, you must shorten $\overline{BD}$ by the amount the stringer

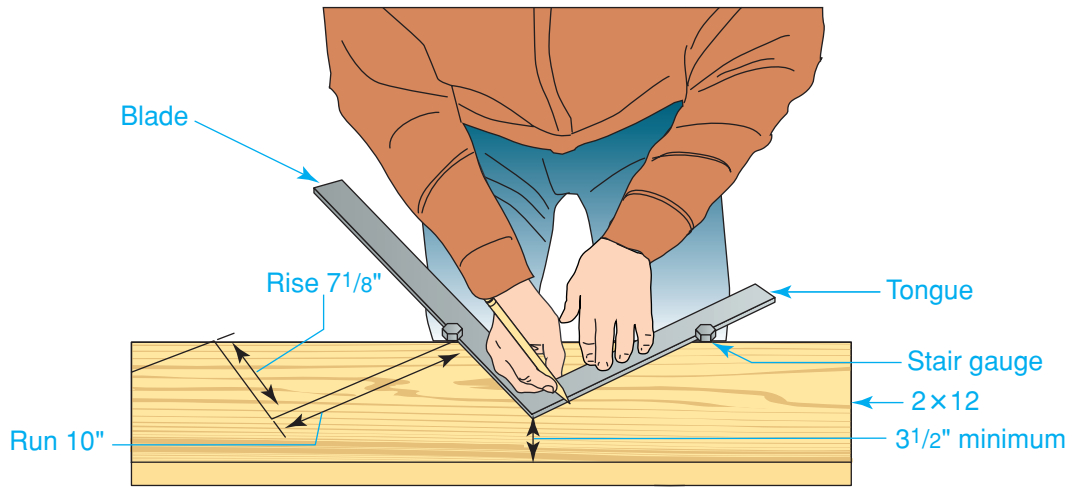


Figure 25-16 Continuing the Layout

Stair Gauges To complete layout on the stringer, use the framing square and stair gauges to "step off" the layout.

was dropped (Figure 25-15). Draw $\overline{EF}$ equal in length to the thickness of the header. Draw line $\overline{FG}$ to square off the stringer.

11. Carefully cut out the first stringer with a circular saw as shown in **Figure 25-18**. Do not overcut intersecting cuts, which will weaken the stringer. Instead, finish with a handsaw or jigsaw. Then set the stringer in position, and check it. If it fits properly, use it as a layout pattern for the others.

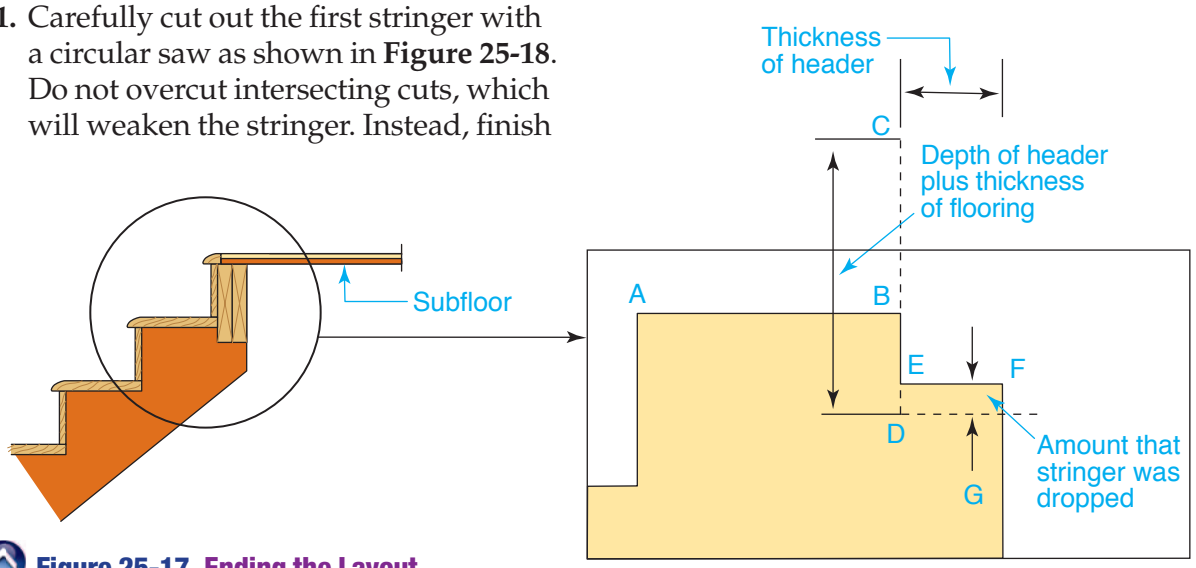
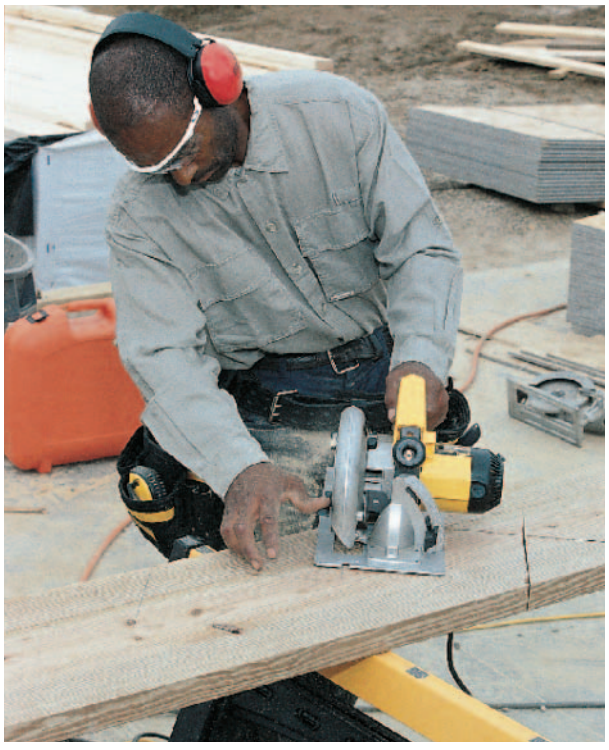
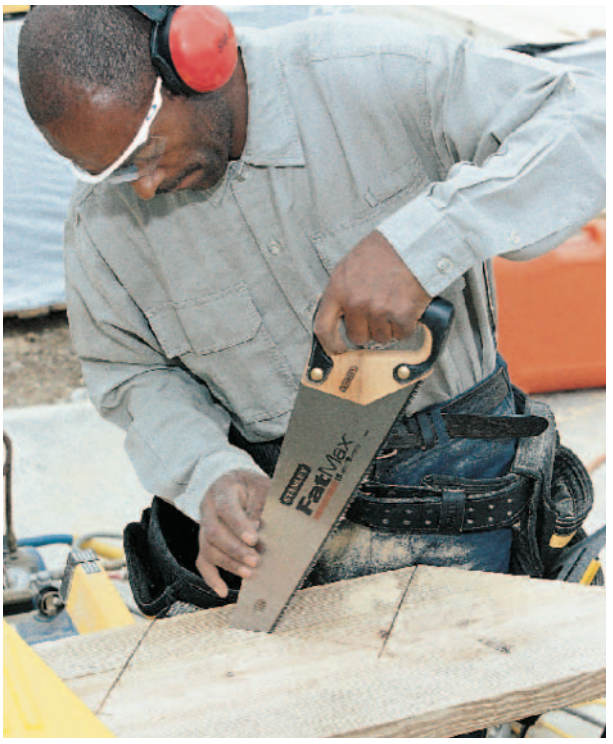


Figure 25-17 Ending the Layout
Header Notch Laying out the upper end of a cut stringer.



A



B

Figure 25-18 Cutting the Stringer
Two Saws With the stringer resting on sawhorses, use a circular saw to cut just along the layout lines. **A**. To avoid overcutting, use a handsaw or jigsaw to finish the cut. **B**. *Why should overcutting be avoided?*

Jon P. Muzzarelli

Installing Stringers

The methods used for framing stairways and securing stringers vary in different regions. Some methods are shown in **Figure 25-19**. The stair builder must determine which method will be used before laying out the stringers. Regardless of method, the goal should be to have a structurally strong, safe stairway.

The stringers are the first stairway members installed. Install stringers as follows:

1. Tack the stringers into position.
2. Check each stringer for plumb by holding the carpenter's level vertically against a riser cut.
3. Check if each stringer is level with the other stringers by setting a carpenter's level across the stringers on the tread cuts.
4. When the stringers are level and plumb, nail them into place. A stringer that lies against a trimmer joist should be nailed to the joist with at least three 16d nails.
5. The bottom of a stringer that rests on the subfloor should be toenailed with 10d nails, four to each side if possible. The nails should be driven into the subflooring and, if possible, into a joist below.

Installing Risers and Treads

After you have placed the stringers, you will install the treads and risers.

1. Cut the treads and risers to length.
2. Nail the bottom riser to each stringer with two 6d, 8d, or 10d nails, depending on the thickness of the stock.
3. If the first tread is 1$\frac{1}{16}$" thick, nail it to each stringer with two 10d finish nails and to the riser below with at least two 10d finish nails. If the first tread is 1$\frac{5}{8}$" thick, a 12d finish nail may be required. Use three nails at each stringer, but do not nail to the riser below. When using hardwood stock, nail holes should be pre-drilled to prevent the stock from splitting. Set all finish nails.
4. Proceed up the stair in this same manner.

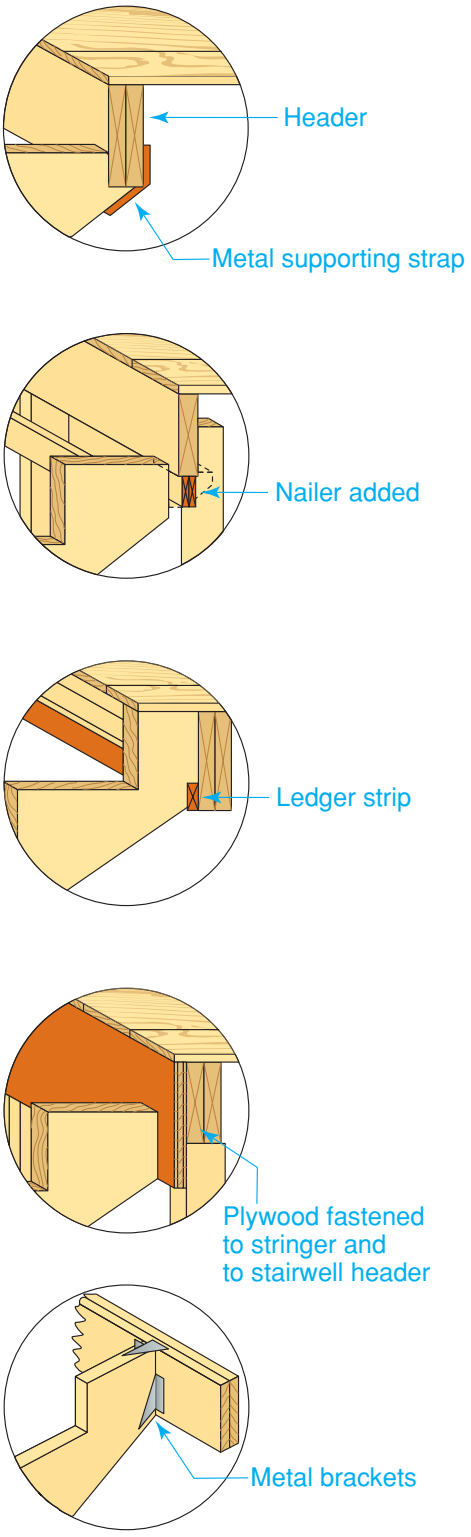


Figure 25-19 Anchoring a Stringer
Various Methods These are some of the ways in which the top of a stringer can be anchored to the framing.

Skirtboard

Sometimes, a skirtboard may be installed. A **skirtboard** is a finished board that is nailed to the wall before the stringers are installed, as shown in **Figure 25-20**. The risers and treads are nailed to the stringers and butted to the skirtboard. The skirtboard protects the wall from damage. It also provides a finished edge against the wall, which makes it easier to paint or wallpaper the adjacent areas.

Prefabricated Stairs

Many stairs are constructed either partly or entirely using manufactured parts. The parts include risers, treads, stringers, and anything else needed to assemble the stair. Parts can be purchased from a local millwork company or ordered online from any number of suppliers. In some cases, a carpenter will cut and install stringers on site, then finish the stair by using prefabricated treads and risers. In other cases, such as housed stairs, the outer stringers are manufactured parts routed out to the profile of the tread, riser, and nosing (see Figure 25-5 on page 727).

Sometimes the treads and risers are assembled with interlocking joinery, as shown in **Figure 25-21**. This is often the case when the stairway is being assembled from manufactured parts. The top of the riser is rabbeted to fit into a groove in the bottom front of the tread. The back of the tread is rabbeted to fit into a groove in the bottom of the next riser. A **rabbet** is a cut or groove along or near the edge of a piece of wood. It allows another piece to fit into it to form a joint. The treads and risers are fitted together and slipped into place. They are then tightened by driving and gluing wood wedges behind them. With this method, the outer stringers are visible above the steps, so the stringer must be of very good quality.

Prefabricated stairs should be assembled following instructions supplied by the manufacturer. It is extremely important to verify the total run and total rise where the stair will be installed. Once the stair has been ordered and arrives on the job site, changes are difficult.

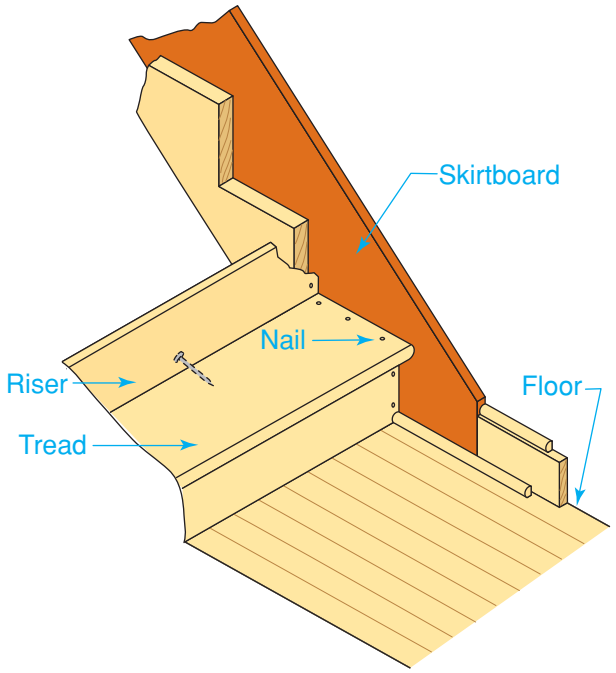


Figure 25-20 Using a Skirtboard
Finished Detail A skirtboard and a rough stringer nailed in place.

Completing the Stair

The handrail, newels, and balusters complete a stair and make it safe to use (see Figure 25-6). These parts may be plain or elaborate, but they should be in keeping with the style of the house. Building codes regulate the placement of these elements.

Handrail For closed stairways, the handrail is typically attached to the wall with adjustable metal brackets. Locating the position of the brackets is not difficult. After the height of the handrail has been decided upon, a chalk line is snapped on the wall and the brackets are aligned with it. They should be screwed to the stairwell framing. A bracket should be located near the top of the railing, near the bottom, and at various locations in between. Some manufacturers recommend that brackets be

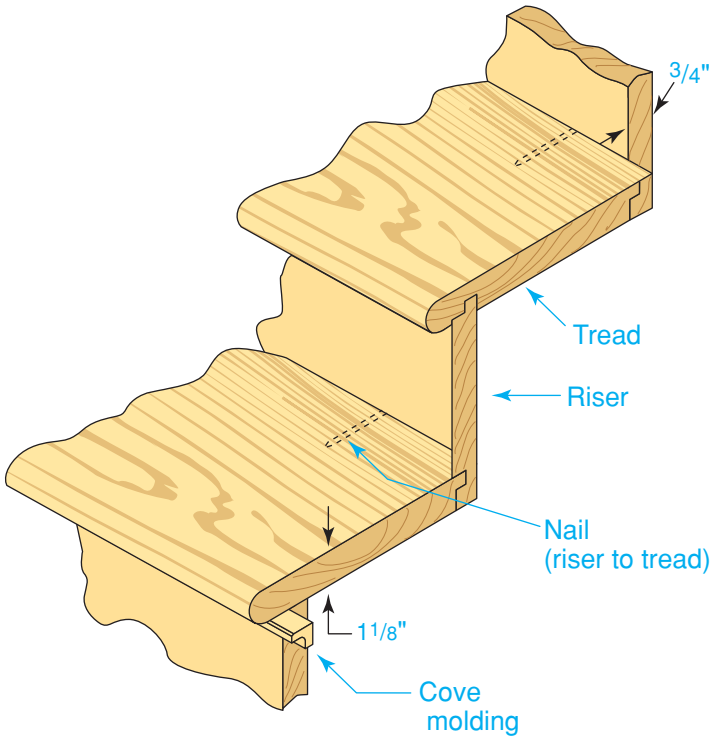


Figure 25-21 Interlocking Joinery
Close Fit Interlocking joinery provides a tight fit between treads and risers. Cove molding can be added under the nosing to conceal the joint there.

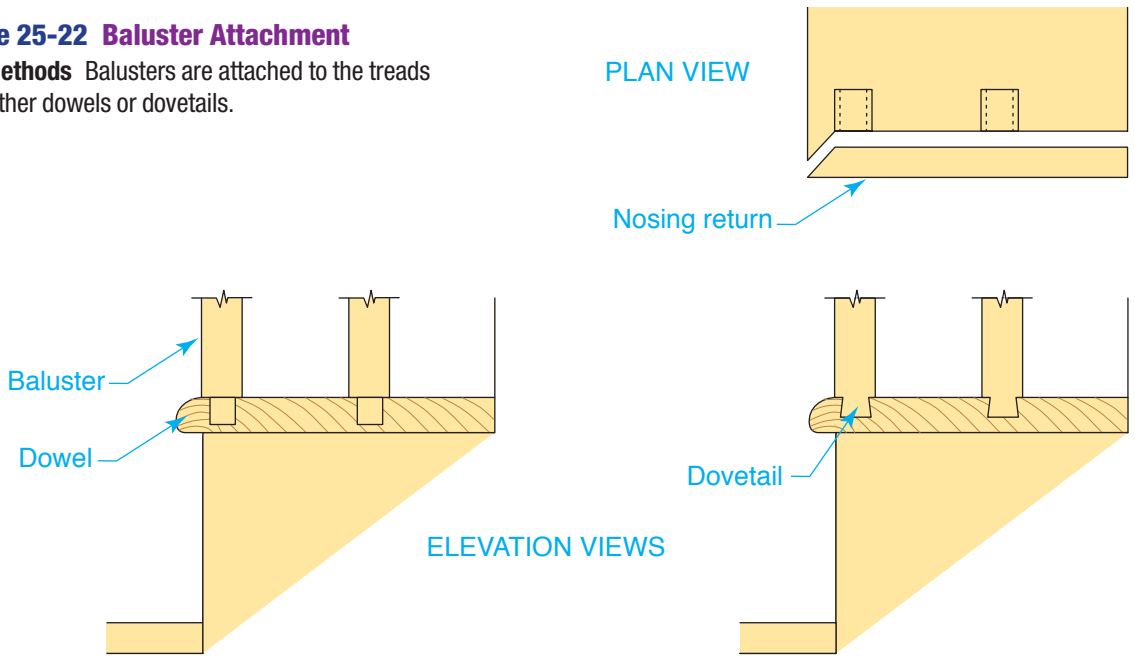
spaced no more than 48" apart, but closer spacing provides extra support. Make sure that that the handrail is **parallel** to the stringer.

For open stairways, the handrail and the balusters are assembled together. If the top of a baluster is cylindrical, it often fits into a hole drilled into the underside of the handrail. If the baluster is rectangular, it may be toenailed to the underside of the handrail with finishing nails.

The balusters are doweled or dovetailed into the treads, as shown in **Figure 25-22**. For the dovetail method, a strip called a *nosing return* is cut to fit the end of the tread, as shown in the plan view of Figure 25-22. Dovetails on the lower ends of the balusters fit into dovetail recesses in the end of the tread. The dovetails are glued into the recesses. The nosing return is then nailed into place to conceal the dovetails. If a baluster later breaks, the return can be removed in order to replace the damaged baluster. Balusters that are dowelled into the treads cannot be replaced as easily.

It is important to understand that balusters are not the primary support for a handrail. That is the function of the newel posts at each end. For this reason, the newel posts should be firmly anchored. Where half-newels are attached to a wall, blocking should be provided at the time the wall is framed.

Figure 25-22 Baluster Attachment
Two Methods Balusters are attached to the treads with either dowels or dovetails.



Other Types of Stairways

There are many types of stairways in addition to those mentioned previously. Some, such as circular stairs, are very complex to build. Others, such as cleat-stringer stairways, are easy to build. Others, such as disappearing stairs, are used to solve particular access problems.

Cleat-Stringer Stairways For a cleat-stringer stairway, the stringers are not cut in order to support treads. This stairway does not normally have risers, and the treads are usually made of thick softwood planks. A cleat-stringer stairway is shown in **Figure 25-23**.

Specialty Stairways In addition to the types of stairways described earlier, a carpenter may be called on to construct or install other types of stairs.

Spiral stairways are prefabricated units that often incorporate a steel support system. They are sometimes used to reach lofts and other secondary areas. Their advantage over other types of stairs is that they take up little floor space. Steps and railings are shipped in pieces for easy handling at the job site. Stairwell dimensions and other framing requirements are provided by the stair manufacturer. However, spiral stairways should not be used as primary stairs. Before ordering a spiral stair, check local

Estimating and Planning

CERTIFICATION PREP

This estimating and planning exercise will prepare you for national competitive events with organizations such as SkillsUSA and the Home Builder's Institute.

Stairway Materials and Labor

Materials

Estimating the quantity of materials for a stairway is done on a piece-by-piece basis. Once the design of the stairs has been determined, make a detailed materials list showing the quantity and quality of the individual pieces required, such as treads, risers, and balustrade parts. Total the cost of the materials. In the case of a stairway built primarily of manufactured components, the manufacturer may furnish a package price.

Labor

Labor costs can be only roughly estimated because of the many variables that will affect construction time. The suggestions below are very rough approximations. All estimates depend on the carpenter's experience, the style of the stairway, and the type of wood.

Example A: For an open stairway less than 12' long and 42" wide:

Step 1 Estimate construction time at 8¾ hours. This includes rough-cutting the stringers and framing and installing the stringers, treads, and risers.

Step 2 Add 3 hours if there is a turn in the stairway involving a platform or landing.

Step 3 Add one hour to install a handrail.

Step 4 Add 2½ hours for the installation of the newel posts, rails, and balusters.

Example B: For a pre-cut stairway less than 12' long and 42" wide:

Step 1 Estimate 6 hours for assembly.

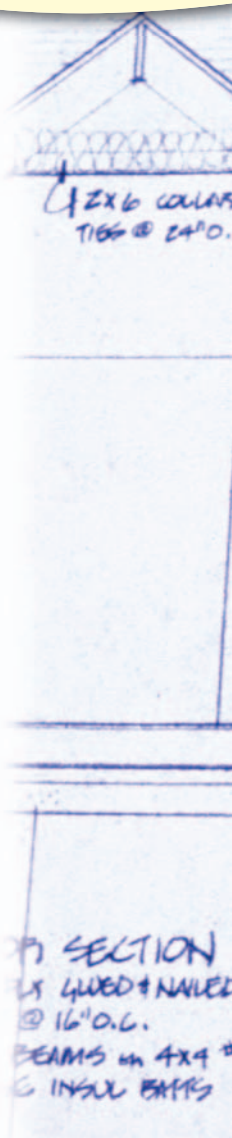
Step 2 If this stairway has a turn that includes a platform, add about 3 more hours.

Step 3 Add 1 hour for a handrail.

Step 4 For an open stairway with newel posts, rails, and balusters, add 2½ more hours.

Estimating on the Job

Suppose your company is to build an open stairway that is 10½' long and 40" wide. It will have one platform. Estimate the time and labor cost for this open stairway if you hire one worker to do the job and pay him or her $22.50 an hour. Round your answer to the nearest dollar.



Step-by-Step Application

Installing a Cleat-Stringer Stairway Basic steps for laying out a cleat-stringer stairway. Note the distance from A to C is the same as the distance from C to D and is equal to the riser height. However, the distance between the floor and line A is less than the riser height to allow for the thickness of the first tread.

Step 1 Determine the total rise and run. Divide the rise by 7. If this does not result in even spacing, adjust the divisor until equal spacings are obtained. Try to keep this spacing between 6½" and 7½".

Step 2 Use a square to lay out a suitable angle at the bottom of the stair. This is shown in Figure 25-23, line B. Set a T-bevel to this angle. Then cut each stringer along the layout line using a circular saw.

Step 3 To locate the position of the first cleat, measure up from the bottom of the stringer. Mark off a distance equal to the riser height minus the thickness of the tread. Use the T-bevel to draw a line parallel to the bottom of the stringer at this point (line A in Figure 25-23). This line represents the top of the cleat and the bottom of the tread.

Step 4 Measure up from line A a distance equal to the riser height and establish point C. Position the T-bevel at point C and mark another line across the stringer. Continue this operation until all tread positions have been located.

Step 5 Lay out and cut the top of the stringer according to whatever method is used to support it.

Step 6 Cut the cleats for each stringer from 1×2 or heavier stock. Screw them in position at each line using suitable woodscrews. Place the stringers in the stairwell and nail them in place.

Step 7 Cut the treads to length. Starting with the bottom tread, place each tread in position. Nail it securely to the cleat.

Step 8 Install a railing system to ensure that the stair can be used safely.

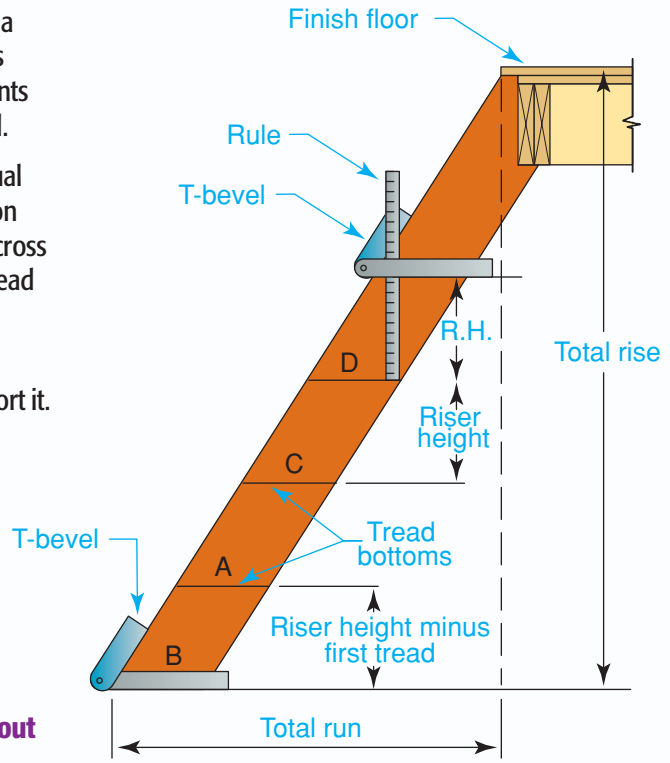


Figure 25-23 Cleat-Stringer Stair Layout

Go to **glencoe.com** for this book's OLC for additional step-by-step procedures, applications, and certification practice.

Figure 25-24 Spiral Stair
Space Saver Note the use of wood for the balusters and treads on this spiral stairway.

building codes for minimum requirements. A spiral stair is shown in **Figure 25-24**.

Hinged stairs or *disappearing stairs* such as the stairway shown in **Figure 25-25**, are often used for access to an attic. They may be made of wood or aluminum. They are installed as a complete unit, fitting into a framed opening in the ceiling. Disappearing stairs swing up into the attic space when not in use. They are suitable only for occasional attic access, not as access to a living area.

Basement stairs can be built much like any other stair and must follow the same building codes. However, basement stairs often incorporate one unusual detail: the lower end of the stairway rests on concrete so they cannot be secured by toenailing. To prevent the stringers from moving, a kick plate is screwed or nailed to the concrete, as shown in **Figure 25-26**. The stringers can then be toenailed to the kick plate. A **kick plate** is a short piece of framing lumber that is used to anchor the bottom of a stair.

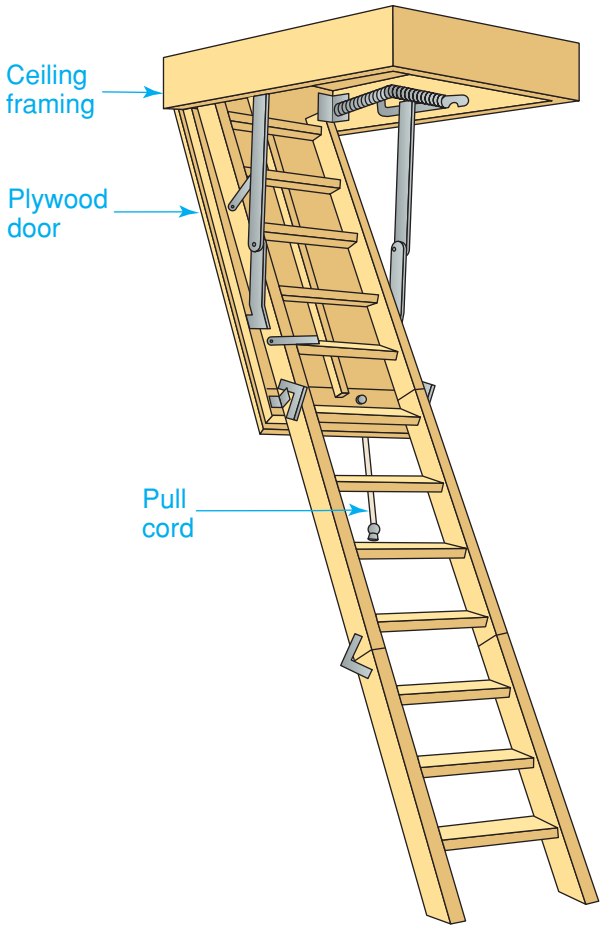


Figure 25-25 Disappearing Stairs
Basic Access When the stairs are in the stored position, the plywood door is barely noticeable because it is painted to match the ceiling.

The stairs in residential construction are usually made of wood. In commercial construction, some stairs are built of wood but fire-resistant metal service stairs may be required by code. Technical advances in metal forming and fabrication have improved the quality of metal service stairs. Such stairs may be classified as fire stairs.

During construction of a house, it is often necessary to build temporary service stairs to enable workers to reach upper levels. These stairs are not made with finished materials because they will only be used during construction. However, any temporary stair should be built with safety in mind. Because it can be built quickly and

Courtesy of Designed Stairs

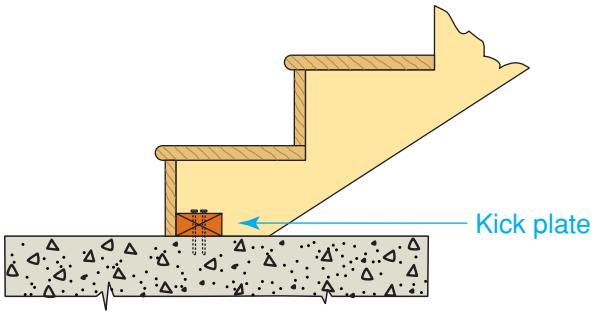


Figure 25-26 Basement Stairs
Kick Plate The lower ends of the stringers should be anchored against a kick plate that has been bolted or nailed to the concrete floor.

inexpensively, a cleat-stringer stair is often used as a temporary service stair. Later on, the stair is removed and a new, permanent stair can be built. Any temporary service stair should be fitted with a sturdy railing to ensure its safe use. Another way to provide a service stair is to install an open riser stair. This would have cut stringers and uses 2× stock as for treads. There are no risers. Layout and construction of this type of stair is much the same as with cut-stringer stairs.

Section 25.2 Assessment

After You Read: Self-Check

1. The total rise of a stairway is the vertical distance between which two points?
2. What is the first task in stairway layout?
3. What precaution should you take when cutting out a stringer for a cut-stringer stairway?
4. On a closed stairway, what supports the handrail?

Academic Integration: Mathematics

5. **Calculating Total Rise and Total Run** Use a calculator to find the total rise and total run of a stairway with 14 treads that are 11" deep, have nosing of ⅜", and have risers measuring 7". A top step has a tread measuring 7".

   Math Concept When using a calculator, convert fractions to decimals. It is useful to memorize common conversions, such as ⅜ = 0.375.

   Step 1: Calculate the unit run. Subtract the nosing from the depth of the tread. Multiply by the number of treads.

   Step 2: Add the depths of any treads that were shortened at the top of the flight.

   Step 3: Calculate the unit rise. Multiply the height of the riser by the number of risers.

   Step 4: Convert your answers to feet, inches, and fractions of an inch.

Go to glencoe.com for this book's OLC to check your answers.

CHAPTER 25

Review and Assessment

Chapter Summary

Section 25.1

The three main parts of a stairway include the treads, the stringers, and a handrail. The treads on cleat-stringer stairways are supported by cleats attached to the stringers. The treads on cut-stringer stairways are supported by notches cut into the stringers. In stairs with more than one flight, the flights are separated by landings. Stair designers must consider headroom, width, riser and tread dimensions, handrails, and balusters. All are important to consider in making a stairway safe and easy to use. In most cases, building codes specify maximum and minimum dimensions.

Section 25.2

The first step in stairway construction is to calculate the unit rise and unit run. Total rise is given on the plans. Total run is based on the unit run. The next step is to lay out the stringers and install them. The third step is to install treads and risers (if any). Finally, the handrail and any balusters are put in place.

Review Content Vocabulary and Academic Vocabulary

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

Content Vocabulary

- stairwell (p. 724)
- treads (p. 725)
- stringer (p. 726)
- risers (p. 726)
- step (p. 726)
- stairway (p. 726)
- balusters (p. 726)
- flight (p. 729)
- winders (p. 730)
- headroom (p. 730)
- skirtboard (p. 740)
- rabbet (p. 740)
- kick plate (p. 744)

Academic Vocabulary

- involves (p. 736)
- process (p. 736)
- parallel (p. 741)

Speak Like a Pro

Technical Terms

2. Work with a classmate to define the following terms used in the chapter: *main stairway* (p. 724), *service stairway* (p. 725), *handrail* (p. 726), *cleat-stringer stairway* (p. 726), *cleats* (p. 726), *cut-stringer stairway* (p. 726), *housed stringers* (p. 726), *balustrade* (p. 728), *angle newel* (p. 729), *landing* (p. 729), *minimum clear width* (p. 730), *total run* (p. 734), *open-riser stairway* (p. 736), *nosing return* (p. 741).

Review Key Concepts

3. Explain the basics methods used to build any stairway.

4. Identify the components of a stairway.

5. Explain how building code requirement affect stairway construction.

6. List the steps of stair construction.

7. Describe how to lay out a cut-stringer stairway.

8. Describe how to install a cleat-stringer stairway.

Critical Thinking

9. Analyze A homeowner has suggested that a spiral staircase be installed as the main stairway in their new home. Is this a good choice? Why or why not?

Academic and Workplace Applications

STEM Mathematics

10. Unit Rise and Unit Run What is an appropriate unit rise and unit run for a stairway whose total rise is 12' and total run is 18'?

Math Concept Sometimes a problem has more than one solution. The final answer requires making a judgment.

Step 1: Convert the total rise to inches. That number is 144" ($12 \times 12 = 144$).

Step 2: Divide 144" by 7", the ideal riser height. The result is 20.57 ($144 \div 7 = 20.57$).

Step 3: Round 20.57 up to the nearest whole number, which is 21. This gives you the total number of risers, and steps, in the stairway.

Step 4: To find the unit rise, divide the total rise by the number of risers. To find the unit run, divide the total run by the number of steps.

Step 5: Since the unit rise comes out to be a bit under 7", the ideal, refigure the plan using 20 steps instead of 21. Compare the two plans, and explain which plan you think is best.

STEM Engineering

11. Architectural Design Evaluate the riser-tread dimensions for a stairway in your school or home. Decide whether the stairway is too steep, just right, or too shallow. Measure the handrail height. How does it compare with the code requirements noted in this chapter? Sketch the basic dimensions of the stairway.

21st Century Skills

12. Career Skills Finish carpenters must undergo a great deal of training and on-the-job instruction in order to learn their trade. Write a paragraph explaining how an apprenticeship that includes on-the-job training would be beneficial to you on your path to becoming an expert finish carpenter. For example, you might list what skills outside of carpentry you would expect to learn through an apprenticeship.

Standardized TEST Practice

CERTIFICATION PREP

Multiple Choice

Directions Choose the best answer to each question.

13. What is the term for a stairway that leads to a basement?

- **a.** secondary stairway
- **b.** primary stairway
- **c.** service stairway
- **d.** finish stairway

14. What is the term for a long piece of 2× lumber that supports a stair?

- **a.** step
- **b.** stringer
- **c.** tread
- **d.** riser

15. When laying out stringers, what should your goal be?

- **a.** to do quick, efficient work
- **b.** to save money on materials
- **c.** to follow the plans closely
- **d.** to have a structurally strong, safe stairway

TEST-TAKING TIP

If you are unsure about a question on a written test, place a check mark next to the question in pencil so that you remember to go back to it. Be sure to erase any stray marks before you turn in the standardized test. Stray marks might cause your test to be graded incorrectly.

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