CHAPTER 7

Ladders, Scaffolds, & Other Support

Section 7.1
Using Ladders & Scaffolds

Section 7.2
Other Support Equipment

Chapter Objectives

After completing this chapter, you will be able to:

- **Identify** various types of ladders and scaffolds.
- **Describe** how to follow the safety rules for working with ladders.
- **Demonstrate** how to set up a straight ladder and a stepladder.
- **Compare** manufactured metal scaffolding to wood scaffolding.
- **Identify** brackets, a pump jack, and a lifeline.

Discuss the Photo

Using a Stepladder A stepladder allows a worker to safely reach areas of the project that do not require the extra height of an extension ladder. *What might happen if the legs of a ladder rest on uneven ground?*

Writing Activity: Research and Summarize

Choose a trade and research the advantages and disadvantages of that trade using aluminum, fiberglass, or wood ladders. Summarize your findings in list form.

Chapter 7 Reading Guide

Before You Read Preview

Carpenters and other tradespeople depend on scaffolds and ladders to work in areas that would otherwise be out of reach. 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

- ladder
- rails
- stepladder
- spreader
- scaffold
- scaffold planks
- competent person
- trestle
- pump jack
- lifeline

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.

- ratio
- injure

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
ladder	a structure made up of two long side pieces joined by multiple crosspieces on which you can step

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

Academic Standards

Mathematics

Measurement: Apply appropriate techniques, tools, and formulas to determine measurements (NCTM)

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

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

Geometry: Data Analysis and Probability: Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them (NCTM)

English Language Arts

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

Use language to accomplish individual purposes (NCTE 12)

Science

Science and Technology: Abilities of technological design (NSES)

Physical Science: Motions and forces (NCTE)

Industry Standards

Using Ladders and Temporary Work Platforms Safely

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

Section 7.1

Using Ladders & Scaffolds

Ladders

Which ladder is self-supporting?

Falls cause the greatest number of deaths in the construction industry. The proper use of ladders and scaffolds reduces the risk of falling. In addition, the use of guardrails and other safety devices can prevent deaths and injuries from falls. Before using ladders and scaffolds, it is very important to read and follow the safety guidelines in this chapter. You should also follow the instructions that come with the ladder or scaffold. They may include special safety instructions. Safety information may also be present on stickers attached to equipment.

A **ladder** is a structure made up of two long side pieces joined by multiple *crosspieces* on which you can step. Ladders are used to climb up and down. Ladders are fast and easy to set up and take down, but they must be moved frequently. They come in lengths from 3' to 50'. The basic parts of a ladder are the rungs, or steps, and the rails. Rungs and steps are the horizontal members that a worker climbs on. **Rails** are the vertical supports to which the rungs or steps are attached.

Types of Ladders

The two basic types of ladders are folding ladders and straight ladders. There are also folding articulated ladders. These ladders are all shown in **Figure 7-1**. Folding ladders

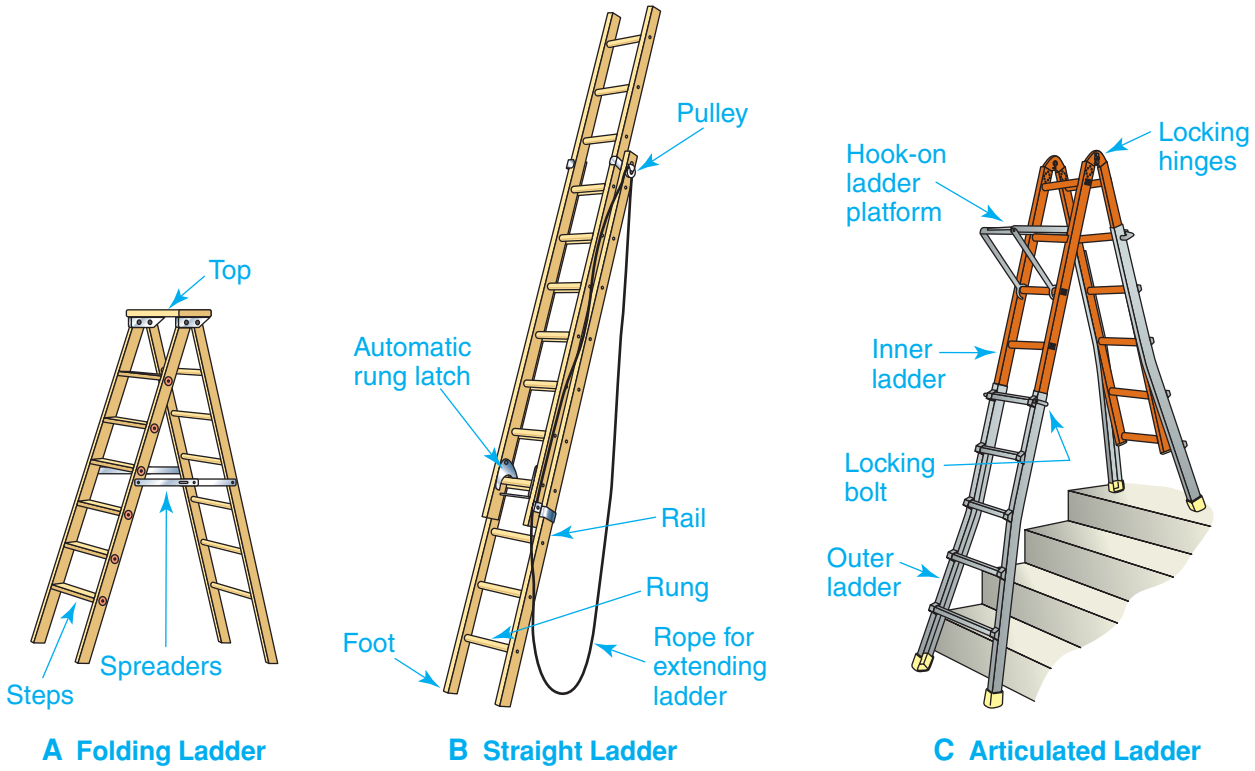


Figure 7-1 Types of Ladders

Folding, Straight, and Articulated **A.** The type of folding ladder shown is a stepladder. **B.** An extension ladder is a type of straight ladder. **C.** An articulated, or multipurpose, ladder.

are self-supporting and are used primarily indoors for reaching low and intermediate heights. They are the most portable type of ladder. A **stepladder** is a common type of folding ladder that has flattened steps instead of rungs. A *folding articulated ladder,* also called a multipurpose ladder, can be adjusted to fit into such spots as stairwells. Each side of the ladder can be adjusted to different lengths.

Straight ladders are used primarily outdoors where greater heights must be reached. They are not self-supporting. Instead, they must be leaned against a wall or some other object. The ladder's working length is the distance from the ground to the top support, measured along the ladder. An extension ladder is a common type of straight ladder that can be adjusted to various heights. It consists of two straight sections joined together. One of the sections can be extended beyond the other by way of a rope and pulley system.

Folding ladders and straight ladders are available in various grades or duty ratings, as shown in **Table 7-1**. The grade indicates the maximum load the ladder can support.

The materials used most often to make ladders are wood, aluminum, and reinforced fiberglass. **Table 7-2** lists the advantages and disadvantages of each.

Table 7-1: Grades of Ladders

Type	Duty Rating (lbs.)	Typical Uses
Household, Type III	200	Light duty. For household use.
Commercial, Type II	225	Medium duty. For painters and light-construction workers.
Industrial, Type I	250	Heavy duty. For contractors and maintenance workers.
Industrial, Type IA	300	Extra heavy duty. For rugged industrial and construction use.

Note: The user's weight, plus any tools, jacks, planks, and materials, must not exceed the duty rating.

Ladder Safety

The following are general safety rules for ladders. They are followed by rules specifically for stepladders and for extension ladders. As always, we strongly advise you to check the manufacturer's manual for any special safety instructions.

- Inspect ladders carefully. Keep nuts, bolts, and other fasteners tight.
- Do not try to repair a damaged ladder. Replace it or have it professionally serviced.

Table 7-2: Ladder Materials

Material	Advantages	Disadvantages
Wood	• Does not conduct electricity when clean and dry • Weight improves stability	• Less durable than other materials • Heavy • Susceptible to weather damage
Fiberglass	• Does not conduct electricity when clean and dry • High strength-to-weight ratio	• Long-term exposure to sunlight can lead to deterioration • Heavier than aluminum • Damage cannot be repaired • Expensive
Aluminum	• Lightweight • Durable • High strength-to-weight ratio • Weather resistant	• Conducts electricity • Damage cannot be repaired

- Keep steps and rungs free of oil, grease, paint, and other slippery substances. Wood ladders should not be coated with any opaque finish. Such a finish will hide cracks.
- Place the ladder on a firm, level surface. Make sure that it has non-slip safety feet.
- Never place a ladder in front of a door or other opening unless the ladder is secured to prevent an accident, or a barricade is used to keep traffic away.
- Never use a ladder as a scaffolding plank.
- Never use ladders after they have been soaked in water for a long time or been exposed to fire, chemicals, or fumes that could affect their strength.
- Always place the ladder close enough to the work to avoid a long, dangerous reach.
- Face the ladder when climbing up or down.
- Keep your weight centered between both side rails.
- Do not use any ladder where direct contact with a live power source is possible. Metal ladders and any ladder that is wet are especially hazardous.
- Do not overload a ladder. A ladder is designed to carry only one person at a time.

Safety with Stepladders

- During use, be sure that stepladders are fully open and the spreader is locked.
- Make sure all locking devices are secure.

JOB SAFETY

LADDER SAFETY Ladders have multiple detailed safety requirements. Safety information is often found on a permanent sticker that is attached to the ladder.

Go to **glencoe.com** for this book's OLC for more on job safety.

- Never step on the stabilizing bars of a stepladder. These are the horizontal bars between the back rails. They are not designed to support a load.
- Never lay tools on the top step.

Safety with Straight Ladders

- Store straight ladders horizontally in a dry, ventilated place, as shown in **Figure 7-2**.
- Make sure that the working length of the ladder will reach the proper height. The ladder should extend at least 3' above a roof or other elevated platform you wish to reach. Never stand on the top three rungs.
- For safety, the foot of the ladder should be a distance equal to one-fourth its working length from the building or other support. The angle created should be approximately 75°.
- To keep the legs from slipping when outdoors, drive a strong stake into the ground behind the ladder. Then tie the bottom of the ladder to the stake with rope.

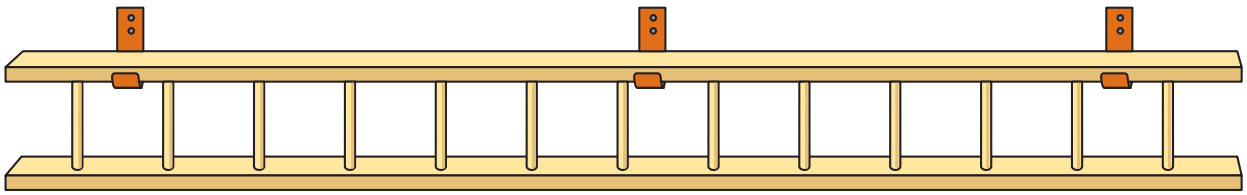


Figure 7-2 Storing a Ladder

Dry and Straight Store a straight ladder horizontally on supports to prevent sagging. Never store ladders where they will be exposed to weather or near a source of heat.

- Do not tie or fasten ladders together to create longer sections. Use an extension ladder instead.
- Always make sure that both side rails are fully supported at top and bottom, as shown in **Figure 7-3**.
- Tie the upper part of a straight ladder to an immovable object to prevent it from shifting.
- Before using an extension ladder, make sure all safety locks are securely hooked over their corresponding rungs.
- Do not adjust the height of an extension ladder while you are standing on it.

Using a Ladder

Ladders are frequently moved around a job site. To avoid accidents, be sure you know how to move a ladder safely. Position yourself at the center of the ladder before lifting it, as shown in **Figure 7-4**. Carry the ladder in a horizontal position, never a vertical one. This will prevent accidental contact with electrical power lines and other objects. In addition, you can control a horizontal ladder more easily and will be less likely to hurt your back.

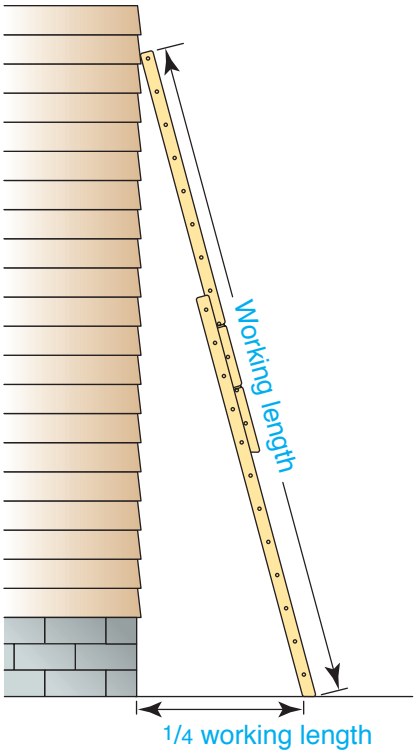


Figure 7-3 Extension Ladder Setup
Proper Pitch and Distance For safety, the *pitch*, or angle, should be approximately 75°. The horizontal distance from the foot of the ladder to the support structure should be one-fourth of the ladder's working length.

Figure 7-4 Carrying a Ladder
Horizontal Movement Carry a ladder horizontally. If you carry it in a vertical position it could accidentally touch electrical power lines.

Step-by-Step Application

Setting Up a Straight Ladder Set up a straight ladder as follows:

Step 1 Brace the lower end against a step or other object so the ladder cannot slide.

Step 2 Grasp a rung at the upper end with both hands.

Step 3 Lift the upper end and walk forward under the ladder, grasping other rungs in turn as you proceed, as shown in the figure.

Step 4 When the ladder is erect, lean it forward into the desired position.

Step 5 Check the angle, height, and stability at top and bottom (see Figure 7-3 on page 201).

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

Before using a stepladder, always be certain that its feet are firmly supported and that its spreader is locked into position. The **spreader** holds the ladder open and prevents it from closing accidentally. Never stand on the top of the ladder because your weight can easily unbalance the ladder and tip it over. Do not step on the bucket tray on the back of some stepladders. It is for holding tools and materials, not people.

When going up or down a straight ladder, grip the ladder firmly and place your feet squarely on the rungs. Make certain your

Figure 7-5 Roof Safety

Extend the Top The top of the ladder should extend above the edge of the roof at least 3'. If the ladder is used when conditions are slippery, it must be tied off (secured) to the building.

work boots and the rungs are free of mud and grease. When using a ladder to access a roof, make sure the ladder extends above the edge of the roof by at least 3', as shown in **Figure 7-5**.

There are limits to how far an extension ladder should be raised. The two sliding sections must overlap each other a certain amount or the ladder will be weak. It will also feel more wobbly when you are on it. The correct amount of overlap is based on the ladder's extended length. Overlap the sections by at least the following amounts:

- 3' for total extended lengths up to 32'.
- 4' for total lengths of 32' to 35'.
- 5' for total lengths of 36' to 47'.

Certain accessories make extension ladders safer to use. A ladder stabilizer, shown in **Figure 7-6**, can be bolted to the top of the ladder. It has arms 4' apart that steady the top of the ladder and prevent it from slipping. Leg levelers such as those in **Figure 7-7** can be attached to the feet of the ladder. They support the ladder on uneven ground.

Reading Check

List *What are the basic parts of any ladder?*

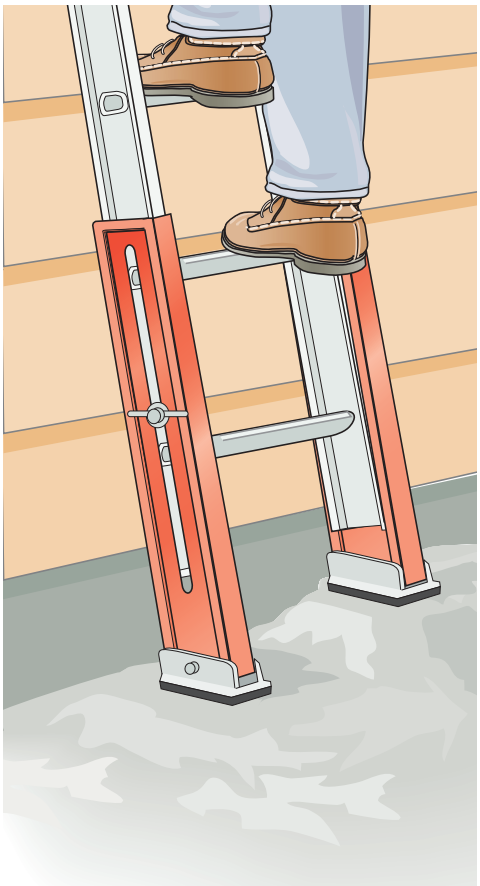


Figure 7-7 Levelers
Adjustable Legs Leg levelers adjust to uneven ground and help to prevent the ladder from tipping.

Figure 7-6 Stabilizer
Wide Arms A ladder stabilizer prevents the ladder from sliding sideways or twisting.

Scaffolds

What is pipe scaffolding?

A **scaffold** is a raised platform used for working at a height. Scaffolds make it possible to work safely, in a comfortable and convenient position, with both hands free. The horizontal parts of a scaffold on which a worker stands are called **scaffold planks**. Because of their stiffness and strength, laminated wood planks made especially for scaffolds are sometimes used. However, some builders prefer aluminum planks because they are lighter in weight and more durable. Standard construction lumber is not recommended for use as scaffold planks.

Commercial metal scaffolding, shown in **Figure 7-8**, is sometimes called *pipe scaffolding*. It has many advantages over scaffolding made from wood. Metal scaffolding is engineered and tested to withstand specific loads. It can be rented as needed, takes up less space than wood scaffolding, and is more weather resistant. It is also easier to assemble and disassemble. The end frames can be put together in a staggered position, making it possible to work from a stairway.

Scaffolds vary in design. For scaffold assembly, the manufacturer's instructions must be carefully followed. When a metal

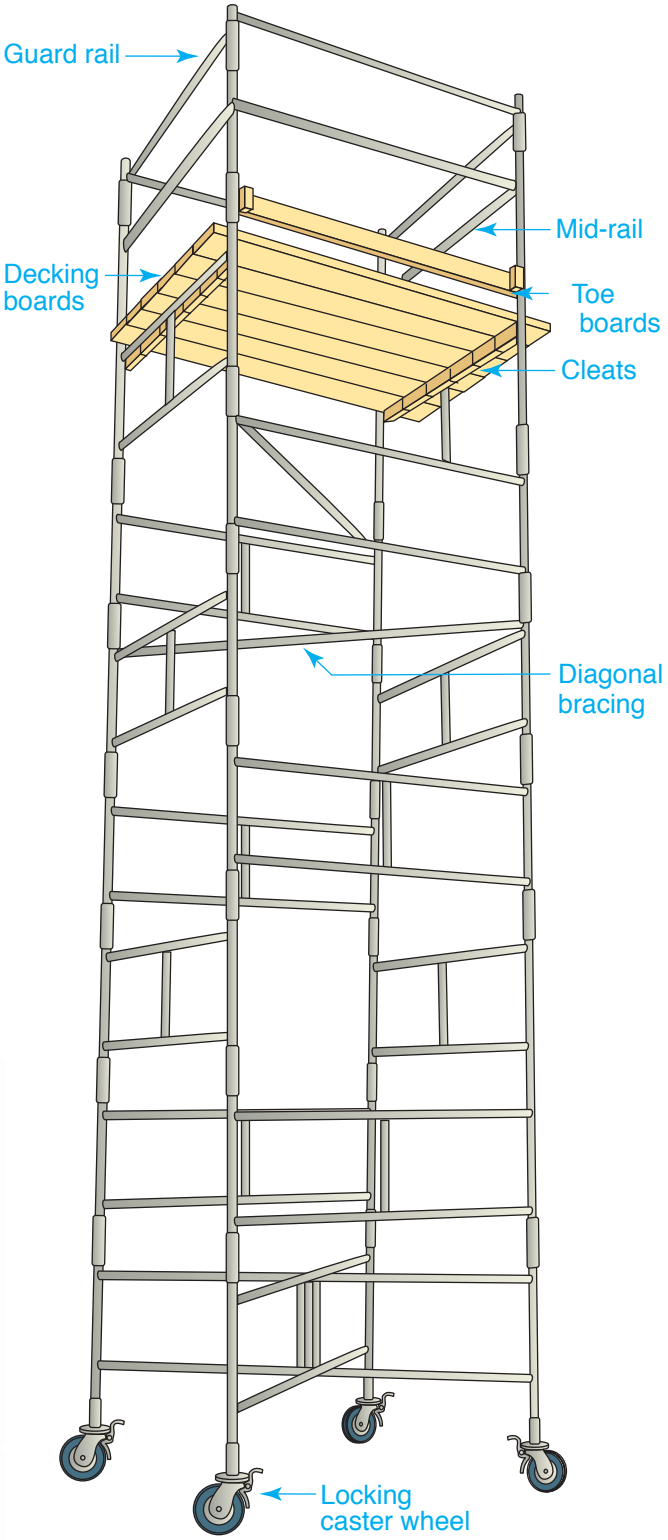


Figure 7-8 Metal Scaffolding
Portable Scaffolding Commercial metal scaffolding assembled for interior use.

JOB SAFETY

SCAFFOLD STABILITY As a general rule, a freestanding scaffold should be restrained from tipping once its height is three times its minimum base dimension (a 3:1 ratio). The minimum base dimension is the shortest leg of the rectangle formed by connecting the points of each of the four legs of the scaffold. This 3:1 ratio holds true even if the scaffold is plumb, level, and square. Some codes allow a less strict 4:1 ratio.

Go to **glencoe.com** for this book's OLC for more on job safety.

JOB SAFETY

SCAFFOLDING SAFETY The following are general safety rules for scaffolding. We strongly advise you to check the manufacturer's manual for any special safety instructions.

- Always follow the manufacturer's instructions when erecting or removing scaffolding.
- Make sure all scaffolding is plumb and level. Use adjusting screws, not blocks, to compensate for uneven ground.
- Some scaffolds have casters or wheels. Make sure these are locked before using the scaffold.
- Provide adequate support for scaffolds. Use base plates, making sure that they rest firmly on the ground. Secure free-standing scaffold towers by attaching guy ropes or wires or by other means.
- Fasten all braces securely.
- Do not climb cross braces. Access to scaffolds should be by stairs or fixed ladders only.
- Provide proper guardrails. Add toe boards when required on planks. A toe board is a lip on the edge of the scaffold platform that prevents a worker's foot from sliding off of the platform. See examples of a toe board in Figure 7-9 on page 208.
- Never use ladders on top of a scaffold.
- Never overload a scaffold. Follow manufacturer's recommendations regarding load limits.
- Inspect the scaffolding regularly and tighten any loose connections.
- Inspect lumber used for scaffold planks. It should be graded for that purpose. Both ends of wood planks should have cleats to prevent the planks from sliding off the supports.

Go to **glencoe.com** for this book's OLC for more on job safety.

scaffold is used indoors, it is sometimes equipped with locking caster wheels. With wheels, the scaffold can be rolled easily from place to place. Never move a scaffold while tools or workers are still on it.

To ensure scaffolding stability, be sure to follow the recommended **ratio** between the base of a scaffold and its height.

Scaffolding should include guardrails to protect workers from falls. For all scaffolding manufactured after January 1, 2000, the Occupational Safety and Health Administration (OSHA) requires that a guardrail be placed between 38" and 45" above the scaffold planks. A mid-rail should be placed about halfway between the guardrail and the planks.

Any part of a scaffold that has been damaged or weakened may not meet OSHA strength requirements. The part must either be repaired, replaced, or reinforced. Otherwise, the scaffold must be removed from service. The scaffolding should be inspected frequently by a competent person. According to OSHA, a **competent person** is someone who has been trained to identify existing and predictable hazards on the job site. This person must also have the authority to take corrective actions to eliminate the hazard.

Dismantling Scaffolds

When dismantling a scaffold, work from the top down. As you remove parts, store them immediately at ground level. Do not stack parts on scaffolding planks because they could easily fall and **injure** someone below. If the scaffolding has been tied or braced to reduce tipping, do not remove the ties or braces until the scaffold has been dismantled to that level. Never throw scaffolding components off the scaffold. This could injure someone below, and it might also damage the component and make it unsafe for future use.

Section 7.1 Assessment

After You Read: Self-Check

1. Name and describe the two basic types of ladders.
2. What should you do if you encounter a ladder that is damaged?
3. What two types of planks are most suitable for use as scaffold planks?
4. What are the advantages of metal scaffolding over wood scaffolding?

Academic Integration: Mathematics

5. **Height-to-Base Ratio** In many codes, the height-to-base ratio for a freestanding (unsecured) scaffold support is 3:1. This means that the height of the scaffold should be at least 3 times the length of smallest base dimension. If not, the scaffold will need to be secured. Colin's scaffold has a base of 2' × 5'. What is the maximum height his scaffold's working platform can be before it has to be secured?

   Math Concept A *ratio* is a comparison of two numbers. Ratios can be expressed with colons (3:1). In the workplace, you may hear the ratio 3:1 expressed as "a three to one ratio."

   Starting Hint Multiply the smallest base dimension by 3 to find the maximum height.

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

Section 7.2 Other Support Equipment

Special Supports

What is a pump jack?

It is not always possible or desirable to work from scaffolding and ladders. This is often the case in cramped work areas or when working atop a roof. Other means must then be found for ensuring a safe way to work.

Brackets

Special brackets are available that can be attached to the frame of a structure. Scaffold planks are then laid on the brackets to form a platform. Some brackets are nailed to sidewall studs while others are bolted to them, as in **Figure 7-9**. Nail-attached wall and corner brackets are secured with 20d nails driven into the stud at an angle through the tapered holes in the bracket. This allows the brackets to be easily removed without pulling the nails. Any nails remaining after the brackets have been removed can be driven flush.

Brackets for working on a roof are attached by nailing through them and into the rafters. They can be removed without pulling the nails. There are several types of roof brackets, as shown in **Figure 7-10**. One style holds a 2×4 or 2×6 against the roof. Another style can be adjusted to various roof pitches, from 90° to level.

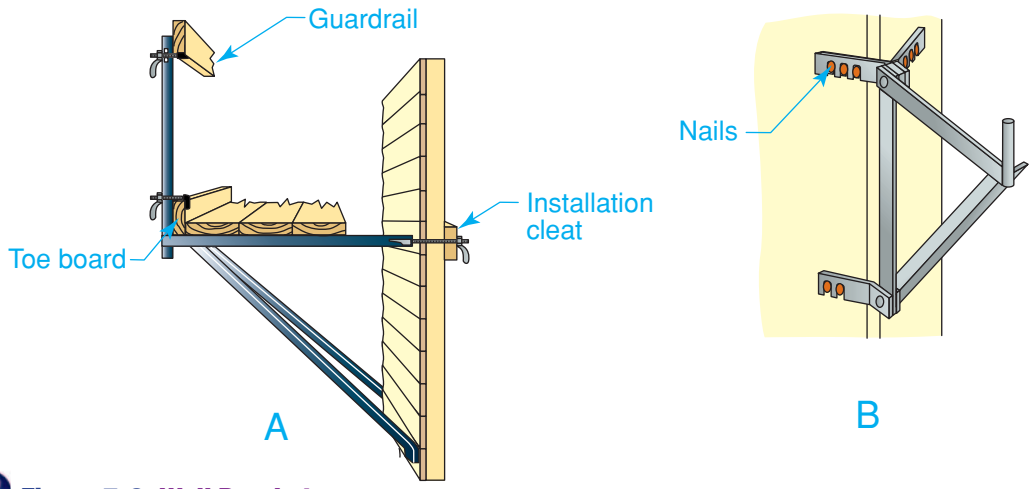


Figure 7-9 Wall Brackets
Types A. Bolt-attached brackets. Note the guardrail. This rail can also be used with other types of brackets. **B.** A nail-attached corner bracket.

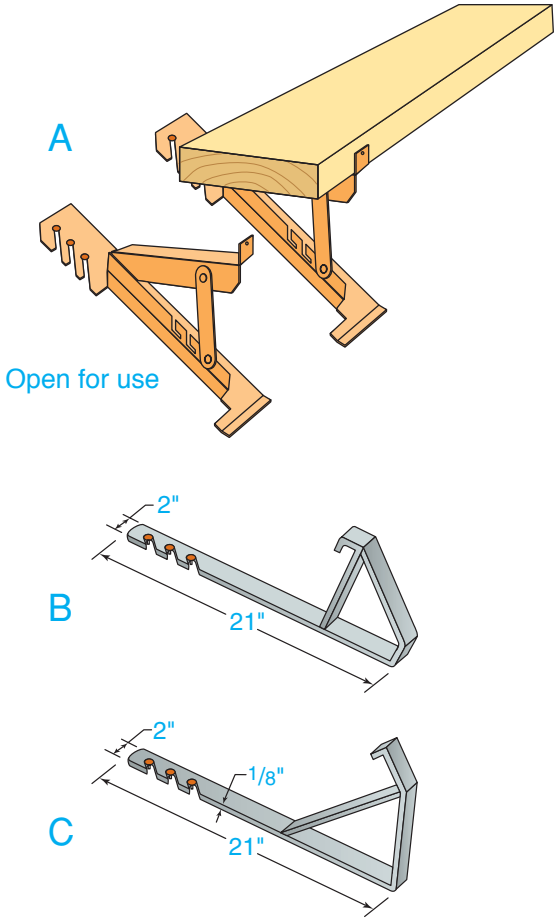


Figure 7-10 Roof Brackets
Types A. The folding roof bracket adjusts to various roof pitches. **B.** This bracket supports lumber at a right angle to the roof. **C.** This bracket positions lumber to provide a level walkway.

Trestles

A **trestle** is a portable metal frame with rungs that is used to support scaffold planks at various heights, as shown in **Figure 7-11**. Trestles are sometimes used by contractors for working on ceilings. They are available in a wide range of sizes and some are adjustable in height. Trestles accept the same types of planks used on standard scaffolds.

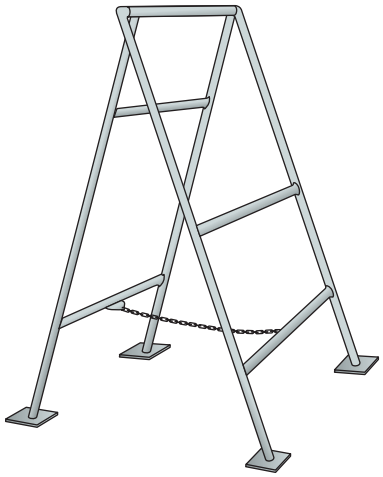


Figure 7-11 A Trestle
Portable Model A folding trestle has crossbars to hold scaffolding planks at various heights.

Science: Motions and Forces

Acceleration of Gravity

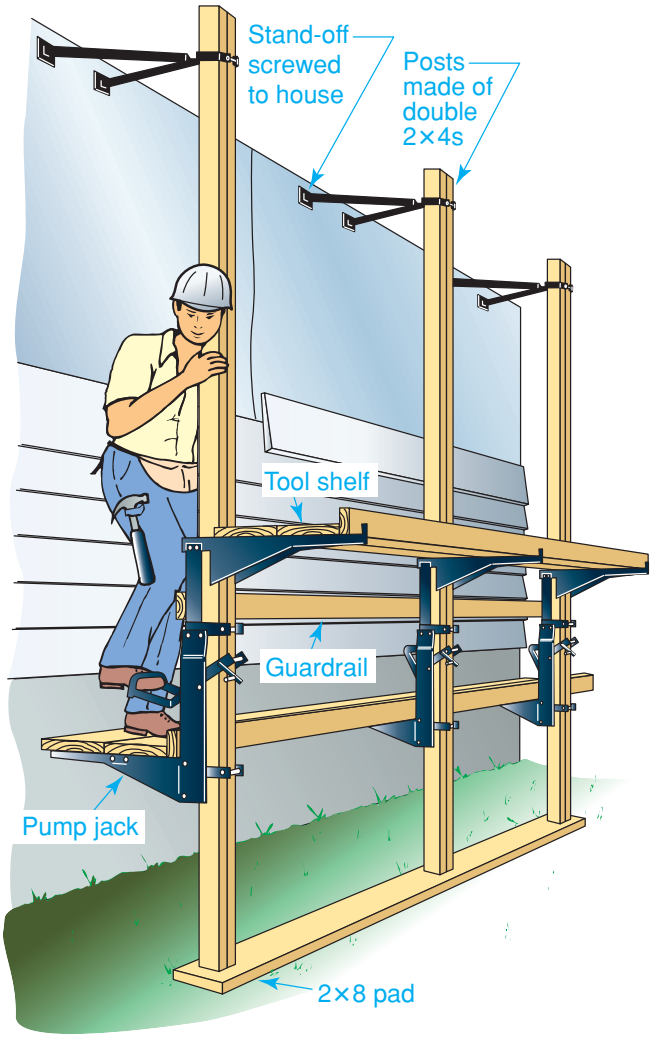
On Earth, a free-falling object accelerates at the rate of about 9.8 m/s. Kent fell from a ladder. Luckily, his lifeline was attached and he only fell two meters before coming to a stop. How fast was he going before his lifeline stopped him? Use the following formula to solve the problem:

$$v = a \times t$$

In this equation, v = velocity (speed), a = acceleration, and t = time:

velocity (m/s) = acceleration (m/s) × time (seconds)

Starting Hint The question "how fast was he going?" is asking you to find the velocity. $v = 9.8$ m/s × 2s. Solve for v.



Though a trestle may resemble a sawhorse, it is designed specifically to support scaffolding. Sawhorses are not intended for this purpose and should not be used to support scaffolding.

Pump Jacks

A **pump jack** is a metal device with a foot pedal that a worker pumps to make it slide up and down on a wood or aluminum post. One type of pump jack is shown in **Figure 7-12**. Two or more jacks in a row support planks that a worker can use as a scaffold. Pump jacks are commonly used to reach the side walls of a house during siding or painting operations. To lower the jack, the worker turns a hand crank.

The wood posts are often created by two 2×4s fastened together. The lumber should be solid, knot-free, and no more than 30' long. For solid support, each post must rest on a wood or steel pad. It must also be anchored to the structure at least every 10' by metal stand-offs nailed or screwed into the studs.

Reading Check

Explain *How are brackets different from trestles and pump jacks?*

Figure 7-12 Pump Jacks
Adjustable Height Pump jacks can be raised or lowered to any height along a wall.

Lifelines

A **lifeline** is a rope intended to prevent a worker from falling. The lifeline is fastened at one end to a secure point on the structure and at the other end to a harness worn by the worker. One type of lifeline is shown in **Figure 7-13**.

According to OSHA regulations, a lifeline must be secured to a structural member above the worker that is capable of supporting a minimum deadweight of 5,400 lbs. This amount accounts for the weight of the worker plus the force of the fall.

Lifelines that are used where they may be subjected to cutting or *abrasion* must have a wire core. For all other lifelines, manila rope or its equivalent, with a diameter of at least ¾" and a minimum breaking strength of 5,400 lbs., must be used. A lifeline should only be long enough to ensure that a worker can fall no more than 6'.

Figure 7-13 Lifeline
Well Secured Harnesses and lifelines must be fastened securely. *Why is this lifeline secured to the ridge of the roof?*

Section 7.2 Assessment

After You Read: Self-Check

1. In what kinds of situations might a worker prefer to set up planks on a bracket or pump jack instead of using standard scaffolding?
2. What might be the advantage of using a pump jack instead of a wall bracket when installing siding?
3. Which type of support would you use if you had a roof with many different kinds of pitches?
4. What is a lifeline, and what is its purpose?

Academic Integration: English Language Arts

5. **Create a Description** Write a one-paragraph description of a form of support found in this section. For each object, include what it looks like, what it is used for, what it is made of, and any other details you can think of. Be sure to include any important safety information.

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

CHAPTER 7

Review and Assessment

Chapter Summary

Section 7.1

The two types of ladders are folding ladders and straight ladders. They come in many sizes and are commonly made of wood, aluminum, or fiberglass. The proper use of ladders and scaffolds reduces the risk of falling. Before using any ladders or scaffolding, it is extremely important to read and follow the safety rules presented in this chapter. Read and follow the instructions in any manual that accompanies the ladder or scaffolding.

Section 7.2

Brackets, trestles, and pump jacks also can be used for support. Brackets are attached to the structure. Trestles and pump jacks are freestanding and support scaffold planks. Lifelines prevent workers from falling more than 6'. They are attached to the structure and to the worker's harness.

Review Content Vocabulary and Academic Vocabulary

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

Content Vocabulary

- ladder (p. 198)
- rails (p. 198)
- stepladder (p. 199)
- spreader (p. 202)
- scaffold (p. 204)
- scaffold planks (p. 204)
- competent person (p. 205)
- trestle (p. 207)
- pump jack (p. 208)
- lifeline (p. 209)

Academic Vocabulary

- ratio (p. 205)
- injure (p. 205)

Speak Like a Pro

Technical Terms

2. Work with a classmate to define the following terms used in the chapter: *crosspieces* (p. 198), *folding articulated ladder* (p. 199), *pipe scaffolding* (p. 204), *abrasion* (p. 209).

Review Key Concepts

3. Identify the basic parts of a ladder and the basic parts of a scaffold.

4. Summarize the safety rules for using an extension ladder.

5. Explain how to set up a straight ladder and a stepladder.

6. Describe the different uses of metal scaffolding and wood scaffolding.

7. Summarize how brackets, pump jacks, and lifelines are used in the construction industry.

Critical Thinking

8. Synthesize A small interior painting company has been asked to paint a structure that has walls and ceilings up to 20 feet high. What types of supports should the company use?

9. Analyze Why would a fiberglass ladder be safer than a metal ladder for someone working close to electrical wires?

Academic and Workplace Applications

STEM Mathematics

10. Right Triangles A ladder is leaning up against a house. The top of the ladder is 24' off the ground. The distance from the foot of the house to the foot of the ladder is 7' from the house. What is the working length of the ladder?

Math Concept If you know the lengths of two sides of a right triangle, you can determine the length of the third using this formula, known as the Pythagorean Theorem: $a^2 + b^2 = c^2$, where a and b are the lengths of the two short sides of a right triangle, and c is the length of the side opposite the right angle.

Step 1: Identify the known values: $a = 24$, $b = 7$.

Step 2: Plug the known values into the formula: $24^2 + 7^2 = c^2$ Solve for c.

STEM Engineering

11. Drawing to Scale The most common scale used in drawing houses is ¼" = 1' (1:48). You are painting an attic vent in the gable of a two-story house. The vent, which is 3' square, is located 24' above the ground. Use ¼" = 1' as your scale and create a side view sketch to show how you would set up an extension ladder to perform this task. Label the important dimensions. Be sure your sketch includes the horizontal distance between the house and the foot of the ladder, the length of overlap needed for the extension section, and the length of the stabilizing arms required.

21st Century Skills

12. Problem Solving One online store has a 4' by 6' base scaffold with wood planks and swivel casters, brakes, and guardrails for $543. It weighs 146 pounds. The sideguard (midrail) for it costs another $75 and weighs another 30 pounds. Another online store has the same size scaffold in aluminum with brakes and casters for $443. It weighs 79 pounds. The Web site offers a two-piece guardrail system for $164 that includes the guardrails and mid-rails, which total 17 pounds. The shipping service will charge $60 for packages up to 100 pounds, $75 for packages up to 200 pounds, and $85 for packages more than 200 pounds. Create a table that organizes the information in the problem to help you determine which scaffold package is least expensive.

	Scaffold #1		Scaffold #2	
Component	cost	weight	cost	weight
Base Scaffold				
Sideguard				
Shipping				
Totals				

Standardized TEST Practice

CERTIFICATION PREP

Multiple Choice

Directions Choose the word or phrase that best answers the question.

13. Which item would not be used with a lifeline?

a. rope **c.** harness
b. stabilizer **d.** structural support

14. Which type of support might be used on a rooftop?

a. stepladder **c.** bracket
b. sawhorse **d.** trestle

15. Which type of ladder is best for a maintenance worker?

a. Household, Type III
b. Commercial, Type II
c. Industrial, Type I
d. Industrial, Type IA

TEST-TAKING TIP

Predict the answer before you read the different multiple-choice options. Then, read each option and choose the one that is closest to your prediction.

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

UNIT 2
Hands-On Math Project

Starting Your Own Carpentry Business

Your Project Assignment

You are ready to start your own carpentry business. You will need to calculate how much money you will need for tools and supplies, and then apply for a business loan that meets your needs and budget.

- **Research** the cost of the tools and equipment you will need to start your business.
- Build It Green **Identify** tools and equipment that can help reduce impact on landfills.
- **Estimate** the total cost of tools and supplies for your first year of business.
- **Research** terms and interest rates for small-business loans.
- **Determine** the size of the loan you will need and calculate the monthly payment, including interest.
- **Create** a three- to five-minute presentation.

Applied Skills

Practice your skills as you do the following:

- **Create** a complete list of tools you will need.
- **Identify** three tools on your list that can help reduce impact on the environment. (Tip: Cordless tools that have replaceable batteries are more environmentally friendly than cordless tools with fixed batteries.)
- **Research** the prices and features of at least two brands and models of each tool on your list.
- **Determine** which tools are best suited to your needs and the best value for the money.
- **Calculate** the total cost of the tools, including any sales tax.

Math Standards

Number and Operations: Compute fluently and make reasonable estimates

Algebra: Use mathematical models to represent and understand quantitative relationships

Algebra: Represent and analyze mathematical situations and structures using algebraic symbols

NCTM National Council of Teachers of Mathematics

The Math Behind the Project

The traditional math skills for this project are computation and algebra. Remember these key concepts:

Order of Operations

When solving an equation, first do all operations inside parentheses. Next, calculate any exponents. An exponent shows the number of times you need to multiply a number by itself. For example, 2^3 means to multiply the number 2 three times ($2 \times 2 \times 2$). Then, working from left to right, do any multiplication and division followed by any addition and subtraction.

Compounding

Interest is the cost for borrowing money. Business loans have compound interest. This means that you pay interest not only on the principal (the amount of the loan), but also on the interest that accrues (grows) on the principal. This process is called compounding. Calculate compound interest using this formula: $A = P(1 + r)^n$. A is the total amount of money you will owe. P is the principal, r is the annual percentage interest rate expressed as a decimal, and n is the number of years you have to repay the loan. Solve for A and then divide this total into monthly payments. For example, if you borrow \$10,000 for five years at 8% annual interest, calculate your monthly payment using the following steps.

1. Convert the percentage to a decimal and set up the equation.	$A = \$10{,}000 \times (1 + .08)^5$
2. Add the numbers in parentheses.	$A = \$10{,}000 \times (1.08)^5$
3. Use a calculator to calculate the exponent. Round to two decimal places.	$A = \$10{,}000 \times 1.47$
4. Multiply the two numbers.	$A = \$14{,}700$
5. Find your monthly payment by dividing this amount by the number of months in the term of the loan.	$\$14{,}700 \div 12 = \$245$

U.S. Small Business Association

Mission: To aid, counsel, assist, and protect the interests of small business concerns, to preserve free competitive enterprise, and to maintain and strengthen the overall economy of the nation.

Go to **glencoe.com** for this book's OLC for more information on this organization.

Project Steps

Step 1 Research

- Research necessary tools and equipment for a general carpenter, and any other supplies you will need to start your business. Be sure to consider tools and equipment that will reduce impact on the environment.
- Compare brands and models of tools. Look on Web sites, in catalogs, and in local stores. Compare features, prices, warranty protection, and brand reliability. Also research cost to rent versus buy.
- Interview at least two contractors or carpenters in your area, asking for their recommendations and for any cost-saving tips.
- Contact the local field office of the Small Business Administration to gather information on rates and terms of loans for new businesses.

Step 2 Plan

- Itemize the tools and supplies you will need for the first year of your new business. List model numbers and prices.
- Create a cost comparison between standard and higher-quality tools. List the pros and cons of each.
- Determine the principal and term of the business loan you will need.

Step 3 Apply

- Determine the total cost of your tool and supply list, including tax.
- Calculate the total cost of the loan over its term based on an 8% annual percentage rate.
- Calculate your monthly payment. If the payment is not affordable, revise your tool list and desired loan.

Step 4 Present

Prepare a presentation combining your research and cost calculations using the checklist below.

PRESENTATION CHECKLIST
Did you remember to…
✓ Demonstrate the research you conducted to make your tool selections?
✓ Thoroughly explain the tool choices you made?
✓ Show how you determined the amount and term of the loan?
✓ Use and present a chart showing your calculations?
✓ Use a presentation program for your slides?

Step 5 Technical and Academic Evaluation

Assess yourself before and after your presentation.

1. Was your research thorough?
2. Was your tool list complete?
3. Were your cost calculations correct?
4. Were the interest calculations and monthly payments correct?
5. Was your presentation creative and effective?

Go to **glencoe.com** for this book's OLC for an evaluation rubric and the Academic Assessment.

McGraw Hill CONSTRUCTION
Construction.com CONNECTION

Go to **glencoe.com** for this book's OLC to read an article titled "Low-Vibration Tools Relieve Hammer Hands" to learn more about innovations in hand tools. Write a summary of this article.