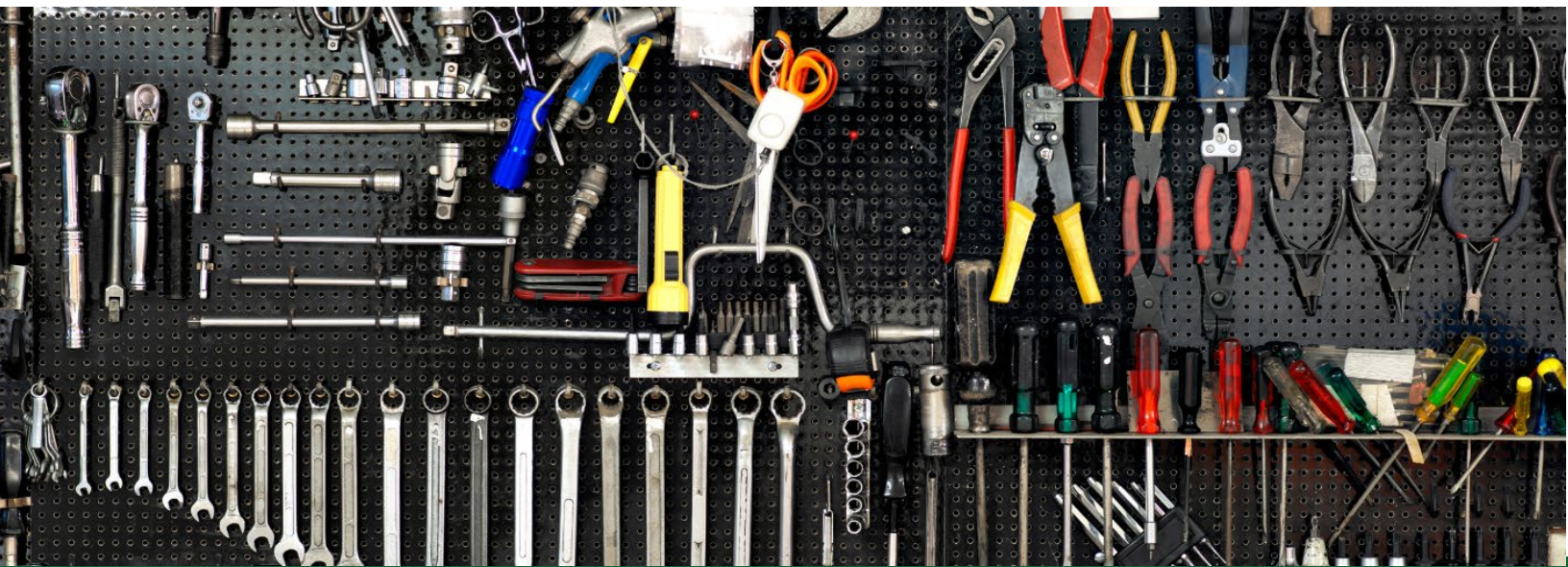


Participant Resource Guide

Mechanical Foundations

September 2026



Course Outline

Module 1: Fasteners

- Module 2: Hydraulics and Pneumatics
- Module 3: Leverage
- Module 4: Physics
- Module 5: Tools Reference Guide



U.S. Department of Transportation
Federal Transit Administration

A program of the Federal Transit Administration administered by the International Transportation Learning Center

Course: Mechanical Foundations

Version Date: September 2026

This document was prepared by the Transit Workforce Center with the financial assistance of the Federal Transit Administration, U.S. Department of Transportation.

Transit Workforce Center

8403 Colesville Road, Suite 825

Silver Spring, MD 20910

Tel: 855-888-NTWC (6892)

Contact us via email at twc@transportcenter.org

Mechanical Module – Fasteners



Objectives

- Identify the various types of fasteners and explain their purpose, including screws, nuts, bolts, washers, staples, retaining hardware, and miscellaneous hardware.
- Explain the advantages and disadvantages of fastener materials.
- Recognize common applications for fasteners.



Participant Resource Guide

Fasteners

**TWC • TRANSIT WORKFORCE CENTER**

Fasteners
Mechanical Foundations
Transit Core Competencies Curriculum (TC3)

U.S. Department of Transportation
Federal Transit Administration
A program of the Federal Transit Administration administered by the International Transportation Learning Center

3

Objectives

- Identify the various types of fasteners and explain their purpose, including screws, nuts, bolts, washers, staples, retaining hardware, and miscellaneous hardware.
- Explain the advantages and disadvantages of fastener materials.
- Recognize common applications for fasteners.

4

Agenda

- Welcome and Introduction
- **1.1** – Introduction to Fasteners
- **1.2** - Screws
- **1.3** – Nuts and Bolts
- **1.4** - Washers, Retaining Hardware, and Staples
- **1.5** - Applications for Fasteners in Transit
- Quiz



5

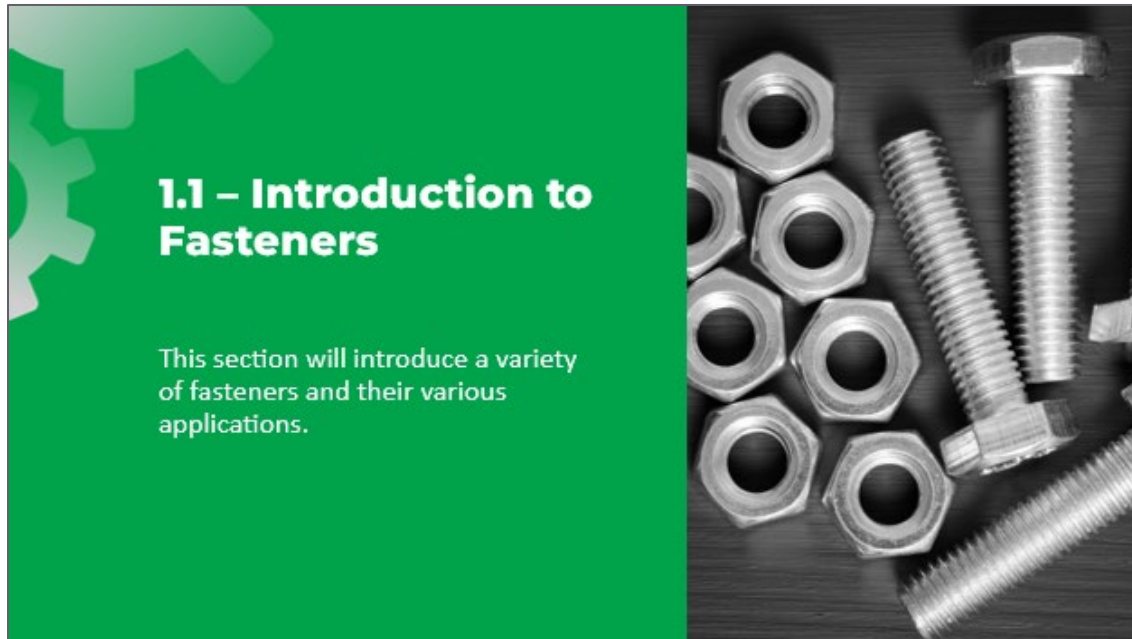
Warm Up

Scenario: You've just opened a new piece of furniture that requires assembly. Inside the hardware bag, you find a variety of fasteners and hardware.

- Why do you think the manufacturer included so many different pieces?
- What do you think some of these fasteners are designed to do?
- Which ones do you recognize?



6



Notes:

- Based on our warm-up discussion, you may already have some experience with fasteners.
- You'll build on any existing knowledge in this section and introduce a variety of fasteners and their various applications.

What are fasteners?

- A category of hardware that is used to secure parts or objects together.
- Common types:
 - Screws
 - Nuts
 - Bolts
 - Washers
 - Staples



Notes:

- The term **fasteners** refers to a category of hardware that is used to secure parts or objects together.
- Typical fasteners include screws, nuts, bolts, washers, and staples.
- Today you will learn about types of fasteners, their use, and how to select the right fastener for the job.

Common Fastener Materials

Material	Common Characteristics
Aluminum	Lightweight; commonly used in transportation applications
Steel	Strong and durable; available in a variety of strength grades
Stainless Steel	Excellent corrosion resistance; commonly used in harsh environments
Brass	Corrosion resistant; softer than steel and often used in specialty applications
Magnesium	Extremely lightweight; requires protection in corrosive environments
Copper	Excellent electrical conductivity; used for specialized electrical applications

Notes:

- Fasteners are made from different materials because no single material is ideal for every application.
- Each material has its own strengths and limitations.
 - For example, **aluminum** is valued for its light weight, while **steel** is commonly selected for its strength.
 - **Stainless steel** is often used where corrosion resistance is important.
- Material selection depends on the job the fastener needs to perform.
- In fact, some fasteners are manufactured to break under stress.
 - This typically occurs when breaking a cheaper part is a fail safe for breaking a more expensive part.

Selecting the Right Fastener Material

When selecting a fastener material, consider factors such as:

- Strength
- Corrosion resistance
- Flexibility
- Ability to withstand pressure
- Long-term durability
- Compatibility with other metals
- Weight
- Cost
- Availability



Notes:

- Selecting the right fastener involves more than choosing the correct size or type.
- The material directly affects how the fastener performs over time.
 - Strength and corrosion resistance are often the primary considerations.
 - Other factors, such as weight, cost, and compatibility with surrounding materials, may also influence the selection.
- The best material depends on the application and operating environment.

Using Compatible Materials

When selecting screws, bolts, nuts, and washers, use compatible materials whenever possible to help prevent:

- Galvanic corrosion
- Uneven strength
- Thermal expansion issues
- Compatibility problems
- Maintenance challenges



Notes:

- When selecting screws, bolts, nuts, and washers, use compatible materials whenever possible to help prevent:
 - Galvanic corrosion – Dissimilar metals can corrode when exposed to moisture.
 - Uneven strength – Different material strengths can create uneven load distribution.
 - Thermal expansion issues – Materials expand and contract at different rates, which can loosen connections.
 - Compatibility problems – Some materials are not designed to be used together and may fail under stress.
 - Maintenance challenges – Mixed materials can make inspection, maintenance, and replacement more difficult.

Knowledge Check



In your own words, what is a fastener?



12

Knowledge Check



Which of the following fastener materials would be best for a situation where corrosion resistance is needed?

(A). Stainless Steel

(B). Aluminum

(C). Magnesium

(D). Wood

13

Knowledge Check



A technician replaces a stainless-steel bolt with a different metal that is not compatible with the original hardware. What is one potential consequence?

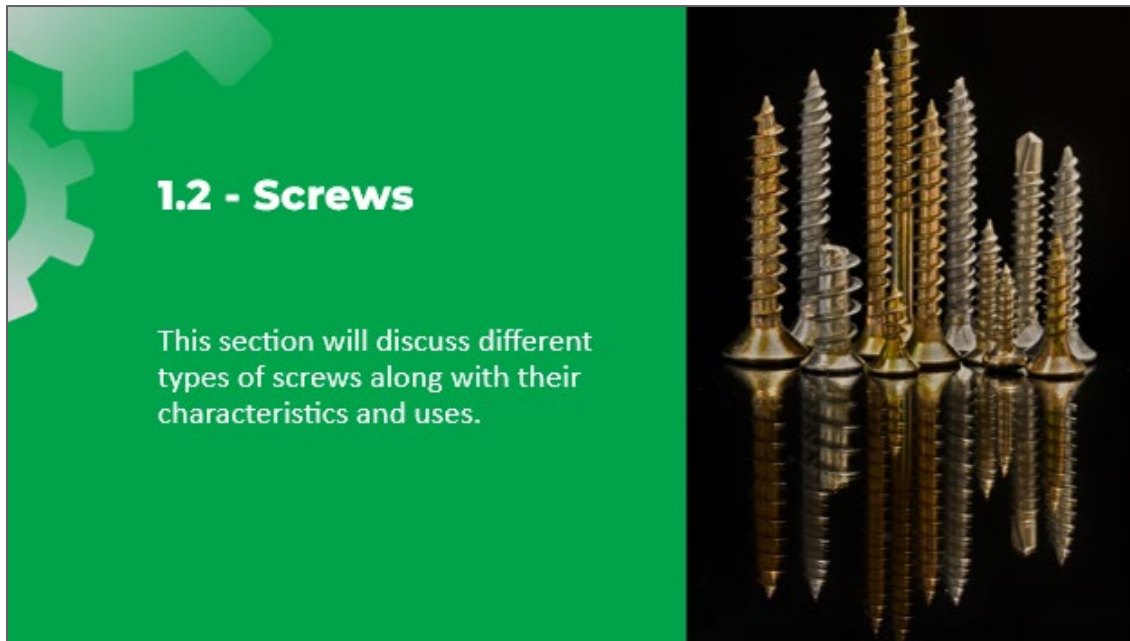
(A). The fastener will be easier to remove.

(B). The assembly may experience corrosion or reduced reliability.

(C). The bolt will automatically become stronger.

(D). The assembly will require fewer inspections.

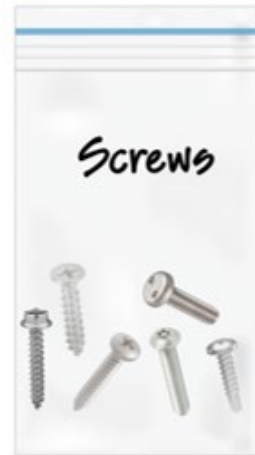
14



Notes:

- This section will discuss different types of screws along with their characteristics and uses.

As we review this section, please take a look at these **screws** as they are passed around the room.



Notes:

- While you review, take a look at the screws being passed around the room.

What is a screw?

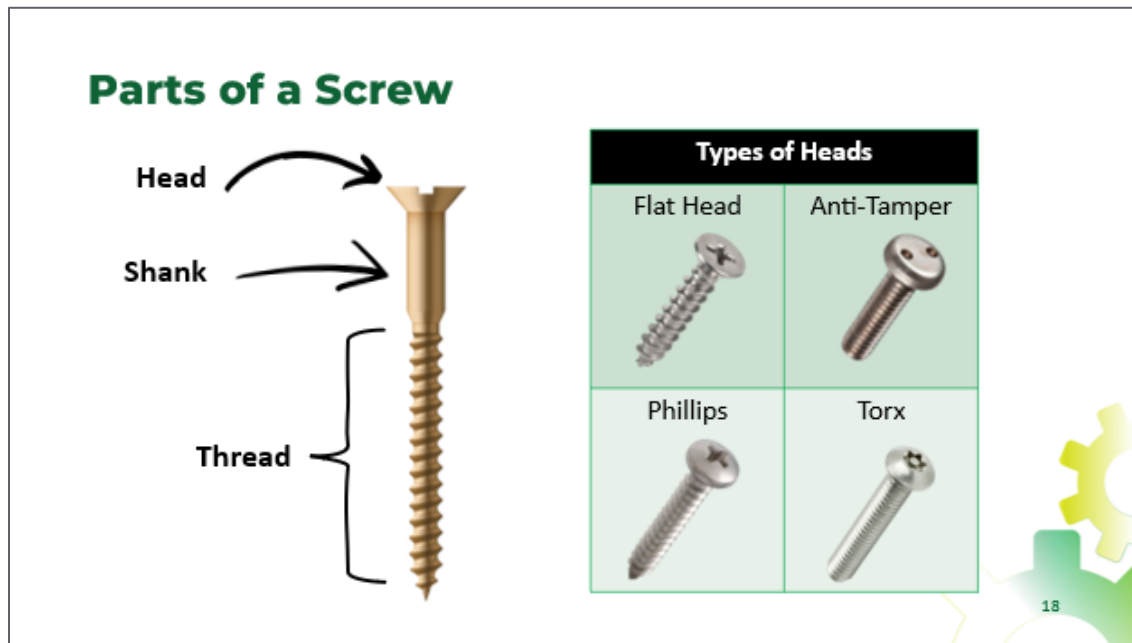
A **screw** is a cylindrical fastener with threads used to secure objects together.

- **Threads** - Engage with a matching threaded hole or nut to create a secure connection
- Used for fastening, assembly, positioning, and adjustment
- Available in a variety of materials and strength levels for different applications



Notes:

- **Screws** are one of the most commonly used fasteners in mechanical systems. They are found in everything from electrical enclosures and vehicle components to track equipment and shop fixtures.
 - The **threads** are what allow the screw to hold materials together. As the screw is tightened, the threads grip the material or engage with a threaded hole or nut to create a secure connection.
 - Some screws, like wood screws and sheet metal screws, create their own threads as they are installed.
 - Others, such as machine screws, require an existing threaded hole or a matching nut.
 - Screws are used in a variety of applications for fastening, assembly, and positioning.
 - Because screws are manufactured in **different materials** and **strength levels**, it's important to select the right screw for the application.
-
-
-
-
-



Notes:

- Although there are many types of screws, they all share the same basic parts. Understanding this terminology will make it easier to identify screws and communicate about them on the job.
 - The **head** is the top portion of the screw. It provides the surface that the tool engages to drive or remove the screw. Different head designs are used depending on the application and the tool required.
 - The **shank** is the smooth section between the head and the threads. Not every screw has a visible shank, but when present, it helps align the materials being fastened and can improve the strength of the connection.
 - The **threads** are the ridges that run along the body of the screw. As the screw is turned, the threads grip the material or engage with a threaded hole or nut to create a secure connection.
- On the right are examples of several common head types you may encounter. Different head designs are selected based on factors such as the tool being used, the amount of torque required, accessibility, or the need to discourage unauthorized removal.
 - **Flat Head:** Designed to sit flush with the surface of the material after installation, creating a smooth, finished appearance.
 - **Anti-Tamper:** Includes a specialized drive that requires a matching security tool, helping prevent unauthorized removal.
 - **Phillips:** Uses a cross-shaped recess and is one of the most common drive types for general-purpose fastening.
 - **Torx:** Uses a six-point star-shaped recess that provides better torque transfer and reduces the chance of the driver slipping or stripping the screw.

Installation Best Practices

- Mark the hole location with a center punch
- Drill a pilot hole when required
- Use cutting fluid or oil when installing self-tapping screws to reduce friction and heat.
- Clamp materials securely using the sandwich technique



19

Notes:

- Proper installation helps create a stronger, more reliable connection while reducing the risk of damaging the fastener or the material.
 - A **center punch** creates a small indentation that helps keep the drill bit from wandering when starting the hole.
 - A **pilot hole** makes it easier to install the screw and reduces the chance of splitting the material or damaging the fastener. Not every screw requires a pilot hole, so always follow the manufacturer's recommendations.
 - **Cutting fluid** or oil reduces friction and heat during drilling and installation. This helps extend tool life and can improve thread quality when working with metal.
 - The **sandwich technique** uses clamps to hold materials tightly together before drilling or fastening. This helps keep the pieces aligned and prevents movement during installation.
- These simple practices improve the quality of the installation and reduce the likelihood of rework or premature fastener failure.
- Now that you've covered how screws are installed, let's examine the different types of screws and where each is commonly used.

Types of Screws



20

Notes:

- The type of screw selected will depend on the thickness of the metal, the type of fastening that is recommended or required, and the desired appearance.
- In the next few slides, you'll review screws that are commonly used for metal work.
- This includes machine screws, self-tapping screws, self-drilling screws, sheet metal screws, hex washer head screws, and anti-tamper screws.



engineeringlearn.com

Machine Screw

- Used in mechanical and electrical assemblies
- Designed to be installed into a pre-threaded hole or matching nut and washer
- Fine thread for greater clamping force



Notes:

- **Machine screws** are commonly used in mechanical and electrical assemblies where a precise, secure connection is needed.
 - Machine screws differ from wood and sheet metal screws because they **do not create their own threads**. Instead, they are designed to be installed into a pre-threaded hole or used with a matching nut and washer.
 - They typically have **fine threads**, which are spaced closer together than those on wood or sheet metal screws.
 - Fine threads provide **greater clamping force**, allow for more precise adjustments, and generally have higher tensile strength than coarse-thread fasteners of the same size.
 - A **thread pitch gauge** is used to identify the spacing between threads so the correct replacement fastener can be selected.
 - Machine screws are commonly found in electrical equipment, control panels, brackets, instrumentation, and other transit components requiring secure, precise fastening.
-
-
-
-
-

Self-Tapping Screw

- Form their own threads as they are installed
- Typically installed in a pre-drilled pilot hole
- Pilot holes are slightly smaller than the screw diameter
- Commonly used when fastening metal, plastic, and other materials



Notes:

- Unlike machine screws, self-tapping screws **create their own threads** as they are driven into the material. This eliminates the need for a pre-threaded hole or matching nut.
- Self-tapping screws are usually installed into a **pilot hole** that is slightly smaller than the screw's diameter. As the screw is turned, its threads cut or form matching threads in the material.
 - Keep in mind that self-tapping does not mean self-drilling. Most self-tapping screws still require a pilot hole before installation.
 - Using the correct pilot hole size is important. If the hole is too small, installation can be difficult or damage the screw. If it's too large, the screw may not hold securely.
- Self-tapping screws are commonly used with **sheet metal, plastics, and other materials** where creating threads during installation is practical.

Sheet Metal Screw

- Designed for fastening thin sheet metal
- Can also be used with plastic and other materials
- Typically have a fully threaded shank with sharp, aggressive threads
- Provides a secure grip by forming threads during installation



Notes:

- Sheet metal screws are specifically designed to **fasten thin pieces of metal** together, but they are also commonly used with plastic, fiberglass, and other materials.
- These screws usually have a **fully threaded shank** with sharp, **aggressive threads** that provide excellent holding power by cutting or forming threads as they are installed.
- Because sheet metal screws are typically **self-tapping**, they create their own mating threads in the material. In most metal applications, a pilot hole is drilled first to make installation easier and improve accuracy.
- Sheet metal screws are widely used throughout transit vehicles and facilities to secure access panels, covers, brackets, electrical enclosures, HVAC components, and other light-gauge metal assemblies.
- Selecting the correct length, diameter, and thread style helps ensure a strong, reliable connection without damaging the material.

Self-Drilling Screw

- Have a drill bit-shaped tip that drills its own pilot hole
- Eliminate the need to pre-drill most metal applications
- Drill, tap, and fasten in a single operation
- Commonly used for fastening sheet metal and light-gauge steel



Notes:

- Self-drilling screws are designed to save time by combining three steps into one.
- As they are installed, they **drill the hole, create the mating threads, and fasten the material**—all in a single operation.
- The key feature is the drill bit-shaped tip. Unlike a self-tapping screw, which usually requires a pilot hole, a self-drilling screw creates its own pilot hole as it is driven into the material.
- These screws are most often used to fasten sheet metal, light-gauge steel, and similar materials, making them a common choice for equipment housings, electrical enclosures, brackets, and metal panels.
- Although self-drilling screws simplify installation, it's still important to select the correct screw size and use the appropriate driver to avoid damaging the fastener or the material.

Hex-Washer Screw

- Feature a hexagonal head with a built-in washer
- The built-in washer helps distribute the clamping force over a larger surface
- Installed using a socket or nut driver for a secure connection
- Available in self-tapping and self-drilling versions



Notes:

- Hex washer screws are easy to recognize by their hexagonal head and **the built-in washer** located beneath it.
 - The integrated washer helps **distribute the clamping force** over a larger area. This helps protect the material from damage and creates a more secure connection.
 - These screws are **installed using a socket or nut driver**, allowing technicians to apply **more torque** than many traditional screwdriver drive types. This makes them a popular choice for fastening metal components.
 - Hex washer screws are commonly used in transit maintenance, construction, and manufacturing to secure sheet metal, brackets, equipment housings, and other metal assemblies.
 - You'll find two common versions:
 - **Self-tapping hex washer screws** require a pilot hole but create their own mating threads during installation.
 - **Self-drilling hex washer screws** have a drill-point tip that drills the hole, forms the threads, and fastens the material in one operation.
-
-
-
-
-

Anti-Tampering Screw

- Designed to discourage unauthorized removal by requiring specialized tools.
- Require a matching security driver for installation and removal.
- Available in a variety of security drive designs such as
 - Pin-in Torx
 - Spanner ("Snake Eyes")
 - Tri-Wing
 - One-Way



Notes:

- Anti-tamper screws are designed to help **prevent unauthorized access** to equipment, panels, or components.
- Unlike standard screws, they require a **specialized driver** for installation and removal.
- In transit systems, you may find them on fare equipment, electrical enclosures, signal equipment, control cabinets, and other components that should only be accessed by authorized personnel.
- Some common examples include:
 - **Pin-in Torx**, which has a small pin in the center of the drive recess.
 - **Spanner**, often called "Snake Eyes," which uses two small holes in the screw head.
 - **Tri-Wing**, which has a three-lobed drive pattern.
 - **One-Way** screws, which are designed to tighten normally but are difficult to remove using conventional tools.
- Although these screws improve security, they are not theft-proof. Their purpose is to discourage tampering and limit access to trained personnel with the proper tools.

Summary and What's Next

- Screws are threaded fasteners used to join materials together.
- Different screw types are designed for specific materials, applications, and installation methods.
- Selecting the correct screw helps ensure a safe, secure, and reliable connection.

Next, we'll learn about nuts and bolts and how they work together to create strong mechanical connections.

27

Notes:

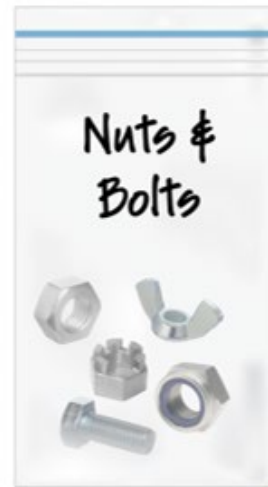
- *What do you think are the most important things about screws you learned in this section?*
- First, screws are threaded fasteners used to join materials together. While they all share the same basic purpose, they come in many different designs to meet different fastening needs.
- Second, different screw types are designed for different applications. We looked at machine screws, self-tapping screws, sheet metal screws, self-drilling screws, hex washer screws, and anti-tamper screws. Each has features that make it better suited for certain materials or installation methods.
- Finally, choosing the correct screw is essential. Selecting the right screw improves strength, reliability, ease of installation, and long-term performance while reducing the risk of damage or fastener failure.
- In the next section, you'll shift our focus to nuts and bolts and learn how they work together to create strong mechanical connections in transit equipment and infrastructure.



Notes:

- In this section, you'll review the purpose, function, and characteristics of nuts and bolts.

As we review this section,
please take a look at these
nuts and bolts as they are
passed around the room.



29

Notes:

- While you review, take a look at the nuts and bolts being passed around the room.

What is a bolt?

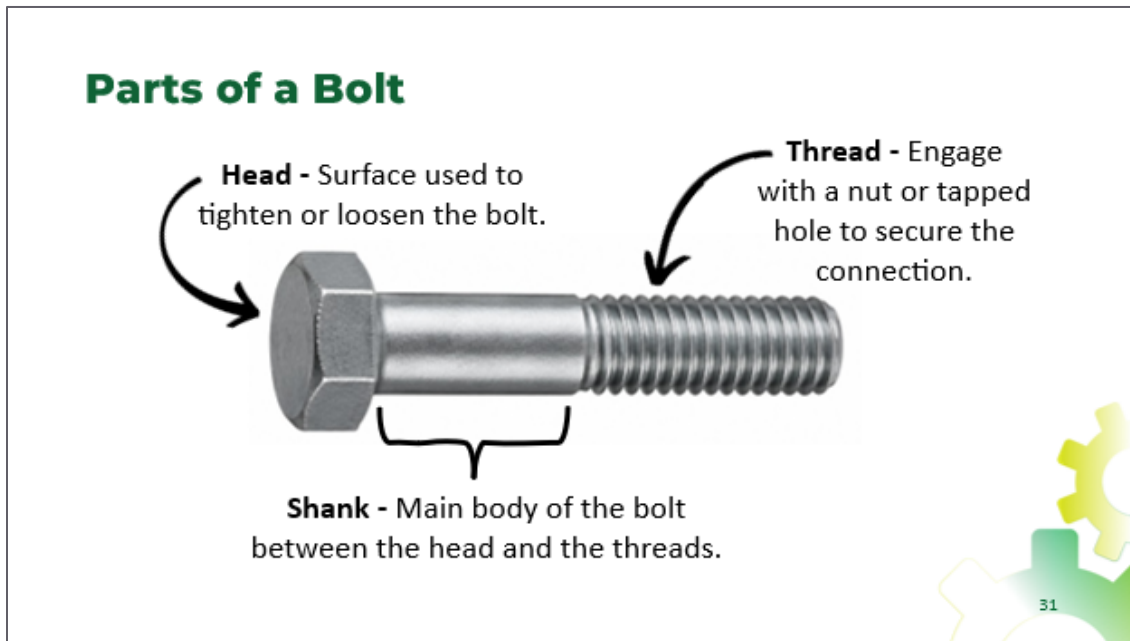
A **bolt** is a threaded fastener used to join two or more parts together.

- Used with a matching nut or installed into a tapped hole
- Typically have a head, shank, and threaded end
- Create strong, secure connections that can be easily assembled, adjusted, and disassembled.



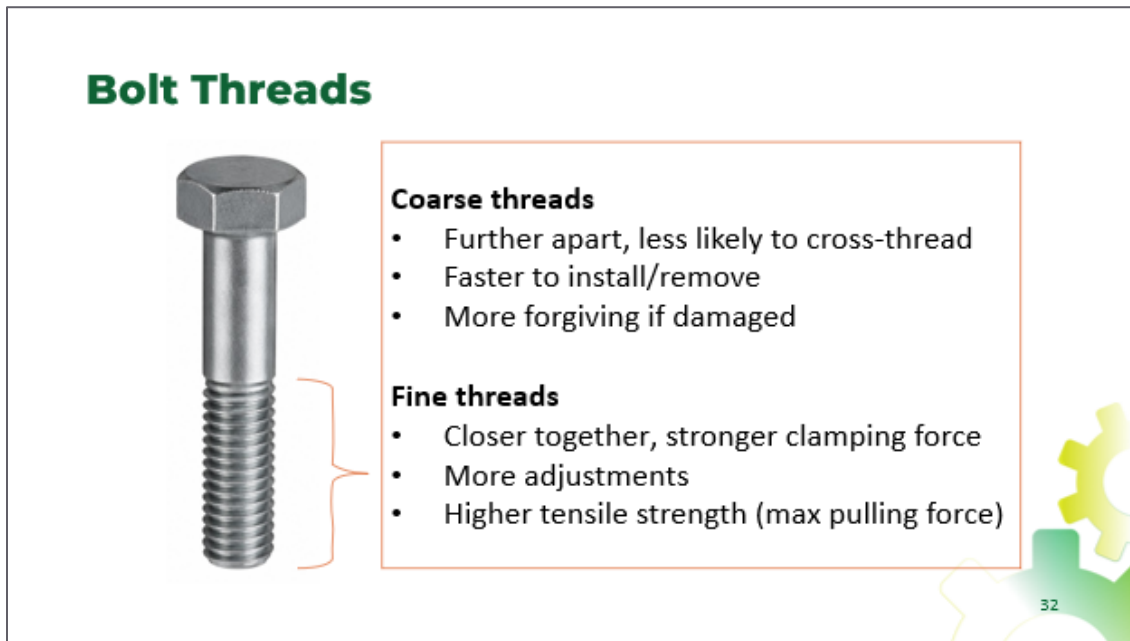
Notes:

- A **bolt** is a threaded fastener used to join two or more parts together.
 - While bolts are most commonly paired with a matching nut, they can also be installed into a tapped hole when the component already has internal threads.
 - Most bolts share the same basic design. They have a head, a shank, and a threaded end that engages with a nut or threaded hole to secure the connection.
 - Depending on the application, a bolt may have a **partially threaded shank** or be **fully threaded**.
 - The amount of smooth shank and threaded length is selected based on the strength and function required for the joint.
 - One of the key advantages of a bolted connection is that it can be assembled, adjusted, disassembled, and reassembled without damaging the components being joined. This makes bolts a popular choice for equipment that requires maintenance or periodic replacement.
 - Bolts are commonly used throughout transit vehicles, maintenance facilities, and infrastructure to secure brackets, equipment, structural components, and mechanical assemblies.
 - Now that you've defined what a bolt is, let's identify the basic parts of a bolt and learn how each contributes to the fastener's function.
-
-
-
-
-



Notes:

- Understanding the parts of a bolt will make it easier to identify, select, and communicate about bolts on the job.
 - The **head** is the portion of the bolt that a wrench or socket grips to tighten or loosen the fastener.
 - Bolts are available with several head styles, but the hex head is one of the most common.
 - The **shank** is the main body of the bolt between the head and the threads.
 - Some bolts have a long smooth shank, while others are threaded almost their entire length.
 - The amount of shank depends on the bolt's intended application.
 - The **threads** engage with a matching nut or a tapped hole to create a secure connection.
 - The threaded portion is responsible for developing the clamping force that holds the joint together.
 - While bolts may vary in length, diameter, head style, and thread length, they all share these same basic parts.
-
-
-
-
-

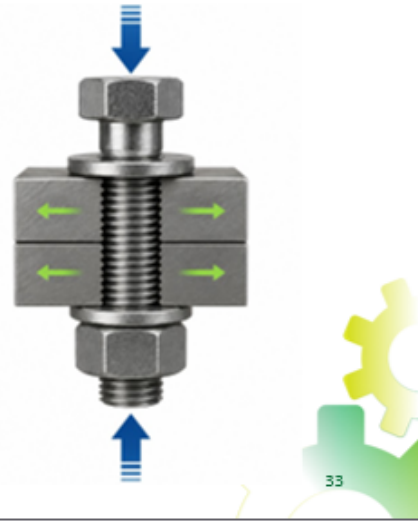


Notes:

- Bolt threads are generally classified as coarse or fine. The difference is the spacing between the threads, and each type is designed for different applications.
- **Coarse threads** have wider spacing between the threads.
 - This makes them quicker to install and remove, less likely to cross-thread during assembly, and more tolerant of dirt, debris, or minor damage.
 - They're commonly used for general-purpose fastening.
- **Fine threads** are spaced closer together.
 - Because more threads engage over the same length, they can provide greater clamping force and higher tensile strength.
 - They also allow for finer adjustments during assembly.
- Neither thread type is "better" than the other. The correct choice depends on the application and the manufacturer's specifications.

How a Bolted Joint Works

- A **bolt and nut** clamp materials together.
- Tightening the bolt creates tension, causing the bolt to stretch slightly.
- The stretched bolt acts like a spring, creating **clamping force**.
- Clamping force and **friction** help keep the joint secure.



Notes:

- A bolt and nut don't simply hold materials together by filling a hole. They work together to create clamping force.
- As the bolt is tightened, it stretches a very small amount. Although the stretch is not visible, it places the bolt under **tension**.
- That slight stretch allows the bolt to behave much like a spring.
- As it tries to return to its original length, it continuously pulls the joint together and **maintains pressure** on the connected materials.
- This pressure, called **clamping force**, creates **friction** between the materials. That friction is what helps keep the joint from loosening during normal operation and vibration.
- Applying the correct amount of tightening force is important.
 - Too little torque may not produce enough clamping force, allowing the joint to loosen over time.
 - Too much torque can overstretch or damage the bolt and the connected components.
- Technicians should always follow the manufacturer's **torque specifications**.
- Using the specified torque helps achieve the proper clamping force without damaging the fastener or the assembly.

Torque-to-Yield (TTY) Bolts

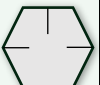
- Designed to stretch permanently during installation
- Tightened using a specified torque and angle procedure
- Commonly used in critical, high-load applications
- Replace after removal unless the manufacturer specifies otherwise.

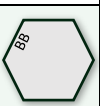
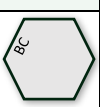
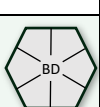
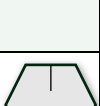
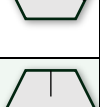
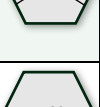
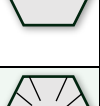
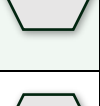


Notes:

- Most of the bolts we've discussed can be reused if they're in good condition and the manufacturer's procedures allow it. However, **torque-to-yield**, or **TTY**, bolts are an important exception.
 - A torque-to-yield bolt is designed to stretch **beyond its elastic limit** during installation. This permanent stretch allows the bolt to produce a very consistent clamping force across the joint.
 - Because the bolt has permanently stretched, it generally **cannot provide the same clamping force a second time**. For that reason, TTY bolts are typically replaced whenever they're removed.
 - Technicians often tighten these bolts using a **torque-plus-angle** procedure. Instead of stopping at a torque value alone, the bolt is tightened to an initial torque and then turned an additional number of degrees to achieve the required stretch.
 - In transit maintenance, you may encounter torque-to-yield bolts on **engines, transmissions, drive systems, suspension components, or other critical assemblies** where maintaining a precise clamping force is essential.
-
-
-
-
-

Bolt Grade Markings & Strength Chart

Inch Steel Bolts							
Bolt Head	Grade / Specification	Material	Nominal Size (inch)	Proof Load	Tensile Strength Min.	Yield Strength Min.	Rockwell Hardness Min./Max.
	Grade 1 - SAE J429 Bolts, screws, and studs	Low or medium carbon steel	1/4"-1-1/2"	33,000	60,000	36,000	B70 / B100
	Grade 2 - SAE J429 Bolts, screws, and studs	Low or medium carbon steel	1/4"-3/4" >3/4"-1-1/2"	55,000 33,000	74,000 60,000	57,000 36,000	B80 / B100 B70 / B100
	Grade 5 - SAE J429 Bolts, screws, and studs	Medium carbon steel or carbon steel with additives, quenched and tempered	1/4"-1" >1"-1-1/2"	85,000 74,000	120,000 105,000	92,000 81,000	C25 / C34 C19 / C30
	Grade 5.1 - SAE J429 Sems	Low or medium carbon steel, quenched and tempered	No. 4-5/8"	85,000	120,000	92,000	C25 / C40
	Grade 5.2 - SAE J429 Bolts, screws, and studs	Low carbon boron steel, quenched and tempered	1/4"-1"	85,000	120,000	92,000	C26 / C36
	Grade 8 - SAE J429 Bolts and screws	Medium carbon/alloy steel with additives, quenched and tempered	1/4"-1-1/2"	120,000	150,000	130,000	C33 / C39
	Grade 8.2 - SAE J429 Bolts and screws	Low carbon boron steel, quenched and tempered	1/4"-1"	120,000	150,000	130,000	C33 / C39
	L9 - Grade 9 Bolts, nuts, and washers	High-strength alloy steel	1/4"-1-1/2"	145,000	180,000	155,000	C38 / C42
	ASTM A307 Grade A Bolts, screws, and studs (general engineering)	Low or medium carbon steel	1/4"-4"	33,000	60,000	36,000	B69 / B100
	ASTM A307 Grade B Bolts, screws, and studs (flanged joints)	Low or medium carbon steel	1/4"-4"	33,000	60,000	36,000	B69 / B95

Inch Steel Bolts							
Bolt Head	Grade / Specification	Material	Nominal Size (inch)	Proof Load	Tensile Strength Min.	Yield Strength Min.	Rockwell Hardness Min./Max.
	ASTM A325 Type 1 High-strength structural bolts	Medium carbon steel, quenched and tempered	1/2"-1" 1-1/8"-1-1/2"	85,000 74,000	120,000 105,000	92,000 81,000	C24 / C35 C19 / C31
	ASTM A325 Type 2 High-strength structural bolts	Low carbon martensitic steel, quenched and tempered	1/2"-1" 1-1/8"-1-1/2"	85,000 74,000	120,000 105,000	92,000 81,000	C24 / C35 C19 / C31
	ASTM A325 Type 3 High-strength structural bolts	Atmospheric corrosion-resistant steel, quenched and tempered	1/2"-1" 1-1/8"-1-1/2"	85,000 74,000	120,000 105,000	92,000 81,000	C24 / C35 C19 / C31
	ASTM A354 Grade BB Bolts and studs	Alloy steel, quenched and tempered	1/4"-2-1/2" >2-1/2"-4"	80,000 75,000	105,000 100,000	83,000 78,000	C26 / C36 C22 / C33
	ASTM A354 Grade BC Bolts and studs	Alloy steel, quenched and tempered	1/4"-2-1/2" >2-1/2"-4"	105,000 95,000	125,000 115,000	109,000 99,000	C26 / C36 C22 / C33
	ASTM A354 Grade BD Bolts, screws, and studs	Alloy steel, quenched and tempered	1/4"-2-1/2" >2-1/2"-4"	120,000 105,000	150,000 140,000	130,000 120,000	C33 / C39 C31 / C39
	ASTM A449 Type 1 Bolts, screws, and studs	Medium carbon steel, quenched and tempered	1/4"-1" >1"-1-1/2"	85,000 74,000	120,000 105,000	81,000 58,000	C25 / C34
	ASTM A449 Type 2 Bolts, screws, and studs	Low carbon martensitic steel, quenched and tempered	1/4"-1"	85,000	120,000	58,000	C25 / C34
	ASTM A490 Type 1 High-strength structural bolts	Medium carbon alloy steel, quenched and tempered	1/2"-1-1/2"	120,000	150,000 min 170,000 max	130,000	C33 / C38
	ASTM A490 Type 2 High-strength structural bolts	Low carbon martensitic steel, quenched and tempered	1/2"-1"	120,000	150,000 min 170,000 max	130,000	C33 / C38
	ASTM A490 Type 3 High-strength structural bolts	Atmospheric corrosion-resistant steel, quenched and tempered	1/2"-1-1/2"	120,000	150,000 min 170,000 max	130,000	C33 / C38

Metric Steel Bolts						
Bolt Head	Grade / Specification	Material	Proof Load	Tensile Strength Min.	Yield Strength Min.	Rockwell Hardness Min./Max.
	Class 4.6	Low or medium carbon steel	220	400 (58,000 psi)	240	HRB-67 / HRB-95
	Class 5.8	Low or medium carbon steel, quenched and tempered	380	520 (75,000 psi)	420	HRB-82 / HRB-95
	Class 8.8	Medium carbon steel, quenched and tempered	600	830 (120,000 psi)	640	HRC-22 / HRC-34
	Class 10.9	Alloy steel, quenched and tempered	830	1040 (150,000 psi)	940	HRC-32 / HRC-39
	Class 12.9	Alloy steel, quenched and tempered	970	1220 (176,000 psi)	1220	HRC-39 / HRC-44
	A2 & A4 Stainless	Steel alloy with chromium and nickel	N/A	500 Min / 700 Typical	210 Min / 450 Typical	—

Key Terms:

- **Tensile strength** - Resistance of a material to breaking under tension.
- **Yield strength** - Stress at which a specified amount of deformation occurs.
- **Proof load** - Axial tensile load a fastener must withstand without permanent deformation.

Measuring Thread Pitch on Bolts

- Used to identify an unknown thread
- Different gauges for metric pitch and imperial pitch
- Includes several leaves with stamped pitch numbers



Notes:

- Measuring thread pitch is necessary to identify an unknown thread.
- To measure pitch, you will need to use a thread pitch gauge.
- One gauge is used to measure metric pitch, another to measure imperial pitch
 - Having both gauges is important as a metric pitch gauge may appear to match some imperial threads (or visa versa)
- A pitch gauge has several leaves with a number stamped on it – this number indicates the pitch.

Measuring Thread Pitch on Bolts



1. Determine whether you need a metric or imperial gauge.
2. Select a thread pitch gauge and choose a blade with a likely pitch.
3. Match the gauge teeth to the bolt threads until they fit perfectly with no gaps.
4. Read the pitch value stamped on the gauge.

Metric Pitch Example: M8-1.25
(8mm dia. bolt with 1.25 pitch)



37



Video

Click the image to watch the video about British Airways Flight 5390 .

Discussion:

- How does using the wrong size bolt impact the clamping force?

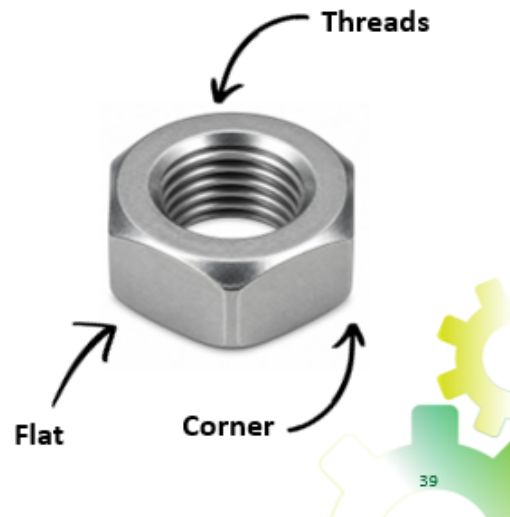


38

What is a nut?

A **nut** is a fastener with internal threads that is used with a matching bolt to join two or more parts together.

- Create strong, removable and adjustable connections
- Typically have internal threads, flats, and corners for tightening
- Available in a variety of designs for different applications.



Notes:

- A **nut** is a fastener with internal threads that works together with a matching bolt to securely join two or more parts.
 - Unlike a bolt, a nut has **internal threads** that engage with the bolt's external threads to create a secure mechanical connection.
 - Most nuts have flats and corners that allow a **wrench or socket** to grip and tighten them.
 - One of the advantages of a bolted connection is that it can be **assembled, adjusted, disassembled, and reassembled** when maintenance or repairs are needed.
 - In some applications, **vibration** or repeated movement can cause a nut to loosen over time.
 - To help prevent this, nuts may be used with washers, cotter pins, nylon inserts, or thread-locking compounds such as Loctite®, depending on the application.
 - Nuts are manufactured in several different designs, each intended for a specific purpose.
-
-
-
-
-



Notes:

- Let's look at some of the most common nut types you'll encounter in transit maintenance.
- **Hex nuts** are the most common type of nut and are used in a wide variety of fastening applications.
 - They're typically tightened with a wrench or socket and paired with a standard bolt.
- **Wing nuts** have two wings that allow them to be tightened or loosened by hand without tools.
 - They're commonly used when a connection needs to be adjusted or removed frequently.
- **Castle, or castellated, nuts** have slots cut into the top of the nut.
 - After the nut is tightened, a cotter pin is inserted through the slots and a hole in the bolt to help prevent the nut from loosening due to vibration.
 - These are commonly used in safety-critical applications where accidental loosening could cause damage or injury.
- **Lock nuts, often called Nylock® nuts**, contain a nylon insert that increases friction between the nut and the bolt threads, helping resist loosening caused by vibration.
 - Many lock nuts are intended for limited reuse because the nylon insert loses effectiveness after repeated installations.
- The type of nut selected depends on the application, the amount of vibration, how often the assembly will be removed, and the level of security required.

Matching and Measuring



Materials: A variety of metric and standard, fine and coarse thread nuts and bolts available for you to inspect.

1. Match the appropriate **bolt** with its counterpart **nut** (size and thread)
2. Use a thread **pitch gage** to measure the pitch of one metric and one imperial (inch) bolt.



41

Fastener Application



Directions: Read each scenario and answer the question by selecting the best response.

Activity

Fastener Application

Directions: Read each scenario and answer the question by selecting the best response.

- A grade 5 bolt is broken and needs to be replaced. After it is in the hole and the nut is tightened, which option will have the least chance of failure?

 - Not greasing the threads with grease
 - Applying grease and oil to the nut
 - Not greasing
 - Greasing the threads with grease
- Which is a good criterion for selecting a fastener?

 - Weight
 - Length
 - Material
 - None of the above
- Which is the best way to ensure that a fastener is not over-tightened?

 - Use a torque wrench to apply the correct torque
 - Use a torque wrench to apply the correct torque
 - Use a torque wrench to apply the correct torque
 - Use a torque wrench to apply the correct torque
- Which is the best way to ensure that a fastener is not over-tightened?

 - Use a torque wrench to apply the correct torque
 - Use a torque wrench to apply the correct torque
 - Use a torque wrench to apply the correct torque
 - Use a torque wrench to apply the correct torque
- Which is the best way to ensure that a fastener is not over-tightened?

 - Use a torque wrench to apply the correct torque
 - Use a torque wrench to apply the correct torque
 - Use a torque wrench to apply the correct torque
 - Use a torque wrench to apply the correct torque

© 2026 Transit Workforce Center - Pg. 1



Activity

Fastener Application

Directions: Read each scenario and answer the question by selecting the best response.

1. A grade 8 bolt is broken and needs to be replaced. Leroy is in the field and has limited replacement options on hand: grade 4 bolts, grade 9 bolts, self-tapping screws, nuts, washers, Loctite in blue. Which option is best?
 - a. Bolt grade 4 sealed with Loctite
 - b. Self-tapping screw and an anchor
 - c. Bolt grade 9
 - d. Washer, bolt combo with a grade 9 bolt
2. Which is **NOT** a fastener that would prevent loosening?
 - a. Wing Nut
 - b. Lock Washer
 - c. Castellated Nut
 - d. Lock Nut with nylon insert
3. Andy wants to make sure the hole he drills is centered to his pencil mark. What is his best option?
 - a. Use two hands on the drill for greater stability
 - b. Press down harder on the drill
 - c. Use a center punch and drill a pilot hole
 - d. Guide the drill bit with a pair of pliers
4. Tyler needs to replace a missing bolt on a machine, but the bolt options you have are all metric. However, the machine uses SAE threads. What should Tyler do?
 - a. Use the metric bolt and force the threads using grease
 - b. Use a thread adapter
 - c. Shear the bolt and then tap new threads that match
 - d. Place an order for the correct replacement part and mark the item as “out of service” until the repair can be made
5. Deb was called in to fix a problem. A wingnut is having a recurring issue: it is vibrating loose during machine operation, causing the attached cover to fall off. What is the best solution to fix this problem?
 - a. Keep the cover off permanently
 - b. Use an alternative such as a nylock nut, a lock washer, or a thread-locking compound like Loctite
 - c. Replace the wingnut with a new one and see if this fixes the problem
 - d. Use a cotter pin to secure the nut in place

Knowledge Check



What are some similarities between screws and bolts?



43

Knowledge Check



What kind of screw would be best for the following scenario?

- **Scenario:** A technician is fastening a metal bracket to a steel support beam. The material has not been pre-drilled, and the technician wants to complete the installation in a single step.

(A). Machine Screw

(B). Sheet Metal Screw

(C). Self-Drilling Screw

(D). Anti-Tamper Screw

44

Knowledge Check



What kind of nut would be best for the following scenario?

- **Scenario:** A technician is securing a component that experiences constant vibration during normal operation. The connection should resist loosening without using a cotter pin.

(A). Wing nut

(B). Lock (Nylock®) nut

(C). Hex nut

(D). Castle nut

45

Summary and What's Next

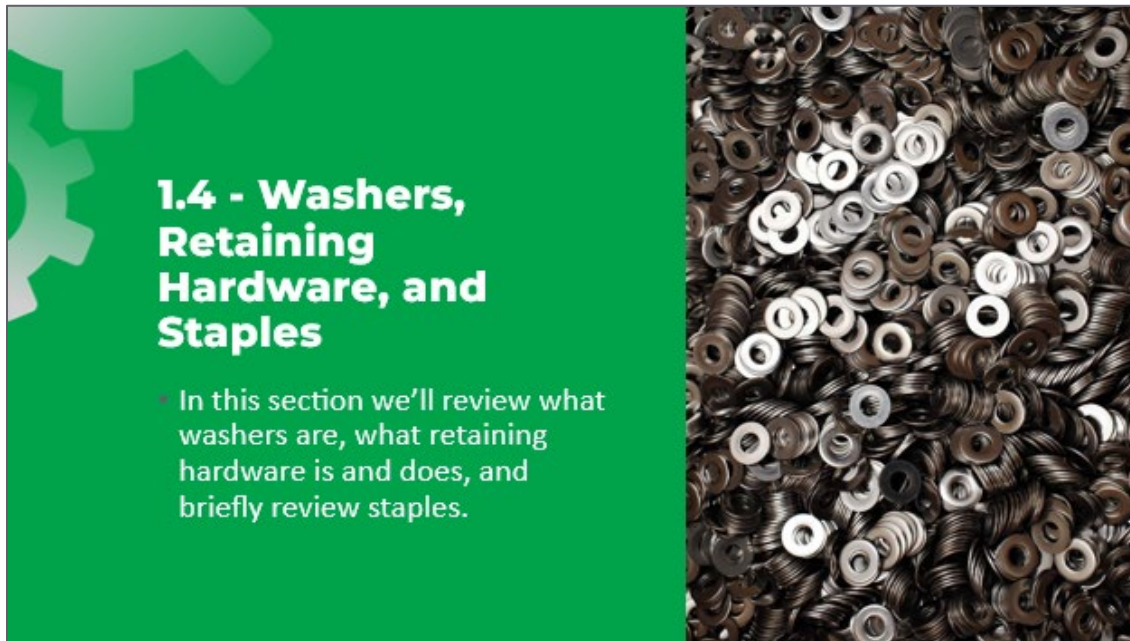
- Bolts and nuts work together to create strong, removable mechanical connections.
- Select the correct bolt type, thread, and grade based on the application and manufacturer specifications.
- Different nut types are designed for specific purposes, such as resisting vibration or allowing quick adjustments.

Next, we'll learn about washers and other fastening hardware that help improve the performance and reliability of fastened joints.

46

Notes:

- *What are the most important things you learned about nuts and bolts from this section?*
 - In this section, you learned that bolts and nuts work together to create secure, reusable connections that can be **assembled**, **adjusted**, and **disassembled** when maintenance is required.
 - You also discussed how to identify bolt characteristics, including **thread type**, **grade**, and **standard versus metric sizing**, and why it's important to follow the **manufacturer's specifications** when selecting replacement fasteners.
 - You explored several common **nut types** and learned that each is designed for a specific purpose, whether it's general fastening, quick hand adjustments, or preventing loosening caused by vibration.
 - Remember that selecting the correct bolt and nut helps ensure a strong, reliable connection and contributes to the safe operation of equipment.
 - Next, you'll look at washers and other fastening hardware. Although they may seem like small components, they play an important role in distributing load, protecting surfaces, and improving the performance and reliability of fastened joints.
-
-
-
-
-



Notes:

- In this section you'll review what washers are, what retaining hardware is and does, and briefly review staples.

As we review this section,
please take a look at these
washers as they are passed
around the room.



Notes:

- While you review, take a look at the washers being passed around the room.

Washers

A **washer** is a thin plate with a hole in the center that is used with bolts, screws, and nuts.

- Help distribute clamping force across a larger surface area
- Designed to help resist loosening caused by vibration.
- Available in a variety of materials to meet different strengths



Notes:

- A **washer** is a simple but important fastener component that is typically used with a bolt, screw, or nut.
 - One of its primary functions is to **distribute the clamping force** over a larger surface area. This helps reduce damage to the material being fastened and creates a more secure connection.
 - Depending on the application, some washers are also designed to **help resist loosening** caused by vibration or movement.
 - Washers are manufactured from a variety of materials, including steel, brass, silicon bronze, stainless steel, and alloy steel.
 - The material is selected based on the strength required and the environment in which the fastener will be used.
 - To improve performance, some washers are **heat treated, coated, or specially treated** to increase durability or provide additional protection against corrosion in environments such as fresh water or salt water.
 - After discussing the purpose of washers, let's look at some of the most common washer types and when each should be used.
-
-
-
-
-

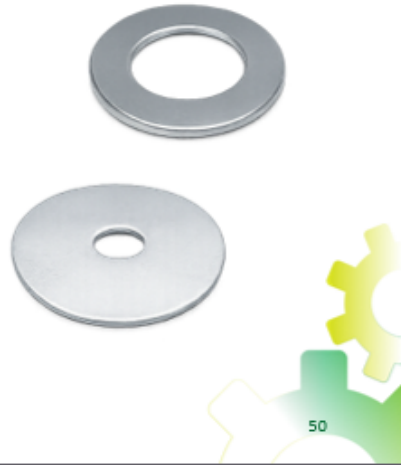
Flat Washers

Flat Washers

- Evenly distribute the load beyond the diameter of the bolt head
- Prevents bolt from slipping through hole

Fender Washer

- An oversized flat washer
- Distributes load even further
- Good for soft materials



Notes:

- **Flat washers** are the most commonly used type of washer.
 - Their primary purpose is to **distribute the clamping force** over a larger surface area, helping protect the material being fastened and creating a more secure connection.
 - Flat washers can also help prevent the bolt or nut from pulling through oversized or worn holes, especially when fastening thinner materials.
- **Fender washers** are a type of flat washer with a much larger outside diameter. The larger surface area distributes the load even farther than a standard flat washer.
 - Because they spread the force over a wider area, fender washers are commonly used with **soft or thin materials**, such as sheet metal, plastic, fiberglass, or wood, where additional support is needed.
 - Selecting the appropriate washer helps improve the strength, durability, and reliability of the fastened joint.

Split Lock Washers

- Helical shape helps maintain tension in a fastened joint
- Helps resist loosening caused by vibration
- Helps maintain clamping force during minor thermal expansion and contraction



Notes:

- Split lock washers have a unique helical shape that acts like a spring when compressed between the bolt head or nut and the material being fastened.
 - As the bolt is tightened, the washer helps maintain tension in the joint, making it more resistant to loosening.
 - Split lock washers are commonly used in applications where vibration could cause a bolt or nut to gradually back off over time.
 - They can also help maintain clamping force when materials expand and contract due to normal temperature changes.
 - While split lock washers can improve the reliability of a fastened joint, they should always be used in accordance with the manufacturer's specifications and are not a substitute for proper bolt torque.
-
-
-
-
-

Star Washers

- Also known as serrated or toothed washers.
- Toothed edges increase grip by biting into the mating surface.
- Help resist loosening caused by vibration.
- Available with internal or external teeth.



Notes:

- Star washers are another type of lock washer designed to help resist fastener loosening caused by vibration.
 - They're also commonly referred to as **serrated washers** or **toothed washers** because of the teeth around their edge.
 - As the bolt or nut is tightened, the teeth bite into the mating surface. This increases friction and grip, helping the fastener resist loosening during normal operation.
 - Star washers are available with either **internal teeth**, which are located around the inside diameter of the washer, or **external teeth**, which extend around the outside edge.
 - The choice between internal and external teeth depends on the application, the amount of gripping force needed, and whether the washer should remain less visible after installation.
-
-
-
-
-

Nord-Lock Washers

- Also known as serrated or toothed washers.
- Toothed edges increase grip by biting into the mating surface.
- Help resist loosening caused by vibration.
- Available with internal or external teeth.



Notes:

- Nord-Lock washers are designed for applications where vibration, dynamic loads, or movement could cause a bolted joint to loosen.
- Unlike traditional lock washers, Nord-Lock washers help maintain the tension in the bolted joint rather than relying only on friction to keep the fastener secure.
- The system consists of **two washers** that are used together. One side of each washer has **cams**, while the opposite side has **radial teeth**.
- When the bolt is tightened, the radial teeth grip the mating surfaces while the cams work together to help maintain bolt tension if the joint begins to loosen.
- Because they are highly effective in demanding environments, Nord-Lock washers are commonly used in heavy equipment, rail applications, and other industries where maintaining a secure bolted joint is critical.

As we review this section, please take a look at these **washers** as they are passed around the room.



Notes:

- Next, let's talk about a variety of retaining hardware and hardware securement options.
- While you review, take a look at the washers being passed around the room.

Hardware Securement: **Cotter Pins**

- Used with a castellated nut and a drilled bolt or shaft
- Inserted through the nut slots and the hole in the bolt or shaft
- Ends are bent to create a secure mechanical lock
- Helps prevent the nut from loosening in critical applications.



Notes:

- **Cotter pins** are used in applications where a nut coming loose could create a serious safety hazard.
- They're typically used with a **castellated nut** and a bolt or threaded shaft that has a hole drilled through it.
- After the nut is tightened, the cotter pin is inserted through the slots in the nut and the hole in the bolt or shaft.
- The ends of the cotter pin are then bent in opposite directions to create a simple mechanical locking system that helps keep the nut from rotating or backing off.
- A **hair-pin cotter** does not require a bending tool and uses a spring tension design for fast, tool-free removal and reuse.
- Cotter pins are inexpensive, reliable, and commonly found on components such as tie rod ends, wheel spindles, axles, and other safety-critical mechanical assemblies.

Hardware Securement: Safety Wire

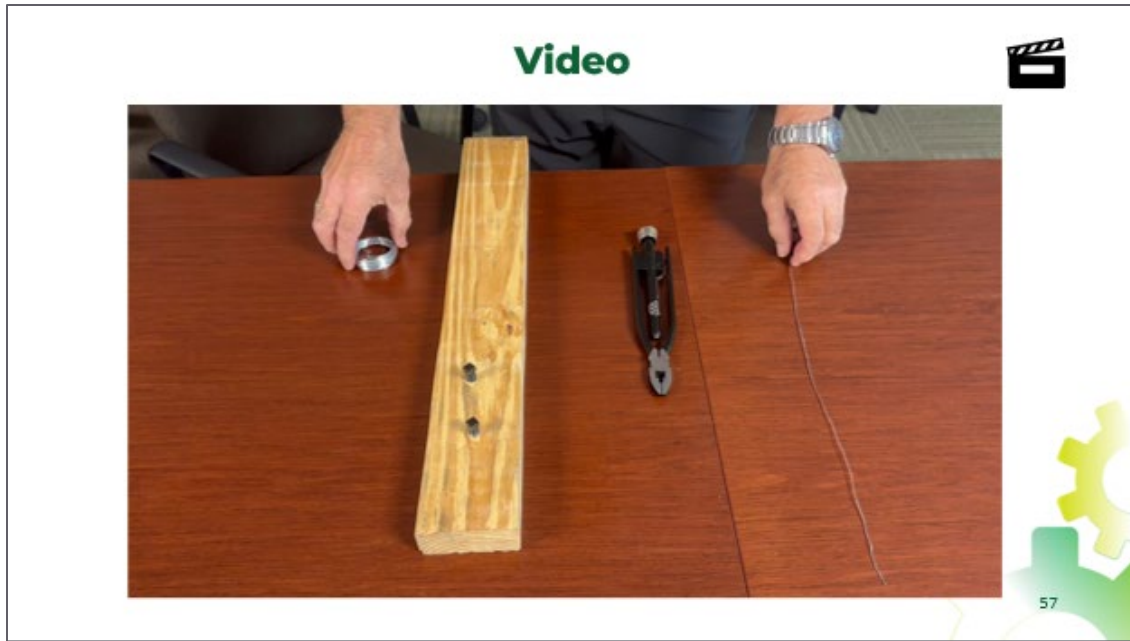
- Used to help prevent fasteners from loosening in safety-critical applications
- Installed through a pre-drilled hole in a bolt or nut
- Twisted wire creates a secondary mechanical restraint
- Commonly used where vibration is expected.



56

Notes:

- Safety wire is another method of preventing fasteners from loosening in critical applications.
 - Instead of relying on friction or spring tension, safety wire creates a physical restraint that helps prevent the bolt or nut from rotating.
 - The wire is threaded through a pre-drilled hole in the bolt head or nut and then twisted securely before being anchored to another fastener or a fixed point.
 - If the fastener begins to rotate, the wire immediately resists that movement, helping keep the assembly secure.
 - Safety wire is commonly used in aviation, motorsports, heavy equipment, and other industries where fastener failure could have serious consequences.
-
-
-
-
-



Notes:

- In this video, we'll see how safety wire is installed.

Hardware Securement: Thread Locker

- Liquid adhesive applied to fastener threads before assembly
- Hardens after installation to help resist loosening
- Available in different strength grades identified by color
- Cure time ranges from 10 minutes to 24 hours, depending on the product.



Loctite Grade	Fastener Size	Breakaway Torque (lb-in)	Prevail Torque (lb-in)	Cure Time (min)	Temperature (°C)
LOCTITE 222	1/4"	6/3	150°C	10	VERY EASY
LOCTITE 242	1/4"	17/8.8	150°C	10	STANDARD
LOCTITE 243	1/4"	20/7	180°C	10	STANDARD
LOCTITE 290	1/4"	10/29	150°C	10	STANDARD

Notes:

- Thread locker is a liquid adhesive that's applied to the threads of bolts, screws, and other threaded fasteners before assembly.
- After the fastener is installed, the material cures and hardens, helping resist loosening caused by vibration while also sealing the threads against moisture and corrosion.
- **Loctite®** is one of the best-known brands of thread locker, and the brand name is often used generically throughout the industry to describe thread-locking compounds.
- Thread lockers are available in several strength grades. Keep in mind that the **color of the bottle or tube does not always indicate the color or strength of the thread locker inside**, so always verify the product number and specifications before use.
- Depending on the product, curing can take anywhere from about **10 minutes to 24 hours**.
- The chart on this slide shows how thread locker strength affects the torque required to loosen a fastener after it has cured. It lists the fastener size, the **breakaway torque** required to start loosening the fastener, and the **prevail torque** required to continue turning it after it begins to move.
- **Transition:** Cotter pins, safety wire, and thread lockers are all examples of secondary retention methods that help keep critical fasteners secure in demanding operating conditions.

Retaining Hardware

- Holds components together when nuts and bolts are not practical
- Often allows parts to rotate or pivot while secured
- Uses spring tension, grooves, or locking features
- Common types include: Spring Clips, C-Clips (E-Clips), Snap Rings, Staples



Notes:

- **Retaining hardware** serves a different purpose than threaded fasteners.
 - Instead of clamping two parts together with a bolt and nut, retaining hardware keeps components from sliding apart while still allowing movement when needed.
 - Many retaining devices rely on spring tension, grooves, or specially designed locking features to hold components securely in place.
 - You'll commonly find retaining hardware in bearings, shafts, wheels, linkages, and other assemblies where components need to rotate or pivot.
 - Throughout this section, you'll look at several common types of retaining hardware and discuss where each is used.
-
-
-
-
-

Spring Clips

- Broad family of retaining hardware
- Bent metal fasteners with spring tension
- Holds components without threaded fasteners
- Common applications include:
 - Hoses
 - Body panels
 - Upholstery



Notes:

- **Spring clips** are not one specific fastener—they're a broad family of retaining hardware designed for different applications.
- They're made from spring steel and use the natural spring force of the metal to grip or retain a component.
- You'll commonly find them securing hoses, body panels, trim pieces, upholstery, wiring, and other components that may need to be removed for maintenance.
- Spring clips provide a simple, reliable fastening method without requiring threads, nuts, or bolts.

C-Clip/E-Clip

- A specialized Spring Clip that snaps into a groove on a shaft
- Compact design for limited-space applications
- Allows parts to rotate or pivot while remaining retained
- Installed and removed using retaining clip pliers



Notes:

- One specialized type of spring clip is the C-clip, which is designed to retain parts on a shaft.
 - **C-clips**, often called **E-clips** because of their shape, are designed to snap into a groove machined into a shaft.
 - Once installed, they prevent components from sliding off the shaft while still allowing them to rotate or pivot freely.
 - Their compact design makes them a good choice when space is limited, and a low-profile retaining device is needed.
 - Because they're spring-loaded, special retaining clip pliers or removal tools are typically used to install and remove them safely.
 - You'll commonly find C-clips on linkages, control mechanisms, and other assemblies where lightweight component retention is required.
-
-
-
-
-

Snap Ring

- Designed for higher-load retaining applications
- Installed in grooves on shafts or inside housings
- Available as internal or external snap rings
- Installed and removed using snap ring pliers



Notes:

- **Snap rings** perform the same basic function as C-clips by preventing components from sliding off a shaft or out of a housing.
 - However, they're generally used in applications that require greater holding strength or where more space is available for installation.
 - Snap rings are available in two common styles. **External snap rings** fit into grooves on the outside of a shaft, while **internal snap rings** fit into grooves inside a bore or housing.
 - Like C-clips, they're installed and removed with special snap ring pliers designed to safely expand or compress the ring.
 - You'll commonly find snap rings in bearings, transmissions, gearboxes, electric motors, and axle assemblies where reliable component retention is essential.
 - We've now covered several common types of retaining hardware. Next, we'll look at staples and other specialized fastening components used in mechanical applications.
-
-
-
-
-

Staples

- U-shaped fasteners with squared corners
- Driven into materials using a staple gun
- Available in various sizes, lengths, and wire gauges
- Commonly used to secure non-structural materials, such as upholstery, fabric, insulation, and trim



Notes:

- Most people are familiar with staples from office staplers, but mechanical staples are much larger and stronger.
 - A staple is a thin piece of metal bent into a **U-shape** with pointed legs that are driven into a material to hold it securely in place.
 - Staples are available in a variety of sizes, lengths, and wire gauges to match different materials and applications.
 - They're commonly used to attach upholstery, carpeting, insulation, fabric, and other non-structural materials to wood or composite surfaces.
 - A **staple gun** drives the staple into the material with enough force to securely anchor it. Staple guns may be manual, electric, battery-powered, or pneumatic, depending on the application.
 - Although staples are quick and effective for securing lightweight materials, they are **not intended for structural or load-bearing applications**.
-
-
-
-
-

Knowledge Check



What is the primary purpose of a flat washer?

(A). To permanently lock a bolt in place

(B). To distribute the clamping force over a larger surface area

(C). To increase the length of the bolt

(D). To replace a lock nut and increase tension

64

Knowledge Check



Which type of retaining hardware is installed in a groove on a shaft to keep a component from sliding off while still allowing it to rotate?

(A). Spring Clip

(B). Staple

(C). C-Clip

(D). Split-Lock Washer

65

Knowledge Check



A mechanic is replacing a fastener on equipment that is regularly exposed to rain and road salt. Which fastener material would be the best choice?

(A). Plain Carbon Steel

(B). Magnesium

(C). Stainless Steel

(D). Copper

66

Knowledge Check



A mechanic needs to secure vehicle upholstery to a wooden seat frame. Which fastener is the best choice?

(A). Snap Ring

(B). Thread Locker

(C). Star Washer

(D). Staple

67

Summary and What's Next

- **Washers** improve fastener performance by distributing load and helping resist loosening.
- **Retaining hardware** secures components while allowing movement when needed.
- **Staples** provide a quick method for fastening non-structural materials.
- Selecting the appropriate hardware improves the safety, reliability, and performance of a mechanical assembly.

Next, we'll explore fastener applications in transit maintenance.

68

Notes:

- *What are the most important things you learned from this section?*
 - You explored several types of hardware that support or enhance traditional fasteners.
 - You learned that washers perform a variety of functions, including distributing clamping force, helping resist loosening, and maintaining bolt tension in demanding applications.
 - You discussed retaining hardware, such as spring clips, C-clips, snap rings, cotter pins, safety wire, and thread lockers, which are used to keep components securely in place when threaded fasteners alone aren't sufficient.
 - Finally, you looked at staples, which provide a quick and effective method for attaching non-structural materials like upholstery, insulation, and trim.
 - One of the key takeaways from this section is that **the right hardware depends on the application**. Understanding the purpose of each component helps ensure fasteners remain secure, reliable, and easy to maintain. Next, let's take a look at how fasteners are used specifically in transit maintenance.
-
-
-
-
-



Notes:

- This section examines the role of fasteners in transit vehicle maintenance.

Common Fasteners and Their Use

Fastener	Purpose	Example
Screw	Join parts	Secure interior panels
Nut & Bolt	Clamp components	Secure flooring, brackets, and equipment (e.g., heat exchangers)
Washer	Distribute load	Distribute load in wheel assemblies
Cotter Pin	Prevent nut rotation	Lock tie rod ends and axle components
Spring Clip	Retain components	Secure fuel lines and wiring
E-Clip	Retain shafts/pins	Retain door linkage and pivot pins

70

Notes:

- This table brings together some common examples and shows where you might encounter them in bus and rail maintenance.
- Note that there isn't a single fastener that's used for every job. Each application has its own requirements based on factors like strength, vibration, movement, accessibility, and the materials being joined.
- For example, you may remove **screws** to access interior panels during routine inspections, replace **nuts and bolts** when installing flooring or mounting equipment, or work with **washers** anytime a bolted connection requires proper load distribution.
- You'll also encounter retaining hardware during maintenance tasks. **Cotter pins** are commonly found on steering and axle components, **spring clips** are used to secure fuel lines and wiring, and **E-clips** are often used to retain door linkage and other pivoting components.
- As you gain experience in the shop, you'll begin to recognize these fasteners and understand why each one was selected for a particular application.

Selecting the Right Fastener

- Selecting the correct fastener helps ensure a safe, reliable, and long-lasting repair.
- Consider the following when choosing a fastener:
 - Strength
 - Torque Requirements
 - Thread Locker
 - Replacement Options



Notes:

- Choosing the right fastener is just as important as installing it correctly.
- Using the wrong fastener can lead to premature wear, corrosion, loose components, or even mechanical failure.
- When selecting a fastener, first consider **its strength**. Using a lower-grade fastener than specified can cause it to break under load.
- Next, think about **material compatibility**. Some metals react with one another and can accelerate corrosion, while others may not provide the durability needed for the environment.
- It's also important to understand the **torque requirements** for the fastener. Some fasteners are designed to be tightened to a specific torque, while others may have torque-to-yield specifications that require replacement after removal.
- If a **thread-locking** compound is required, select the correct strength for the application. Keep in mind that some thread lockers are designed to be removable, while others create a much more permanent bond.
- Finally, if the original fastener is unavailable, only use an approved **replacement** or alternative that meets the manufacturer's requirements. Substituting the wrong fastener can compromise the safety and reliability of the repair.

Fastener Identification



Directions – Label the following fasteners using the word bank below.

Try to complete this activity without looking back at your notes.

Activity

Fastener Identification

Directions: Label the following fasteners using the word bank below.

Word Bank		
• Flat Washer	• Cotter Pin	• Turn Screw
• Bolt	• Hex Nut	• Snap Ring
• Lock Washer	• Lock Washer Nut	
• Plug-in Nut	• Self-Locking Nut	

1.  _____

2.  _____

3.  _____

4.  _____

5.  _____

6.  _____

7.  _____

8.  _____

9.  _____

10.  _____

© 2026 Transit Workforce Center - Pg. 1



Activity

Fastener Identification

Directions – Label the following fasteners using the word bank below.

Word Bank

- Flat Washer
- Bolt
- Anti-Tamper Screw
- Phillips Head Screw
- Cotter Pin
- Hex Nut
- Castellated Nut
- Self-Drilling Screw
- Torx Screw
- Snap Ring



1. _____



2. _____



3. _____



4. _____



5. _____



6. _____



7. _____



8. _____



9. _____



10. _____

Fastener Identification





1.)



2.)



3.)



4.)



5.)

73

Fastener Identification





6.)



7.)



8.)



9



10.

74

Knowledge Check



A transit mechanic is reinstalling an interior access panel after performing routine maintenance. Which fastener is most commonly used for this application?

(A). Machine Screw

(B). Spring Pin

(C). Cotter Pin

(D). Snap Ring

75

Knowledge Check



During an inspection, a mechanic removes a cotter pin from a tie rod end to replace the steering component. Why is the cotter pin used in this application?

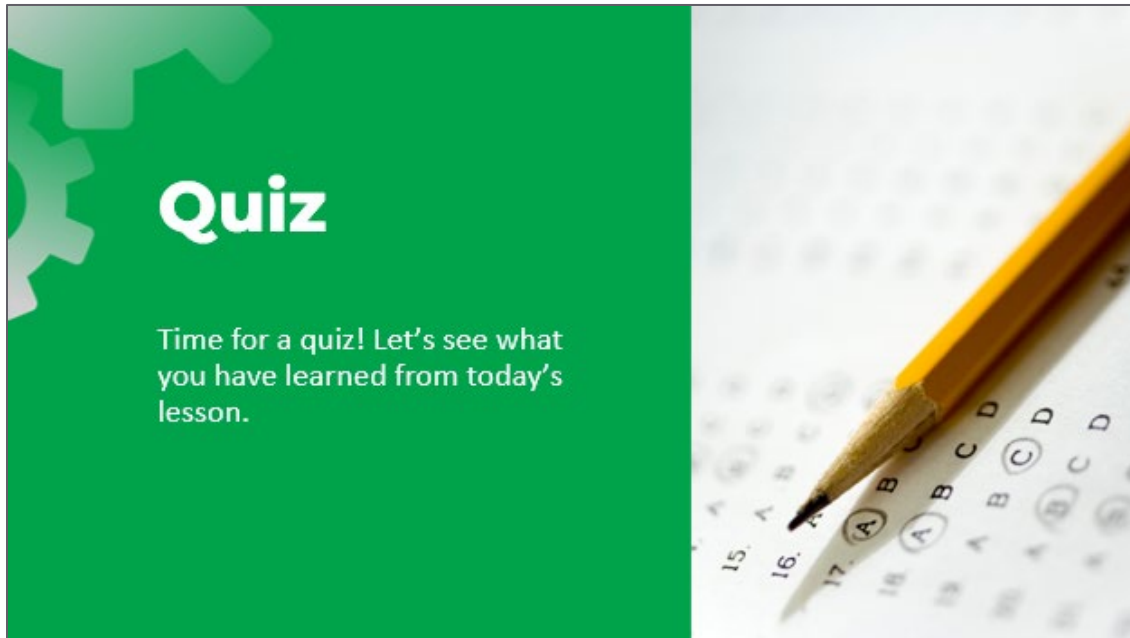
(A). To distribute the load across the joint

(B). To increase the bolt's strength

(C). To prevent the castellated nut from loosening or rotating

(D). To seal the threads from moisture

76



Notes:

- Time for a quiz! Let's see what you have retained from today's lesson.

Revisiting Objectives

- Identify the various types of fasteners and explain their purpose, including screws, nuts, bolts, washers, staples, retaining hardware, and miscellaneous hardware.
- Explain the advantages and disadvantages of fastener materials.
- Recognize common applications for fasteners.

78

Notes:

- If you were explaining today's objectives to someone else, how would you summarize what they mean and why they matter?
- Which of today's objectives do you feel most confident about? Which were most challenging?
 - Explain your reasoning.
- Can you give an example of how you could apply one of today's objectives in a real-world situation?
