MAC-111, Machining Technology I

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Orientation and Introduction

Introduction

Concept Content:

In this section you will give an introduction of yourself to your class. This is an opportunity to state your relevant experiences and credentials to teach this subject along with your personal background. This can help connecting with students. You can make a video introduction and upload it to this page as well.

Also, this is where you will give a brief overview of the course and what it's contents will be. There is a section later on in this module where you will give more detail about the course.

Course Syllabus

Concept Content:

This is where you will upload the syllabus. You can do this either by uploading the syllabus text here or you can upload a copy of the syllabus under the resources tab for this section. If you do upload it to the resources, please be sure to give instructions to your students to look for the syllabus there.

Course Resources

Concept Content:

This is where you would outline student support resources such as tutoring services, listing your office ours, contact info for support for your college's learning management system, etc. If there are documents you wish to upload, be sure to upload them to the resources tab and give instructions for the students to find the documents there.

Course Overview

Concept Goals:

Student Learning Outcomes:

1. Understand and utilize basic safety protocols in the machine shop such as proper use of personal protective equipment, and other guides to OSHA standards.

2. Know how to use machining tools such as drill machines, saws, bench grinders, etc.

3. Understand the basics of how to set up and run a milling machine and a lathe machine.

4. Understand precision measurement and use of basic measuring tools such as rulers, micrometers, calipers, etc.

Concept Content:

This course provides additional instruction and practice in the use of precision measuring tools, lathes, milling machines, and grinders. Emphasis is placed on setup and operation of machine tools including the selection and use of work holding devices, speeds, feeds, cutting tools, and coolants. Upon completion, students should be able to perform basic procedures on precision grinders and advanced operations of measuring, layout, drilling, sawing, turning, and milling.

Module	**Module Learning Objectives**
Module 1 - Week 1 - Safety	• Describe the hazards of a bandsaw (SLO 1, SLO 2) • List the proper safety precautions needed when using a bandsaw (SLO 1, SLO 2) • List and describe different types of personal protective equipment and their functions (SLO 1) • Describe methods of proper hand tool care (SLO 1, SLO 2)
Module 1 - Week 2 - Measurement	• Understand how to read a ruler (SLO 4) • Accurately measure lengths using dial calipers and micrometers (SLO 4) • Add, subtract, and reduce fractions (SLO 4)
Module 1 - Week 3 - Saws and Drills	• Observe proper safety practices with saws and drills (SLO 1) • List the different parts of a band saw (SLO 2) • List the different accessories and cutting tools used with a drill press (SLO 2)
Module 1 - Week 4 - Cutting Speeds, RPM Calculations, and Machine Formulas	• Calculate speeds and feeds accurately (SLO 3) • Calculate RPM needed for milling/lathe operations accurately (SLO 3)

Module 1 - Week 5 - Overview of Milling Machines	• Properly identify the components of a milling machine (SLO 3) • Properly identify machining accessories (SLO 3) • Define how drilling, tapping, and boring works (SLO 3)
Module 1 - Week 6 - Overview of Lathes	• Correctly identify parts of a lathe machine (SLO 3) • Correctly define/describe basic lathe operations (SLO 3) • Understand basics of thread cutting (SLO 3)
Unit 2 - Week 7 - Mid-Term	• Demonstrate an understanding of this week's material
Module 3 - Week 8 - Projects & Turning Tapers	• Utilize milling and lathe machines to create basic projects (SLO 3)
Module 3 - Week 9 - Projects	• Utilize milling and lathe machines to create basic projects (SLO 3)
Module 3 - Week 10 - Projects	• Utilize milling and lathe machines to create basic projects (SLO 3)
Module 3 - Week 11 - Projects	• Utilize milling and lathe machines to create basic projects (SLO 3)
Module 3 - Week 12 - Projects	• Utilize milling and lathe machines to create basic projects (SLO 3)
Module 3 - Week 13 - Projects	• Utilize milling and lathe machines to create basic projects (SLO 3)
Module 3 - Week 14 - Projects	• Utilize milling and lathe machines to create basic projects (SLO 3)
Module 4 - Week 15 - Final Exam	• Demonstrate understanding of course material

Instructor Note: This is a 15 week course. If you need a 16th week due to your semesters being 16 weeks, you may have to create a 16th week.

Notes/Helpful Tips

Next Steps...

Your Census assignments are REQUIRED in order to remain in the class and they MUST be completed prior to the Census Date **[insert census date here]**. **If you do not have a census date requirement, you can delete this section.**

Effective note taking is also important for not only this course, but for your career as well. Note taking is a great way to retain information. The process of taking notes can keep you alert and focused on the information being presented. It also keeps your mind engaged with what you are hearing, increasing the likelihood you will retain that information. Note taking can also allow you to better organize your thoughts on the information being discussed.

Here is a video that provides some tips for effective note taking.

Unit 1 - Introduction to the Course (Weeks 1-6)

Week 1 - Safety

Concept Goals:

By the end of this week, you should:

- Describe the hazards of a bandsaw (SLO 1, SLO 2)
- List the proper safety precautions needed when using a bandsaw (SLO 1, SLO 2)
- List and describe different types of personal protective equipment and their functions (SLO 1)
- Describe methods of proper hand tool care (SLO 1, SLO 2)

Concept Content:

Welcome to MAC-111! We will start our introduction section with an overview of shop safety. We will cover proper use of hand tools, band saw safety, and personal protective equipment (PPE).

This week's material:

Reading:

Embedded Below

Videos:

Embedded Below

Assignment:

Week 1 Quiz - Located under the assignments tab - 10 Questions

Band Saw

Woodworking Machine Band Saw

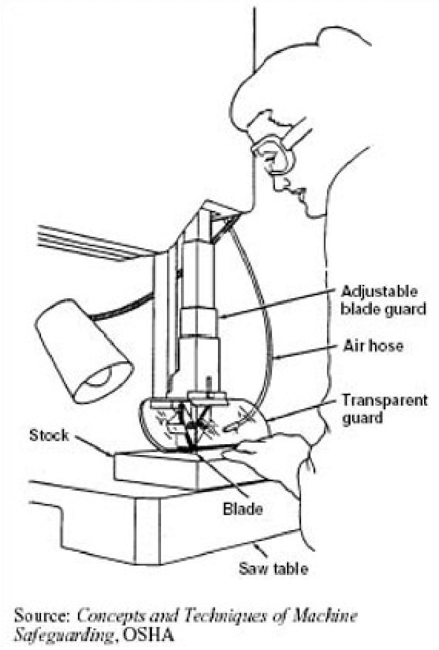


figure: Woodworking Machine Band Saw A

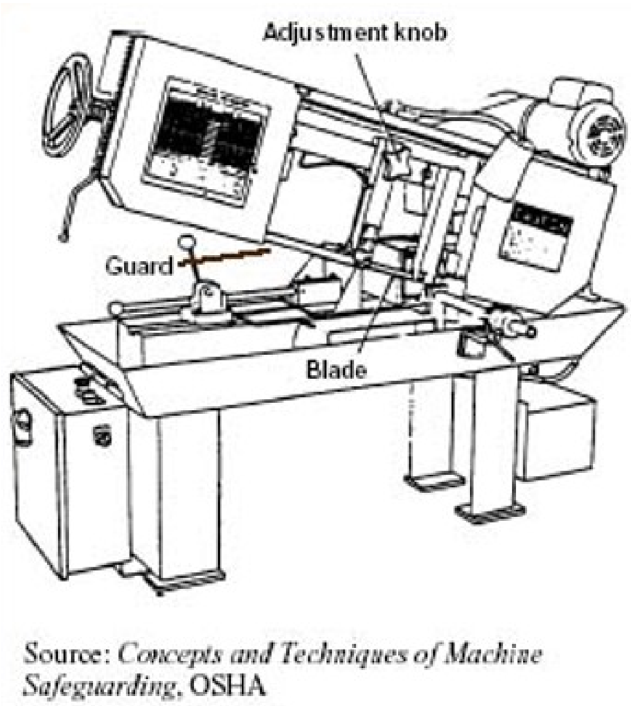


figure: Woodworking Machine Band Saw B

Bandsaw Safety Lesson (CC)

Video Link: https://www.youtube.com/embed/_fJv2f6-014
https://www.youtube.com/watch?v=_fJv2f6-014

Band Saw Hazards

- POO - contact with blade
- Nip points at the rollers and pulleys
- Kickback – less likely than with a table saw
- Chips and broken teeth
- Power transmission hazards

Band Saw Case Histories

…The guard on the band saw was approximately 1.50 ins. above the meat being cut. The engineered pusher plate was not being used by Employee #1, when he was slicing the short ends of the meat. The meat slipped, causing Employee #1's left index finger to make contact with the cutting edge of the band saw blade. This resulted in a partial amputation of his finger. Employee #1 was not hospitalized.

On August 16, 2013, Employee #1 was operating a McNeil Femco band saw to cut six pieces of foam approximately 21 in. by 21 in. for a customer. This customer was yelling and distracting the employee. As a result, the employee turned around towards the customer and the employee's hand made contact with the running blade. Employee #1 stated that approximately 7 in. of the blade was exposed. A coworker called paramedics and the employee was transported to LA County USC Medical Center, where he required surgery for lacerations to his hand. Employee #1 was hospitalized for four days.

Band Saw Controls

- Guard unused portion of blade above and below table
- Adjust the sliding guard
- Assure that blade pulleys are guarded
- Use a blade brake remain at saw until it stops
- Do not reach near blade until stopped
- Make turns by pivoting at blade
- Do not use a wide blade for sharp turns
- Assure proper blade tension
- No loose clothing, jewelry, secure hair
- Eye Protection

Drill Presses

Hazards of Drill Presses

Electric drill presses use a rotating bit to drill or cut holes in wood or metal. The holes may be cut to a desired preset depth or completely through the stock. A basic drill press operation consists of selecting an appropriate drill bit, tightening the bit in the chuck, setting the drill depth, placing the material on the drill press bed, securing the work to the bed so that it will not rotate during drilling, turning the drill press on, and pulling the drill press lever down so that the drill bit will be lowered into the stock. (See Figure 40.)

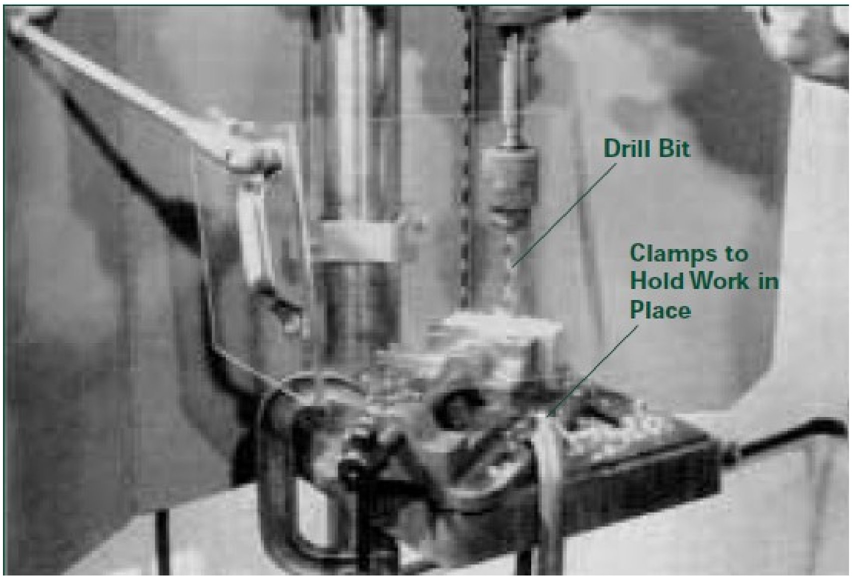


Figure 40 Drill Press with a Transparent Drill Shield

Amputations typically occur when the operator's gloves, loose-fitting clothing, or jewelry become entangled in the rotating drill bit. Here are some other causes of drill press-related amputations:

- Inadequately guarding points of operation or power-transmission (such as belt and pulleys) devices;
- Removing a part from a drill press while wearing gloves;
- Making adjustments to the drill press, such as setting the depth, securing the material to the drill press bed, and repositioning the wood or metal, while the drill bit is still rotating;
- Changing the drill bit with the operating control unprotected so that a falling object or otherwise bumping the switch can accidentally start up the press spindle and tool assembly;
- Performing servicing and maintenance activities, such as changing pulleys and belts, without deenergizing and locking/taging out the drill press.

Case History #20

A mechanic amputated the first joints of his left index and middle fingers while changing the belt position on a multi-pulley drill press. While the mechanic was pulling the belt on, it suddenly went around the outside pulley, pulling the mechanic's fingers through the nip point.

Case History #21

A machinist amputated his left index finger at the first joint while drilling holes in a machined part. As he moved the part to begin drilling another hole, his gloved hand got caught in the drill bit.

Source: OSHA IMIS Accident Investigation Database.

Safeguarding and Other Controls for Drill Presses

For drill presses, you must be protected from the rotating chuck and swarf that is produced by the drill bit. Guarding at the point-of-operation is difficult because of the nature of the drilling press. The following primary safeguarding methods can be installed to guard the operator and other employees from rotating parts, flying chips, and cuttings:

- Specifically designed shields can be attached to the quill and used to guard this area. For example, telescopic shielding that retracts as the drill bit contacts the piece or a more universal-type shield can be applied.
- Automatic machines and high-production machines could have enclosures designed and installed to guard the employee from the entire drilling operation.
- Install guarding over the motor, belts, and pulleys.
- Install an adjustable guard to cover the unused portion of the bit and chuck above the material being worked.

The following are some secondary safeguarding methods, work practices, and complementary equipment that may be used to supplement primary safeguarding or alone or in combination when primary safeguarding methods are not feasible:

- Automatic machines and high-production machines could use barricades to separate the employee from the entire drilling operation.
- Develop and implement safe work (operating) practices, such as removing the chuck immediately after each use, for drill press operations and conduct periodic inspections to ensure compliance.
- Train and supervise all operators until they can work safely on their own.
- Use the drill press only for its intended purposes.
- Instruct employees not to wear gloves, jewelry, or loose-fitting clothing while operating a drill press and to secure long hair in a net or cap.
- Make sure that operators secure material to the drill press bed with clamps (work-holding equipment) before drilling, so that the material will not spin and strike the operator. The operator should not manually secure the work to the drill press bed while drilling holes.
- Do not adjust the drill press while the drill bit is still rotating.
- Replace projecting chucks and set screws with non-projecting safety-bit chucks and set screws.
- Cover operator controls so that the drill press cannot be turned on accidentally.
- Shut off the drill press when not in use or when left unattended for any period of time.
- Perform servicing and maintenance under an energy control program in accordance with the Control of hazardous energy (lockout/tagout), 29 CFR 1910.147, standard.

Minor Servicing

At times, OSHA recognizes that some minor servicing may have to be performed during normal production operations, so a lockout/tagout exception is allowed. See the 29 CFR 1910.147(a)(2)(ii) Note, for details. For example, minor drill press tool changes and adjustments may be performed without lockout/tagout if the machine's electrical disconnect or control (on/off) switches control all the hazardous energy and are: 1) properly designed and applied in accordance with good engineering practice; 2) placed in an off (open) position; and 3) under the exclusive control of the employee performing the minor servicing task.

Source: 29 CFR 1910.147(a)(2)(ii) Note.

Cord- and Plug-connected Electric Equipment

The OSHA LOTO standard would not apply when employees are performing servicing and maintenance work on a cord- and plug-connected drill press if the press is unplugged and the plug is in the exclusive control of the employee performing the task. The employee would be able to control the press from being energized by controlling the attachment plug.

Source: 29 CFR 1910.147(a)(2)(ii)(A).

Applicable Standards

- 29 CFR 1910.147, Control of hazardous energy (lockout/tagout).
- 29 CFR 1910.212, General requirements for all machines.
- 29 CFR 1910.213, Woodworking machinery requirements.
- 29 CFR 1910.219, Mechanical power-transmission apparatus.

Sources of Additional Information

  - OSHA Publication 3067, Concepts and Techniques of Machine Safeguarding (http://www.osha.gov/Publications/Mach_Safeguard/toc.html)
  - OSHA Machine Guarding eTool (http://www.osha.gov/SLTC/etools/machineguarding/index.html)
  - OSHA Lockout/Tagout Interactive Training Program (http://www.osha.gov/dts/osta/lototraining/index.htm)
  - OSHA Publication 3157, A Guide for Protecting Workers from Woodworking Hazards (http://www.osha.gov/Publication/osha3157.pdf
  - ANSI B11.8-2001, Safety Requirements for Manual Milling, Drilling and Boring Machines with or without Automatic Control

- ANSI O1.1-2004, Safety Requirements for Woodworking Machinery

figure: "Sparks fly in 19th Civil Engineer Squadron [Image 8 of 12]" by DVIDSHUB is licensed under CC BY 2.0.

1910.133

Employers must provide eye protection for employees whenever they are exposed to potential eye injuries during their work if engineering or work practice controls do not eliminate the risk of injury.

Eye and face PPE purchased after July 5, 1994 must comply with ANSI Z87.1-1989, American National Standard Practice for Occupational and Educational Eye and Face Protection, and must be distinctly marked to facilitate identification of the manufacturer.

What are some of the causes of eye injuries?

- Dust and other flying particles, such as metal shavings or sawdust
- Molten metal that might splash
- Acids and other caustic liquid chemicals that might splash
- Blood and other potentially infectious body fluids that might splash, spray, or splatter
- Intense light such as that created by welding and lasers

Safety Spectacles

- Made with metal/plastic safety frames
- Most operations require side shields

- Used for moderate impact from particles produced by such jobs as carpentry, woodworking, grinding, and scaling

figure: "Safety Eyewear" by DJSparky is licensed under CC BY-SA 4.0.

Goggles

- Protect eyes, eye sockets, and the facial area immediately surrounding the eyes from impact, dust, and splashes
- Some goggles fit over corrective lenses
- Corrective lenses include contacts and glasses.

figure: "Neiko 53829A Lab Safety Goggles, Impact and Chemical Splash Resistant | Indirect Ventilation, Polycarbonate Lens, ANSI Z87.1" by shop8447 is marked with CC0 1.0.

Welding Shields

Protect eyes from burns caused by infrared or intense radiant light, and protect face and eyes from flying sparks, metal spatter, and slag chips produced during welding, brazing, soldering, and cutting

figure: "130829-N-GM561-132" by SurfaceWarriors is licensed under CC BY-SA 2.0.

1910.133(a)(5)

Also see 1910 Subpart Q, Welding, Cutting & Brazing.

Laser Safety Goggles

Protect eyes from intense concentrations of light produced by lasers.

figure: Laser Safety Goggles

Face Shields

- Protect the face from nuisance dusts and potential splashes or sprays of hazardous liquids
- Do not protect employees from impact hazards

figure: Face Shield

figure: Foot Protection

1910.136

Safety footwear must meet the minimum compression and impact performance standards and testing requirements established by ANSI Z41-1991, if purchased after July 5, 1994. Protective footwear purchased before that date must comply with ANSI Z41-1967.

What are some of the causes of foot injuries?

- Heavy objects such as barrels or tools that might roll onto or fall on employees' feet
- Sharp objects such as nails or spikes that might pierce the soles or uppers of ordinary shoes
- Molten metal that might splash on feet
- Hot or wet surfaces
- Slippery surfaces

Safety Shoes

- Have impact-resistant toes and heat-resistant soles that protect against hot surfaces common in roofing, paving, and hot metal industries
- Some have metal insoles to protect against puncture wounds
- May be designed to be electrically conductive for use in explosive atmospheres, or nonconductive to protect from workplace electrical hazards

figure: Safety Shoes

Conductive Shoes

Electrically conductive shoes protect against the buildup of static electricity. Essentially, these shoes ground the employees wearing them.

Employees working in explosive and hazardous locations such as explosives manufacturing facilities or grain elevators must wear conductive shoes to reduce the risk of static electricity buildup on an employee's body that could produce a spark and cause an explosion or fire. During training, employees must be instructed not to use foot powder or wear socks made of silk, wool, or nylon with conductive shoes. Foot powder insulates and retards the conductive ability of the shoes. Silk, wool, and nylon produce static electricity.

Conductive shoes are not general-purpose shoes and must be removed upon completion of the tasks for which they are required. Employees exposed to electrical hazards must NEVER wear conductive shoes.

Electrical Hazard, Safety-Toe Shoes

Electrical hazard, safety-toe shoes are nonconductive and will prevent your employee's feet from completing an electrical circuit to ground.

They can protect employees against open circuits of up to 600 volts in dry conditions. These shoes should be used in conjunction with other insulating equipment and precautions to reduce or eliminate the potential for providing a path for hazardous electrical energy. NOTE:

Nonconductive footwear must not be used in explosive or hazardous locations; in such locations, electrically conductive shoes are required.

Metatarsal Guards

A part of the shoes or strapped to the outside of shoes to protect the instep from impact and compression

figure: "File:Nitti MetatarsalGuard.jpg" by Sebastien.bruggeman is marked with CC0 1.0.

Using tools for their intended purpose cuts down on workplace accidents.   Following a few additional safety guidelines also keeps you safe when working with hand tools and cutting tools.

No matter which manufacturing subindustry you work in, more than likely your job involves working with tools. Whenever you work with hand and cutting tools, you need to follow certain safety guidelines to avoid workplace accidents.

What Is a Tool?

A tool is a handheld or power device used to perform one task at a time.

Tools fall into two categories:

- Hand tools
- Power tools

Hand tools are powered manually, while power tools are driven by a power source. Each hand and power tool has a specific use.

Cutting tools may be either a hand tool or a power tool.

- Equipment is not the same thing as a tool. Unlike a tool, a piece of equipment performs more than one operation at a time.

Hand Tools

Hand tools are tools that are powered manually, such as pliers, wrenches, and hammers.

Hand tools aren't limited to the workplace. In fact, you probably have a few hand tools around your home.

Hundreds of different types of hand tools exist. Some tools that are common in the workplace include

- Files
- Hammers
- Pliers
- Saws
- Screwdrivers
- Wrenches

Common Tool Injuries

Certain injuries are common when working with hand and power tools:

- Electric shock
- Flash burns
- Falls
- Hand and eye injuries
- Hearing loss
- Crushing, cuts, or loss of body part
- Ergonomic injuries

Employers must provide you with PPE if you're exposed to the following hazards when working with hand and power tools:

- Falling, flying, abrasive, or splashing objects
- Harmful dusts, fumes, mists, vapors, or gases

Hand Tool Hazards

You can avoid many workplace accidents simply by using hand tools as they're intended and performing routine maintenance.

The greatest hazards posed by hand tools result from misuse and improper maintenance.

- If you use a chisel as a screwdriver, the chisel’s tip may break and fly off, hitting you or your coworkers.

Basic Tool Safety Rules

To avoid injury, you must handle tools properly. These basic rules help prevent hazards associated with the use of hand and power tools:

- Keep all tools in good condition with regular maintenance.
- Use the right tool for the job.
- Examine each tool for damage before use; don't use damaged tools.
- Operate tools according to the manufacturer's instructions.
- Properly use appropriate PPE.

Hand Tool Safety Guidelines

Many guidelines for hand tool safety are simply common sense. Keep these safety guidelines in mind as you work with safety tools:

- Make sure that saw blades, knives, and other sharp tools point away from the aisle areas and away from nearby coworkers.
- Keep knives and scissors sharp. Dull tools are more hazardous than sharp ones.
- Remove cracked saw blades from service.
- Don't use wrenches with jaws sprung to the point where slippage occurs.
- Keep impact tools, such as drift pins, wedges, and chisels, free of mushroomed heads.
- Don't use tools with splintered wooden handles.
- Wear proper PPE, such as safety goggles and gloves. The JobHazard Analysis (JHA) determines what the proper PPE is.

- Avoid distractions and focus on the task at hand.
- Only use a tool for its intended purpose.
- Never alter a tool.
- Keep floors clean, dry, and free of debris to prevent slips and trips around dangerous hand tools.
- Use spark-resistant tools when working near explosive items, such as flammable gas, highly volatile liquids, and other substances.

Use Spark-Resistant Tools

If you're working near items that may explode, such as flammable gases, make sure that you use spark-resistant tools that are made of nonferrous metals. (Nonferrous metals don't contain iron.)

Sparks produced by iron and steel hand tools may ignite. Instead, opt for spark-resistant tools made from brass, plastic, aluminum, or wood.

Spark-resistant tools are also called nonsparking and spark-proof and refer to tools made of nonsparking metals, such as brass, bronze, Monel metal (copper-nickel alloy), copper-aluminum alloys (aluminum bronze), copper-beryllium alloys (beryllium bronze), and titanium.

Cutting and Slicing Tools

A cutting tool is any tool that cuts material. It may be either a hand tool or power tool.

Hand tools, such as knives, scissors, box cutters, and razor blades, cut textile fabrics, soft rubber products, and sheet metals.

Power cutting tools, such as saws, cut and shape metal, wood, and plastic.

Cutting Tool Safety Guidelines

Cutting tools cause many cuts and punctures every year. You can avoid many of these accidents by following cutting tool safety guidelines:

- Wear the correct hand protection, such as gloves, to protect against accidental cuts and vibration.
- Ensure that you're using the proper tool based on the material you're working with.
- Understand the correct operation and use of the tool.
- Use only sharp blades and sharp tools that are in good condition.
- Focus on what you're doing.
- Don't try to catch a dropped tool.
- Use paper, not fingers, to test a tool's sharpness.
- Never use a knife as a substitute for other tools, such as a screwdriver or bottle opener.
- Never alter a tool.
- Always follow the tool manufacturer's instructions.
- Never carry a sharp tool in your pocket. Always use a sheath or a tool belt. If you must carry the tool with the blade exposed, then point the sharp end downward, away from your body.
    - You should always use a sheath or a tool belt to carry a sharp tool.
    - If you must carry the tool with the blade exposed, then point the sharp end downward, away from your body.

The Proper Way to Cut

To avoid injury, it's important to cut outward, away from your hand.

- When you work with a cutting tool, remember to start the cut close to your body.
- The cut outwards, away from your body. Make sure to keep your hand away from the cutting area.

Proper Cutting Tool Storage

If you don't store cutting tools properly, injury can result. Fortunately, you can reduce your risk of injury by following a few simple storage guidelines:

- Always put the cutting tool back when you're done using it.
- Never leave a cutting tool on a table, chair, sink, or desk.
- Place the sharp part of the tool in a sheath or cover.
- If you can't store the sharp part in a sheath or cover, place the tool in a toolbox or at the back of a workbench, with the handle facing you.

- If a cutting tool isn’t being used, then it should be stored safely in a drawer, toolbox, or knife rack.

Hand Tool Care and Upkeep

Several hand tool safety guidelines relate to the care and upkeep of your tools. For example, a dull blade is more likely to cause injury than a sharp one.

Before you work with any tool, always inspect it for signs of wear and damage. Don't use

- Knives or scissors with dull blades

- Cracked saw blades
- Wrenches that have jaws sprung to the point that they slip
- Tools with splintered wooden handles
- Impact tools with mushroomed heads
    - You should never use an unsafe hand tool. For example, if a screwdriver has a rounded bit, you should file it, or discard it.

Don't ever use an unsafe hand tool.

How to Maintain Your Tools Video - 3.5 Minutes

Things to remember

- A tool is a handheld or power device used to perform one task at a time.
- Unlike a tool, a piece of equipment performs more than one operation at a time.
- The greatest hazard posed by hand tools results from misuse and improper maintenance.
- Keep all tools in good condition with regular maintenance.
- Use the right tool for the job.
- Examine each tool for damage before use. Don't use damaged tools.
- Operate tools according to the manufacturer's instructions.
- Properly use appropriate PPE.
- Knives and scissors must be sharp; dull tools are more hazardous than sharp ones.
- Don't use wrenches with jaws sprung to the point where slippage occurs.
- Keep impact tools free of mushroomed heads.
- Use spark-resistant tools around flammable substances.
- Cutting tools may be either a hand tool or a power tool.
- Never carry the tool in your pocket. Always use a sheath or a tool belt.
- Don't ever use an unsafe hand tool.

Week 2 - Measurement

Concept Goals:

By the end of this week, you should:

- Understand how to read a ruler (SLO 4)
- Accurately measure lengths using dial calipers and micrometers (SLO 4)
- Add, subtract, and reduce fractions (SLO 4)

Concept Content:

Welcome to week 2! This week we will go over measurements.

This Week's Material:

Reading:

Embedded Below

Video:

Reading the Steel Rule - 7 Minutes - This video does a good job at showcasing the concepts you will read about below.

Exercises:

How to Read a Caliper - Also embedded below

Reading a Micrometer - Also embedded below

Assignment:

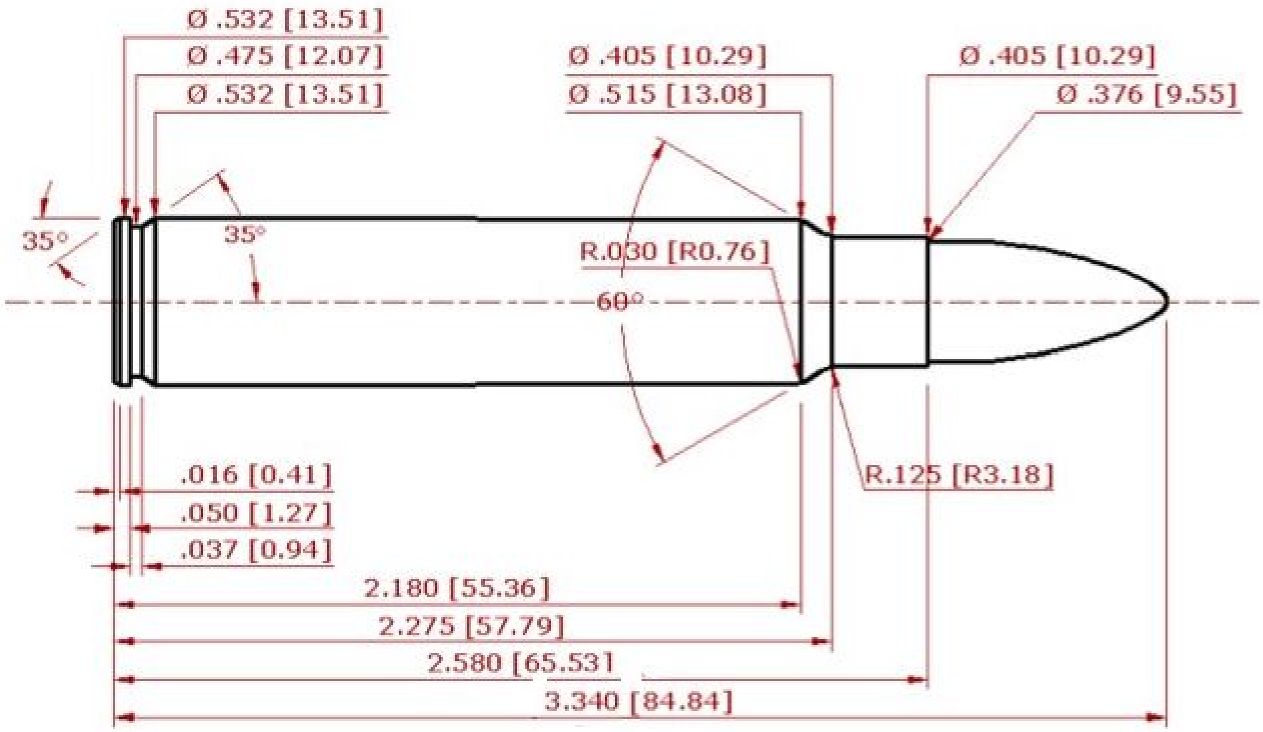
Week 2 Quiz - Located Under Assignments Tab - 10 Questions

Machining and Measurement

- Desired Part – what the customer wants
- Part Features – Determine *function* of the part
- Drawings – Engineer's/Drafter's plan showing part features
- Dimensions – Controls sizes of part features
- Tolerances – Controls deviation from specified dimensions
- Measuring Tools – Must be able to determine whether a dimension meets the specified tolerance.

Try It

How many tools are indicated in the image below?



Correct Answer

\(3.340\pm0.010'' \)

Measurement Systems and Fractions Overview

Measurement Systems

- **English** (inches)
  - Standard in the U.S.
  - Uses fractions and decimals
    - For example: 1/8” or 0.125”
- **Metric/SI** (mm)
  - Global usage, standard for many U.S. trading partners (i.e. you will need to be familiar with it to work at some companies who have international business)
  - Uses decimals only, not fractions
    - For Example 1.75 mm

Fractions

- Part of a whole
- Inches are commonly divided into parts
  - 2, 4, 8, 16, 32, 64
  - For example 5 out of 8 parts is 5/8
- Improper fractions are larger than 1
  - For example: 31/8
  - Always reduce to a mixed number: 31/8 = $3\frac{7}{8}$
- Get to know common conversions to and from decimals
  - For example: 1/8” = 0.125”; 1/16” = 0.0625”
  - Table in textbook (Figure 2.2.1, page 68) or in shop reference (pages 7 – 8)

Working with Fractions

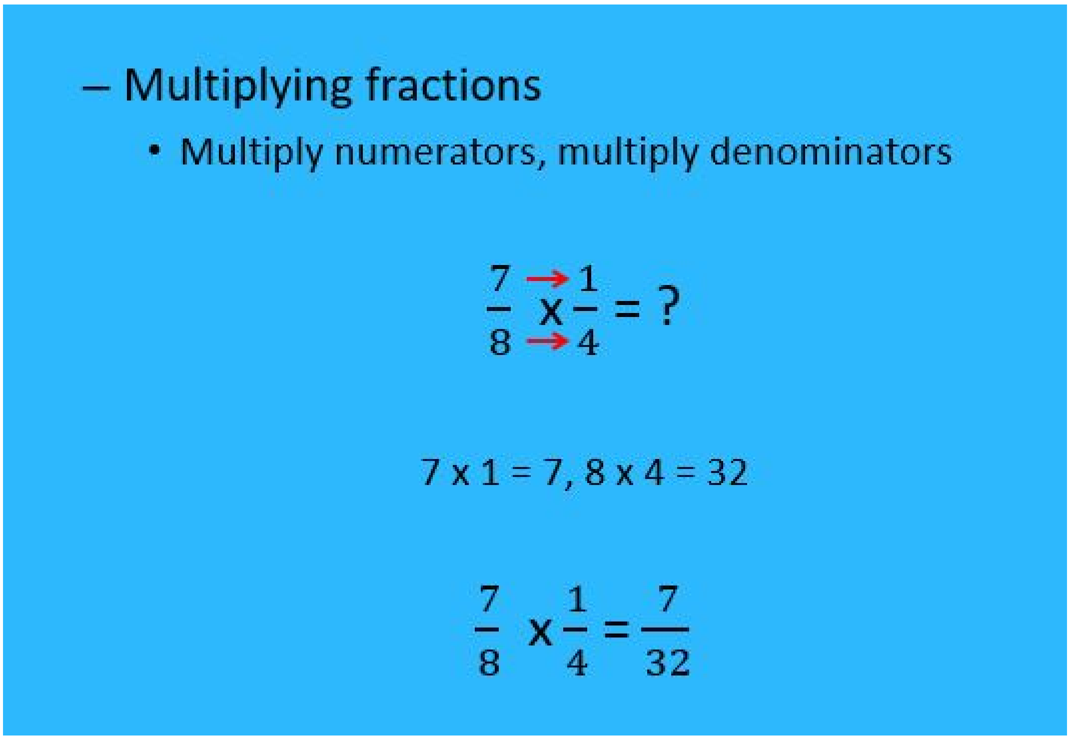
- Comparing fractions
  - Convert to the same denominator (equivalents) then compare numerators to determine relative size

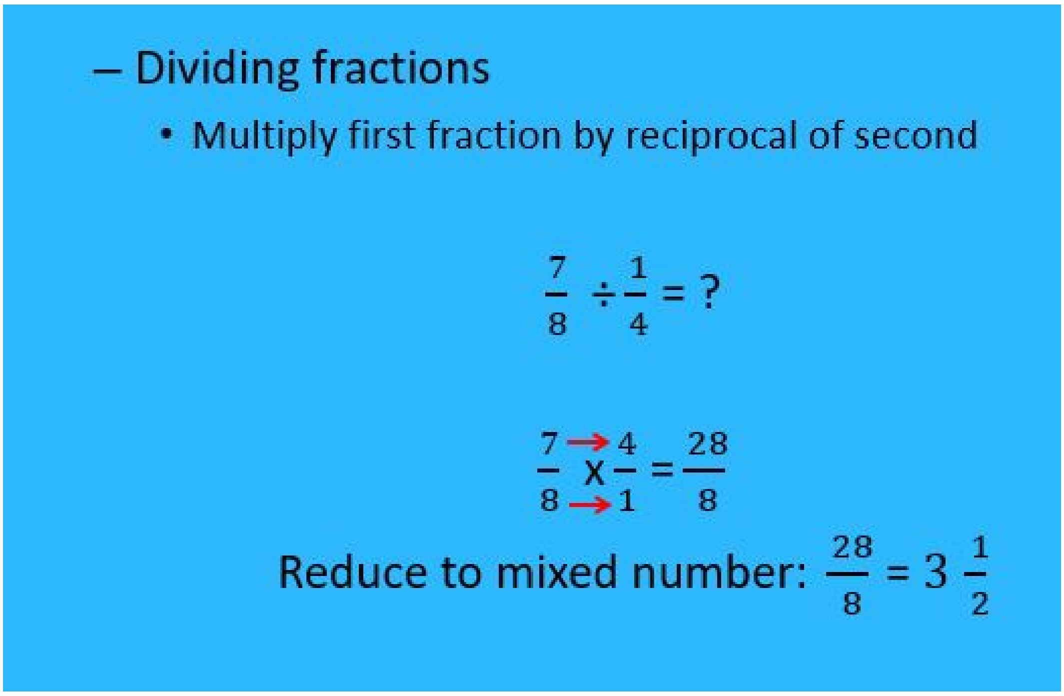
$$\frac{7}{8} \text{ vs. } \frac{27}{32}$$

$$\frac{7}{8} = \frac{14}{16} = \frac{28}{32}$$

multiplying numerator (top) and denominator (bottom) by 2 each time

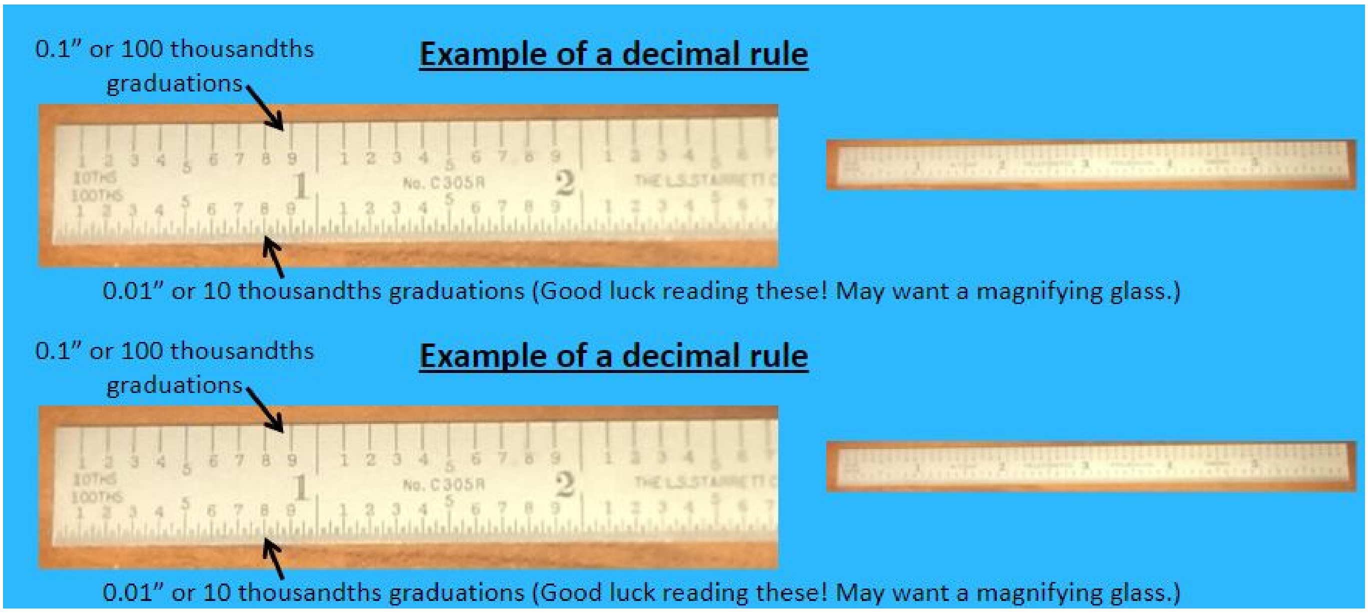
$$\frac{27}{32} < \frac{28}{32}, \text{ so } \frac{7}{8} > \frac{27}{32}$$





Rules

- Flat measuring tools with a graduated scale
- Graduations commonly of 1/8”, 1/16”, 1/32”, and 1/64” for fractional rules
- Graduations of 1/10”, 1/50”, and 1/100” for decimal rules
- Graduations of 1mm and 0.5mm for metric



Here is an example of a Pocket Rule with sliding clip:

figure: Ruler

The science that deals with systems of measurement is called: **METROLOGY**

Graduations

- Lines representing the divisions on a rule are called GRADUATIONS.
- Some have the smallest unit of measure marked on the steel rule.
- Most have the number of graduations per inch.

Three most commonly used GRADUATIONS

- Metric
- Fractional
- Decimal

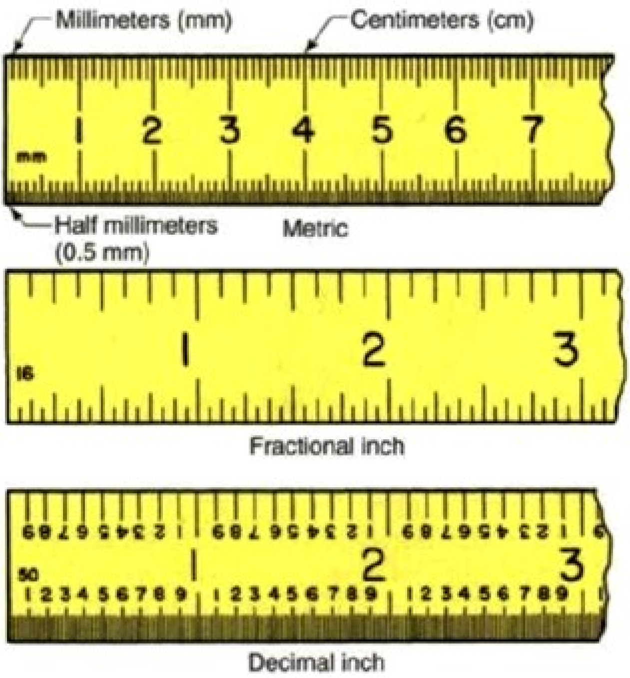


figure: Graduations

We will be using Fractional Graduations on a steel rule using English measurement

figure: steel ruler

Care of your steel rule

- Is a precision measuring tool.
- Not to be used to pry things open or as a screwdriver.
- It may sometimes be advisable to make your measurement from a line other than the zero point.

- Avoid dropping the rule.
- Don’t just throw it in a drawer when not in use.

So, just what fraction, what measurement is the dark line?

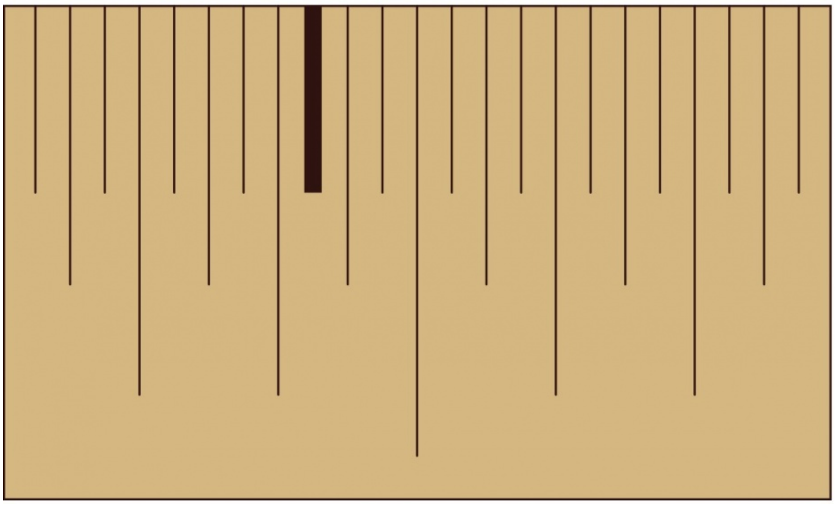


figure: measurement

Halves

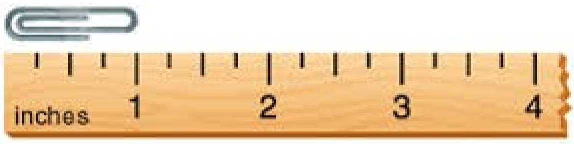


figure: Halves

Fourths

What fraction or measure is each yellow line?

figure: measurement

Fourths

What fraction or measure is each yellow line?

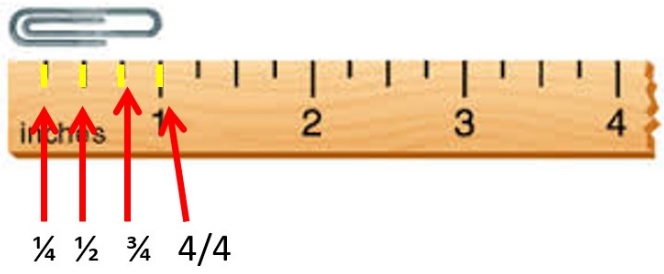


figure: measurement

Eighths

What fraction of measure is each red line?

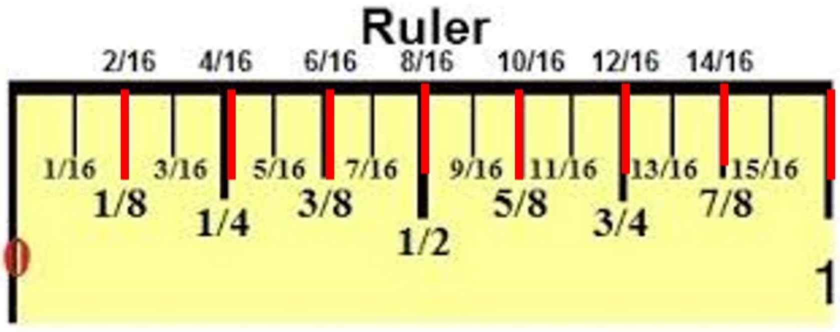


figure: measurement

Sixteenths

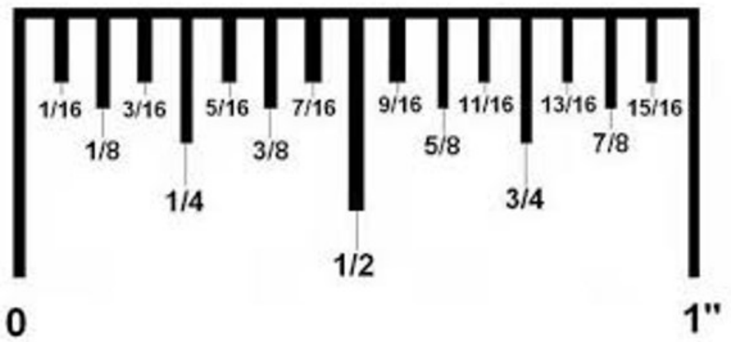


figure: measurement

Thirty-seconds

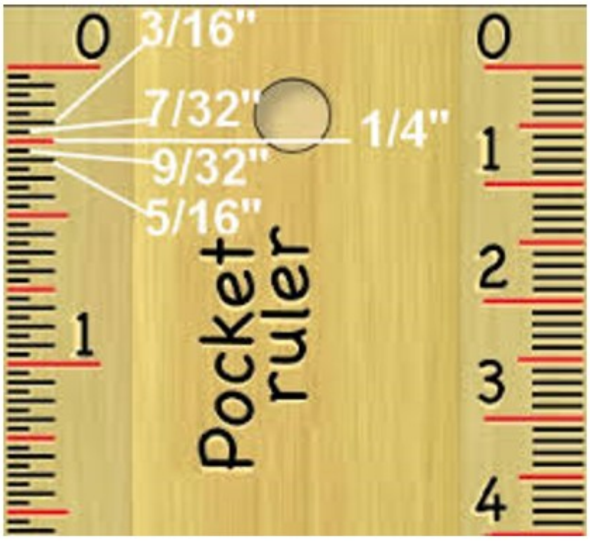
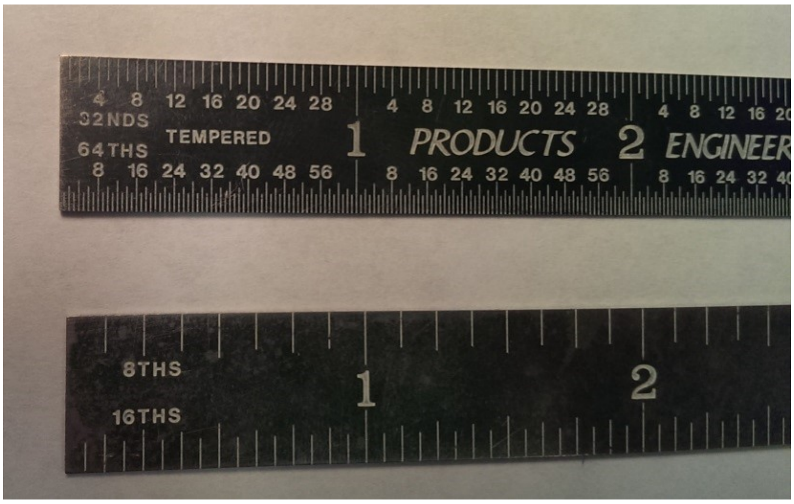


figure: measurement

Review of Terminology

- Shop reference: 180 – 190 (180 – 182 review)
- Graduation (discussion on page 180 may help)
- .001” = One thousandth (of an inch)
- .1” = .100” = One hundred thousandths (100/1000=1/10)
- .0001” = One ten thousandth = 1/10,000; “One tenth”
- (Beware last paragraph on 182 before “Micrometers” is misplaced. Should be on page 190.
- Measuring with a rule:



In class demonstration of Micrometer

- Use very accurate screw thread
- Calibration and wear adjustment
- Types include outside micrometer calipers, inside micrometers, and depth micrometers, as well as specialty types

Types

The anvil and spindle of a screw thread micrometer fit the form of the thread.
A disc micrometer.
A blade micrometer.
A conical micrometer.
A multiple-anvil micrometer with the flat and rod anvils.
A multiple-anvil micrometer can be used to measure from the edge of a hole to a flat surface, or to measure height.

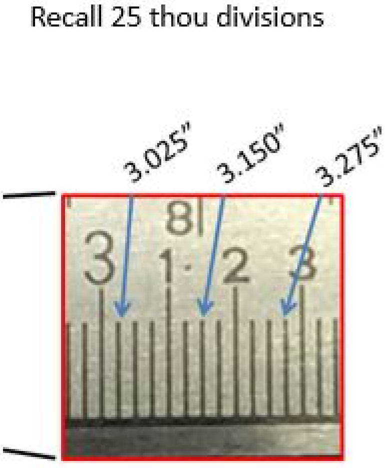
Usage

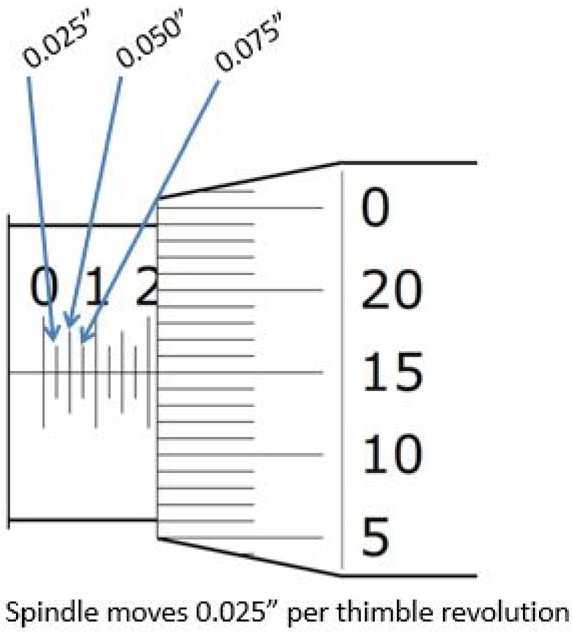
Wrap the little finger around the frame when using a 0–1" micrometer. Then rotate the thimble with the thumb and forefinger. Two fingers can be wrapped around the frames of larger micrometers.
A ball attachment can be added to the anvil, spindle, or both to allow measuring concave surfaces or from a flat surface to an edge of a hole.
Measuring with a micrometer with a range of 3–4". Gently pivot the micrometer while turning the thimble so that the anvil and spindle become parallel with part surfaces.
A micrometer with interchangeable anvils that can measure from 6–12" with one frame size.

Care

- Don’t drop or use as a hammer
- Keep in a case when not in use
- Maintain and keep/store clean and dry
- Keep away from moving machinery – mills
- Finger prints contain water and salt
- Not all stainless steel is created equal

Reading





Summary

- Reviewed divisions of length
- Micrometer features/terminology
- Types of micrometers
  - Haven't covered inside, or depth micrometers
- Usage of micrometers
- Care of micrometers
- Reading micrometers - .025"/revolution

Hands on Practice

- Gage pins with micrometers
  - Measure diameter of gage pins and self check
- Gage blocks with micrometers
  - Measure thickness of gage block and self check
- Optional: larger micrometers
  - Measure large block
  - Calibration to a standard

Click here to do an online exercise.

Dial Calipers

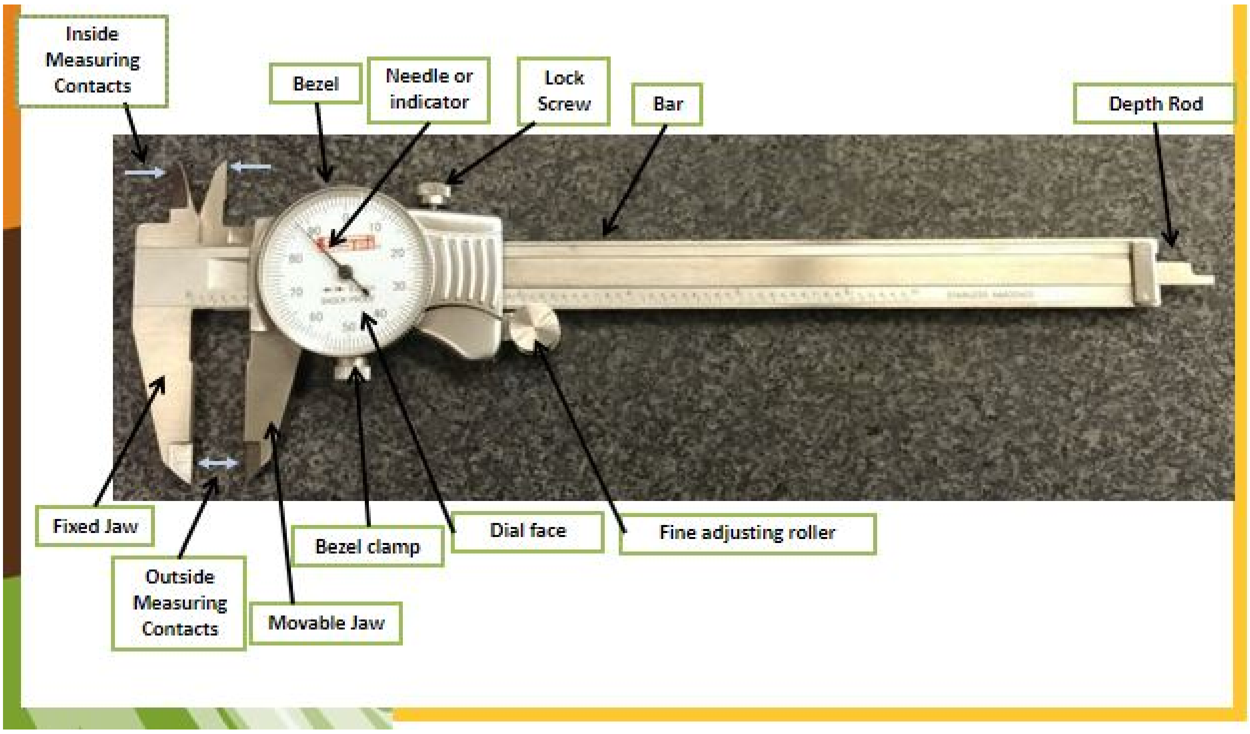
Similar to Slide Caliper

- Graduated scale along the bar
- Fixed and movable jaws

Measures

- External
- Internal
- Depth
- Step dimensions

Terminology



Outside Measurement

Step Measurement

Inside Measurement

Depth Measurement

Graduations, Range, and Reading

Smallest Graduation - 0.001”

Range of caliper - Commonly 6” – 8”

Distance in one revolution - 0.100”

Watch **this slide show** and take the online quiz (8 questions).

Types of dial faces

Continuous

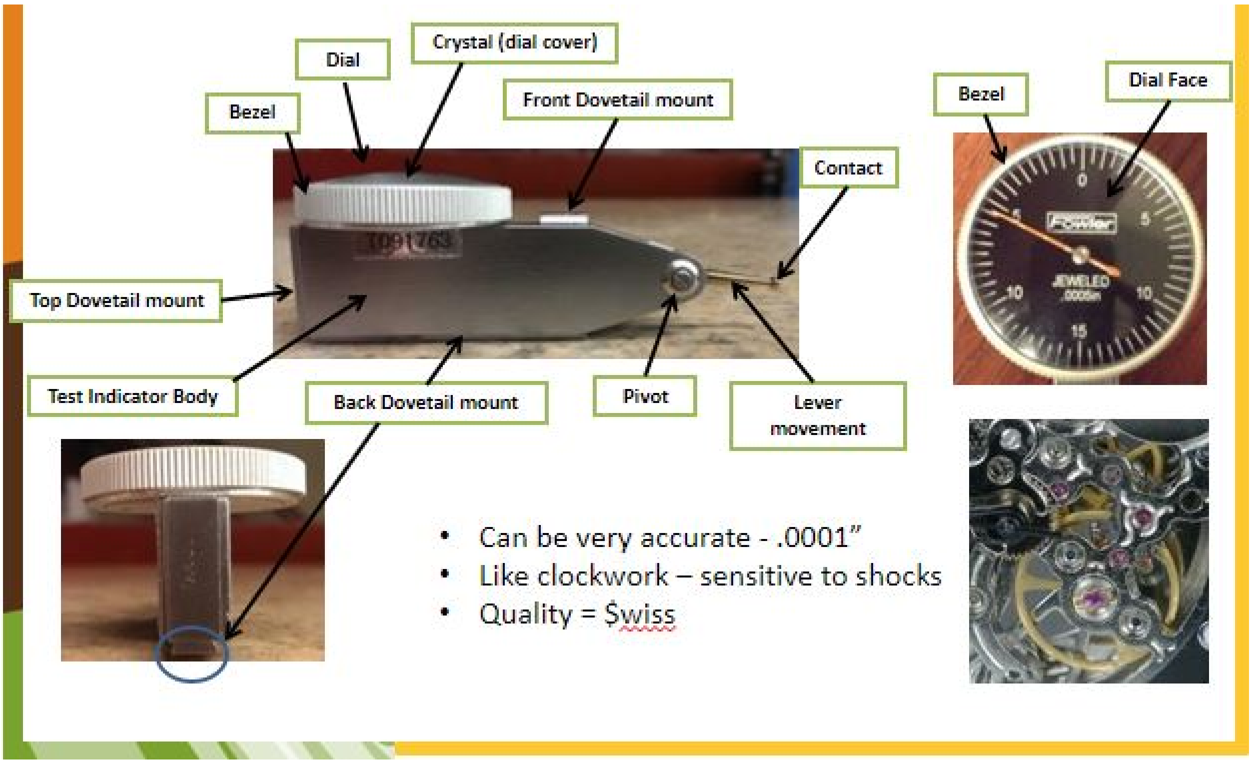
E.g. - Dial Caliper

Balanced

Equally numbered on both side of zero mark

Ranges?!

Terminology



Week 3 - Saws and Drills

Concept Goals:

By the end of this week, you should:

- Observe proper safety practices with saws and drills (SLO 1)
- List the different parts of a band saw (SLO 2)
- List the different accessories and cutting tools used with a drill press (SLO 2)

Concept Content:

This week we will go over saws and drills. Both of these tools are widely used in machine shops so you will need a good knowledge of how they work. We will discuss the basics of using them and safety protocols.

This week's material:

Reading:

Embedded Below

Videos:

Bandsaw Safety - 10 Minutes

Drill Press 101: Tool Training - 7 Minutes

Assignment:

Week 3 Quiz -10 Questions

Saws

- The Power Saw is a machine tool designed to cut material to a desired length or contour. It functions by drawing a blade containing cutting teeth through the workpiece. The power saw is faster and easier than hand sawing and is used principally to produce an accurate square or mitered cut on the workpiece.

Power Saw Safety Guidelines

- Power Saws have some special precautions to be observed, in addition to those described earlier in this lesson plan, as follows:

1. Keep hands away from the saw blade of the band saw when in operation.
2. Be sure the power supply is disconnected prior to removal or installation of saw blades.

3. Use a miter guide attachment, work-holding device, or a wooden block for pushing metal workpieces into the blade of the vertical band saw wherever possible. Keep fingers well clear of the blade at all times.
4. When removing or installing band saw blades, handle with care. A large springy blade can be dangerous if the operator does not exercise caution.

Band Saws

- The typical band saw uses a continuous band blade. A drive wheel and an idler wheel support and drive the blade. There are two types:
  - **Horizontal type:** the blade is lowered onto the material to be cut.
  - **Vertical type:** the workpiece is fed into the blade.

Band Saw Components

- **The base**, which can contain a coolant reservoir and a pump for conveying the coolant to the work.
- **The table**, which supports the vise or other types of workholding devices and the material being sawed, located on top of the base.
- The vise, adjustable to accommodate various sizes and shapes of material to be held. On some machines the vise may be swiveled so that material may be sawed at an angle.
- **The frame**, supports and carries the blade. The machine is designed so that the saw blade contacts the work only on the cutting area. Some machines feed by gravity or are power fed with the feed being adjustable.
- **The blade**, is picked out using the criteria described in the hacksaw section but also will include proper material of the blade itself as well as best tooth design option for the material being cut.

Vertical Band Saw

- The metal-cutting vertical band sawing machine is made in a variety of sizes and models by many manufacturers. The size is determined by the throat depth, which is the distance from the saw band to the column.

Vertical Band Saw

Vertical Band Saw Components

- **The column** sometimes contains the speed indicator dial, which indicates the speed in feet per minute (FPM) and may also house a butt welder for creating or repairing blades.
- **The head** is the large unit at the top of the machine that contains the idler wheel, the drive motor switch, the tension adjustment handwheel and mechanism, a flexible air line for clearing chips, and the adjustable post which supports the upper saw guide.
- **The base** drive wheel, the motor, and the transmission. The transmission may have multiple speed ranges. A shift lever on the back of the base can be placed in the range desired or in neutral. The base also supports the table and contains the lower guide, which is mounted immediately under the table slot. If equipped with power feed, the mechanism is located within the base, along with the feed adjustment handle and foot pedal on the front of the base.

Horizontal Band Saw

- The horizontal band saw does the same job as a hacksaw but does it more efficiently. The blade of the band saw is actually a continuous band which revolves around a drive wheel and idler wheel in the band support frame. Two band guides use rollers to twist the band so that the teeth are in the proper cutting position. The guides are adjustable and should be adjusted so that they are just slightly further apart than the width of the material to be cut. This will give maximum support to the blade and help assure a straight cut.
- The vise on the horizontal band saw comes in many capacities and the stationary jaw can be set at several angles. The movable jaw adjusts automatically to whatever position the stationary jaw is in when the vise handwheel is tightened.

Horizontal Band Saw

- The horizontal bandsaw is typically operated hydraulically by controls either on a control box or mounted to the hydraulic ram itself, which is usually located on the front of the machine. A speed and feed chart is sometimes provided on the machine, but when it is not, consult the operator's manual for the proper settings for sawing.
- A coolant pump is located in the base, which serves as a coolant reservoir. The coolant cools the saw band and also washes away chips from the cut before they can clog the blade.

Abrasive Cutoff Saws

- Abrasive cutoff saws, aka Chop saws are typically used on material too hard for a metal saw to cut. The wheels used are akin to a grinding wheel in that they are bonded abrasive and "self-sharpening" as old abrasive falls away, fresh cutting edges are introduced.
- Be advised that even during proper use, large amounts of sparks and dust will be generated as well as a heating of the workpiece.

"Chop Saw US Navy" by U.S. Navy photo by Mass Communication Specialist 3rd Class David A. Cox, U.S Navy is in the Public Domain

Abrasive Cutoff Saw

Metal Cutting Circular Saws

- Metal Cutting Circular Saw aka Cold saws are used when a more accurate cut, less heating of material, straighter cut or lower RPM is desired vs the abrasive cutoff saw. Cold saws produce small curled chips vs the sparks, dust, and debris of the chop saw.

"Cold Metal Cutting Saw" by Billbee, U.S Navy is licensed under CC BY-SA 4.0

Cold Metal Cutting Circular Saw

How to Use a Metal Cutting Circular Saw

- Before you begin, follow these steps:

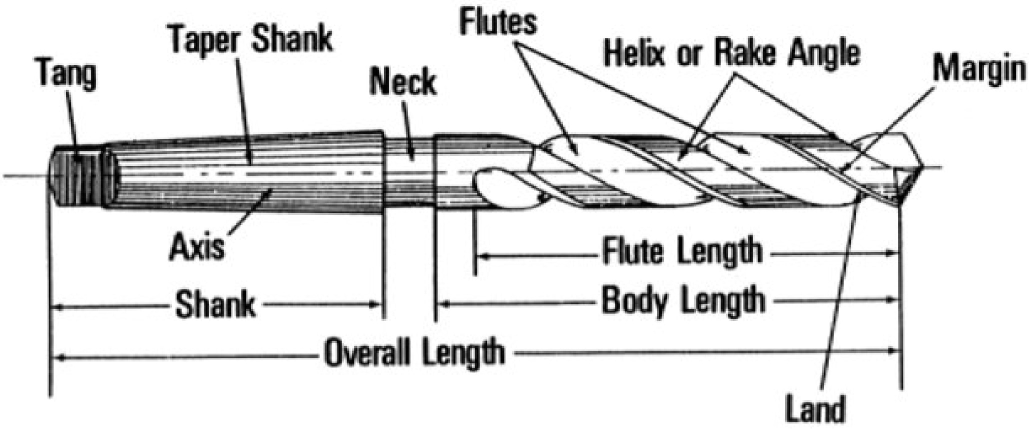
1. Make sure the saw is in good working order including the wheel, clamp, base, guards and cord.
2. Choose the best wheel for your application. Thinner cuts faster, thicker take more abuse, such as skip or broken cuts. Always reference any instructions/recommendations that accompany the wheels.
3. Always wear the proper safety equipment to protect yourself from the sparks, dust and debris. These may include a face shield, safety glasses, thicker gloves, dust mask, hearing protection and an apron or shop coat.
4. When cutting flat bar, cut with the thin profile vertical. The saw will cut the thin edge easier. Angle should be set with two ends down, resembling a tent when viewed from the end.
5. Be mindful of the "exhaust" of the saw, making sure there are no flammables, people, animals, fragile or anything else that could be harmed by expelled debris.
6. Verify the set-up by making sure wheel is square to the work, saw is stable and secure, long work is supported, stable and secure as well.
7. Keep saws clean – make sure they are unplugged or main power is off and clean blades, guards and table/clamping before and after each use.
8. Make sure you create crisp, clear layout lines and double check where the wheel is going to cut prior to turning on power, adjust as necessary.
9. Avoid over pressuring the blade, this will only shorten the life of the blade and reduce productivity. Follow the Owner's Manual recommendations.

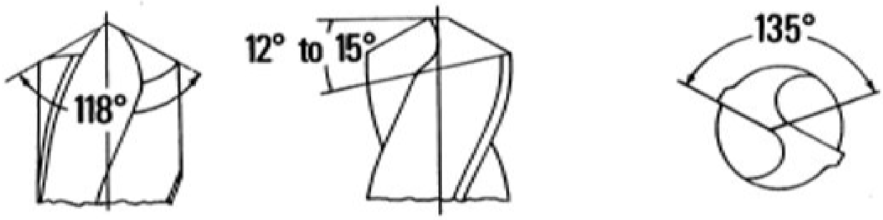
Twist Drills

– Straight shank

– Tapered shank

Shape of Standard Drill Bit





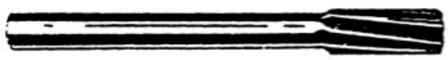
General Class of Work

Cutting tools used for Drill Press Operations

Center Drill (Combination drill and countersink)

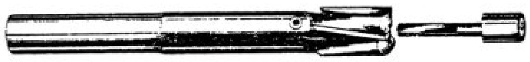
Reamers

– Straight shank



– Tapered shank

Counterbore or spot facer with pilot

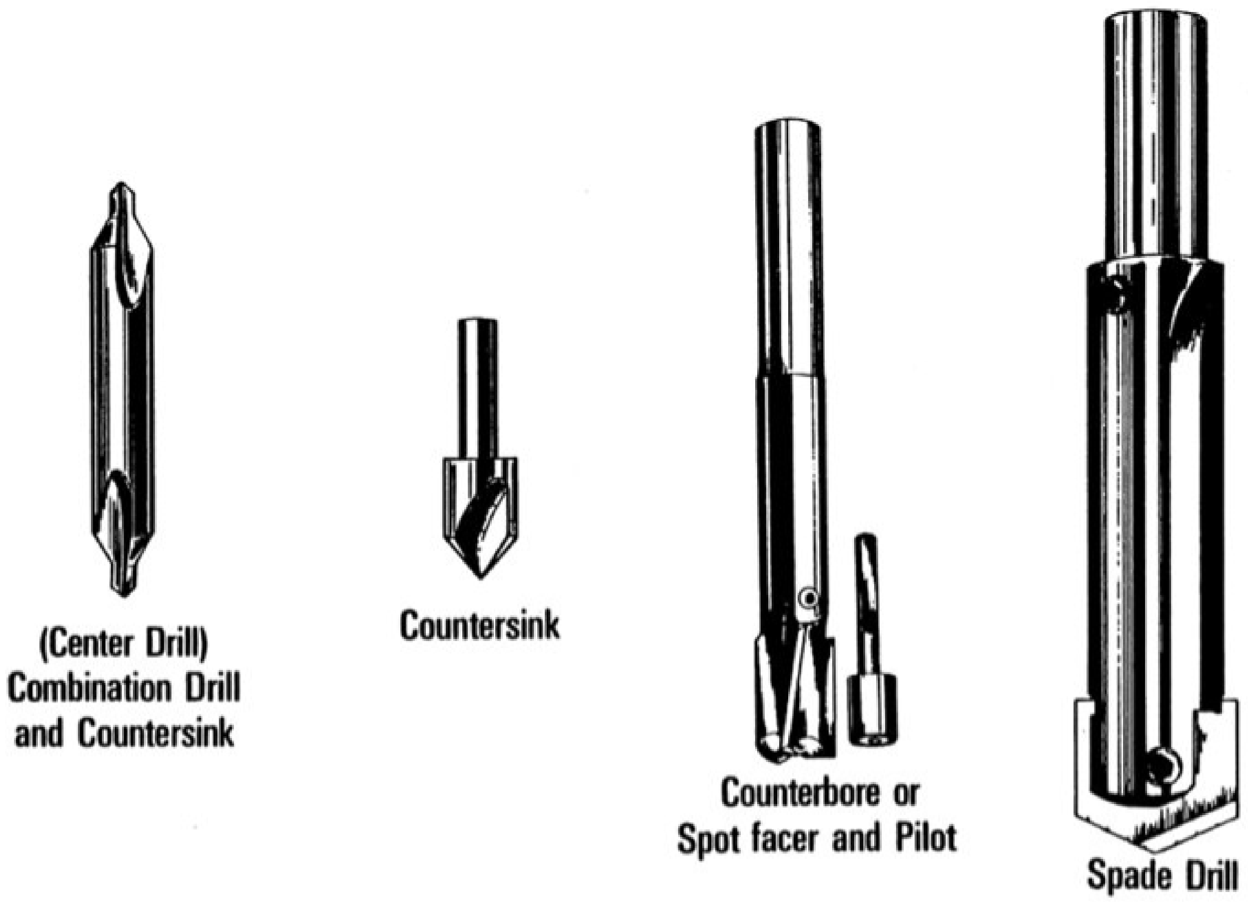


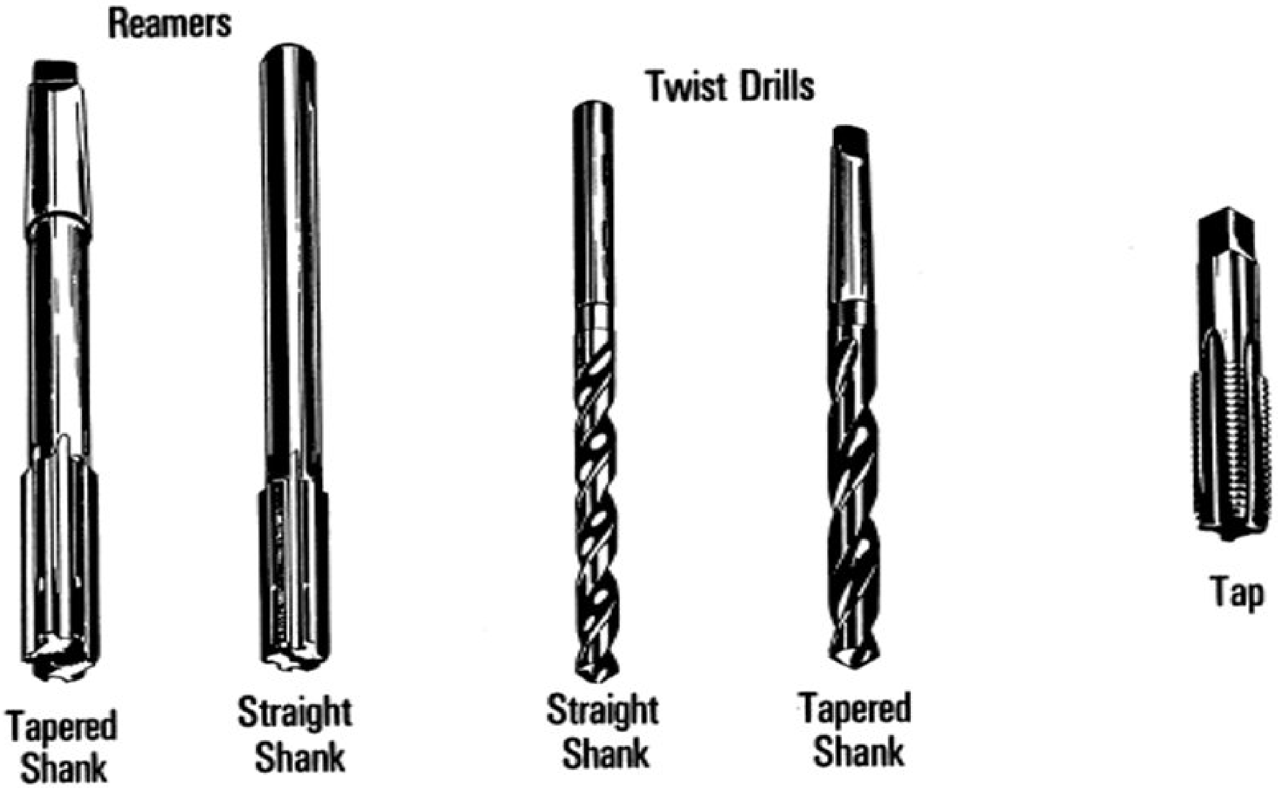
Countersink (They can come with different angles)

Tap

Spade Grill

Cutting Tools



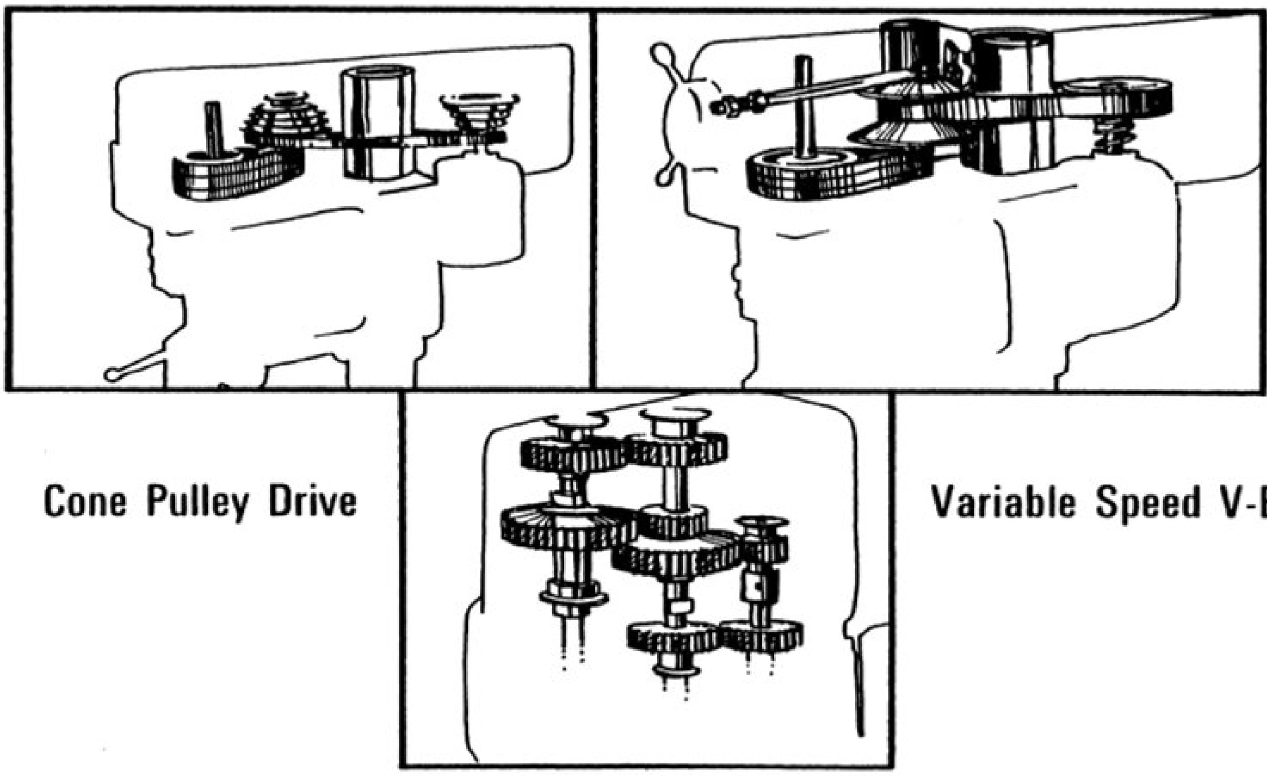


Types of Drill Press Drives

- **Cone pulley drive**: Found on most sensitive type bench and floor mounted machines; speeds are obtained by changing belt position.

- **Variable speed drive**: Found on sensitive type floor mounted machines; speeds are obtained by turning the speed selector.

- **Gear head drive**: Found on floor mounted machines like box column and radial drill presses; speeds are obtained by changing gears



Cone Pulley Drive

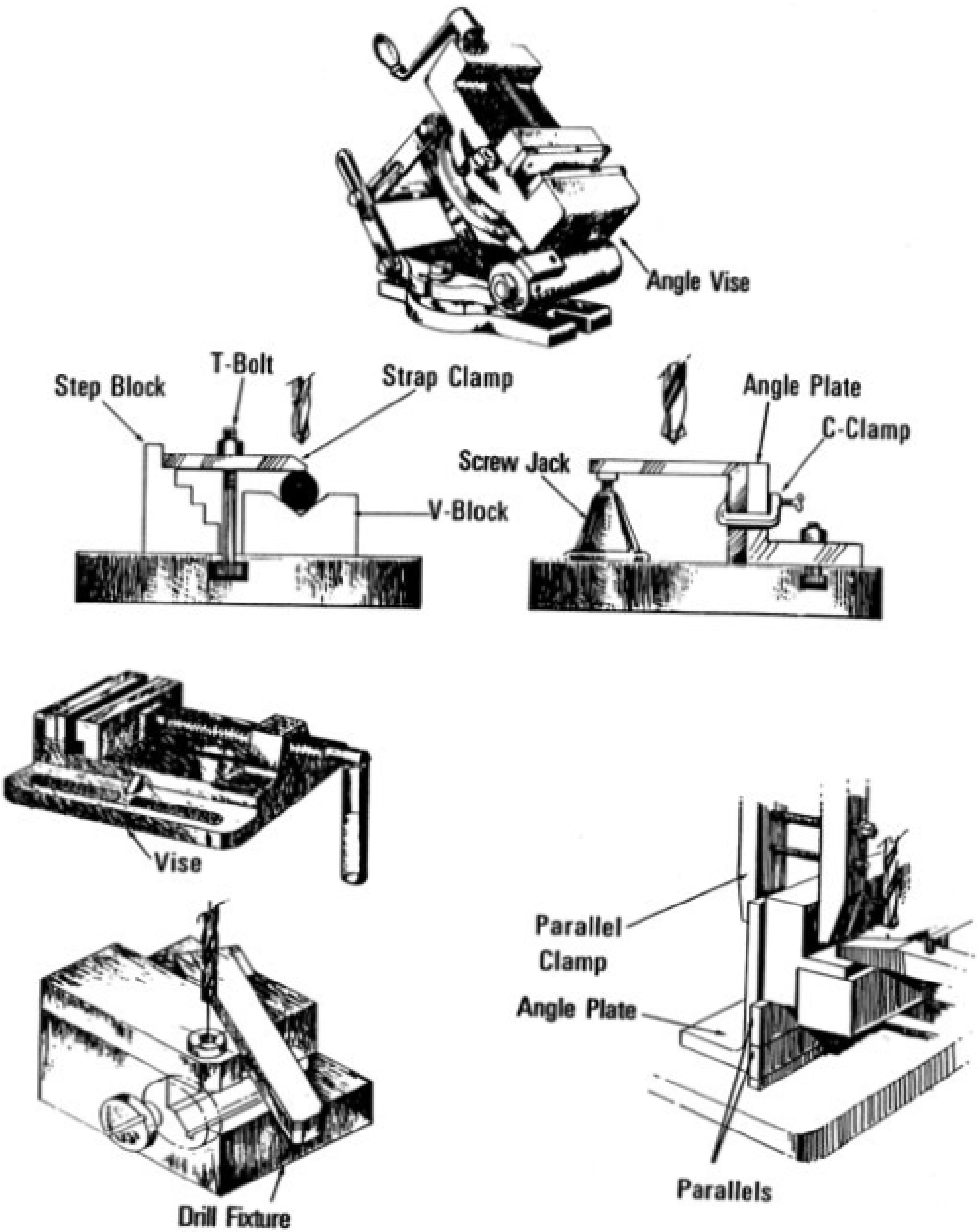
Variable Speed V-Belt

Gear Head Drive

Workholding and set-up devices used in drill press operations

Angle vise	Angle plate
Parallel clamp	V-block
C-clamp	Vise
Drill fixture	Parallels
Strap clamp	Screw jack
T-bolt	Step block

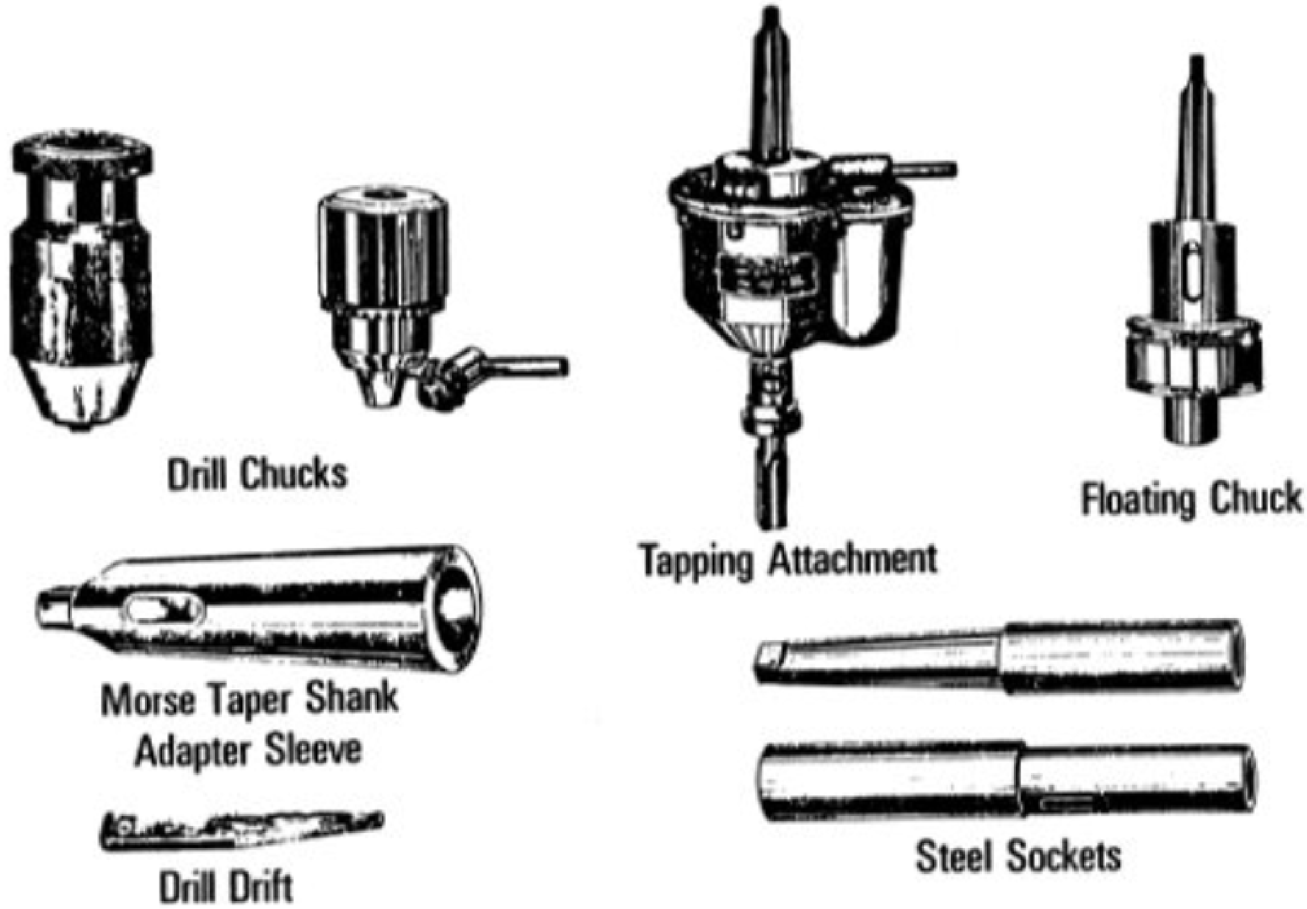
Note: All workholding devices must be secured to the table with clamps or bolts.



Workholding and Set-up Devices

Attachments and Accessories used with Drill Presses

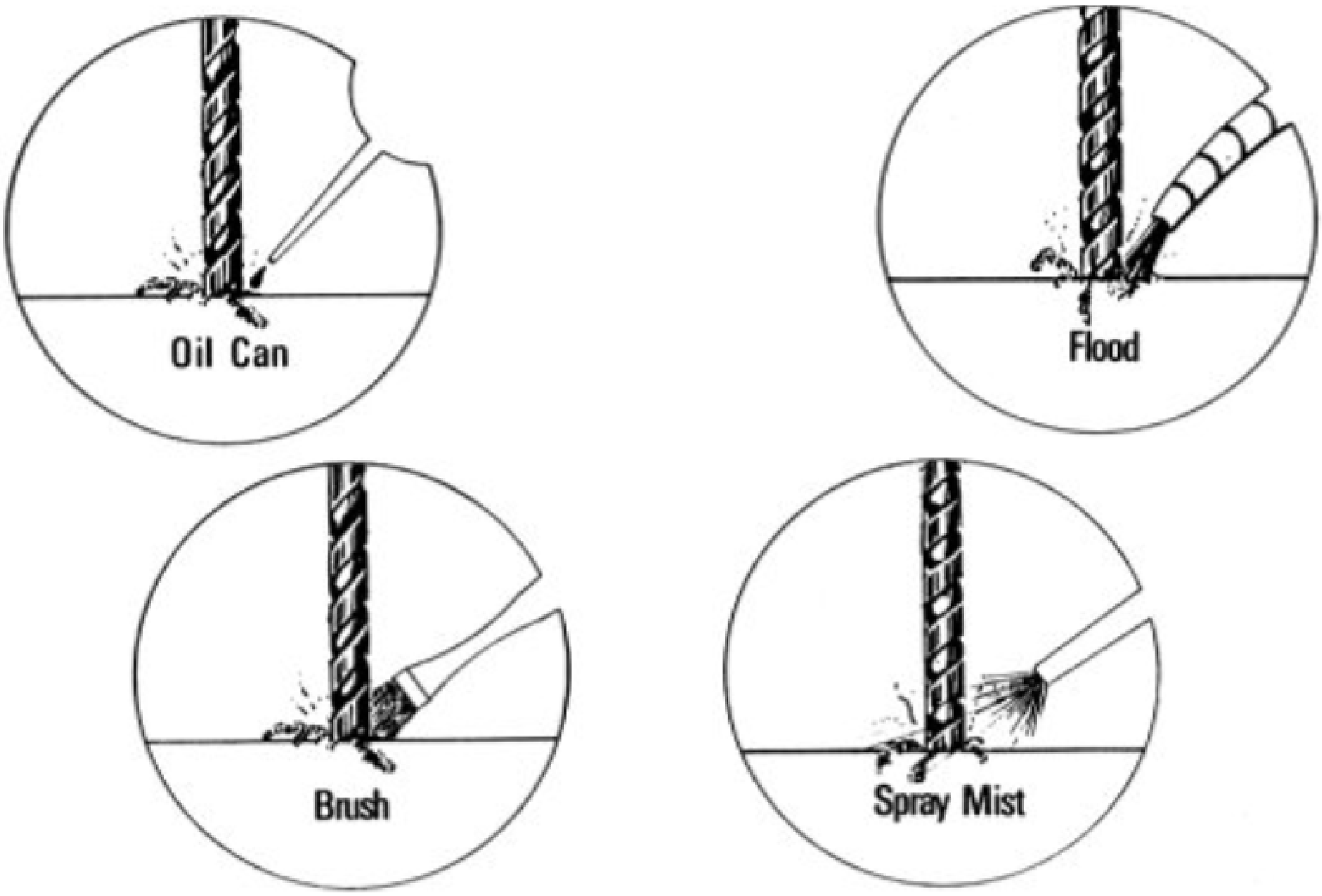
- Tapping attachment
- Drill chuck
- Floating chuck
- Morse taper shank adapter sleeve
- Steel sockets
- Drill drift



Devices for Holding Cutting Tools

Methods of Applying Coolants

- Oil can
- Spray mist
- Flood
- Brush



Coolant Applications

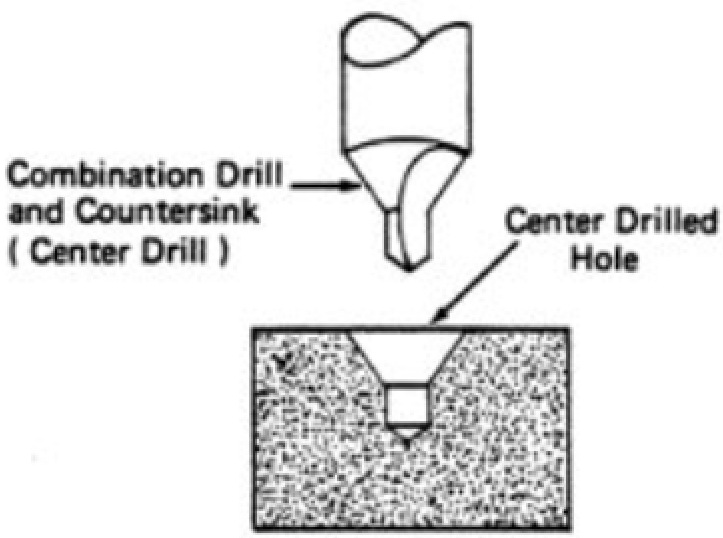
Rules for the safe Operation of the Drill Press

- **Eyes**: Always wear safety glasses to protect your eyes from chips.
- **Clothing**: Always wear tight-fitting clothes to prevent them from being caught in revolving parts.
- **Guards**: Never operate the drilling machine with guards removed.
- **Chuck key or drill drift**: Should be removed immediately after using; never leave key in drill chuck or drift in spindle because if machine is turned on they will be thrown and possibly cause injury.
- **Watches and rings**: Remove before operating drill press or any machine to prevent possible accidents.
- **Chips**: Remove with a brush, never your hands.
- **Rags**: Should never be used while machine is running, and never left on the table of a running machine.
- **Work**: Should always be held in a vise or other workholding device that is secured to the table
- **Feed Pressure**: Ease up when the drill is breaking through so it will not grab and leave a big burr.
- **Drill Chuck**: Designed to hold straight shank drills and tools; should never be used to hold tools with tapered shanks.
- **Drill Drift**: The only tool that should be used to remove tapered shank tools from spindles or sleeves.
- **Machine in motion**: Never clean or make adjustments while machine is running.
- **Hands**: Never pick a drill, work, or any tool that you have been using as it is hot and will burn; use a rag.
- **Table**: Should be kept clean and free of tools to prevent accidents and possible damage to tools.

- **Spindle Tapers**: Should never be cleaned when spindle is turned by power.
- **Deep Holes**: Interrupt the feed occasionally to break up chips and clear the drill.
- **Chucks and other tools with tapered shanks**: Always place on the table under tool so when you break the taper with the drill drift it will not fail and damage the tool or table of the drill press.
- **Floor**: Keep work area clean and free of slippery materials or chips to prevent accidents.
- **Drill Press**: Clean machine and floor after using drill press.
- **Tools**: Clean oil or coolant from drills and other tools and put them up in the proper place.
- **Hair**: Long hair must be secured under a gar, in a hair net, or tied back to prevent it from being caught by rotating parts of the drill press.

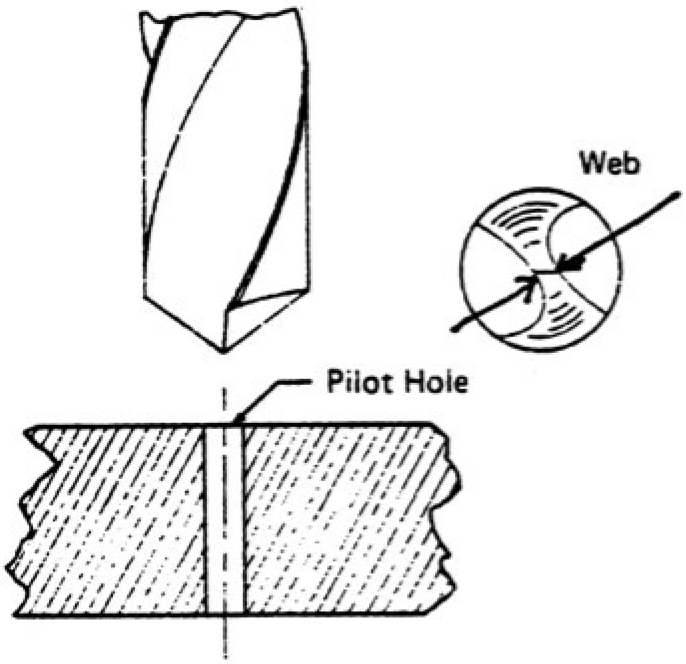
Operations Performed on The Drill Press

- **Center Drilling**: Making a hole with a tapered top so the drill will start in location desired.



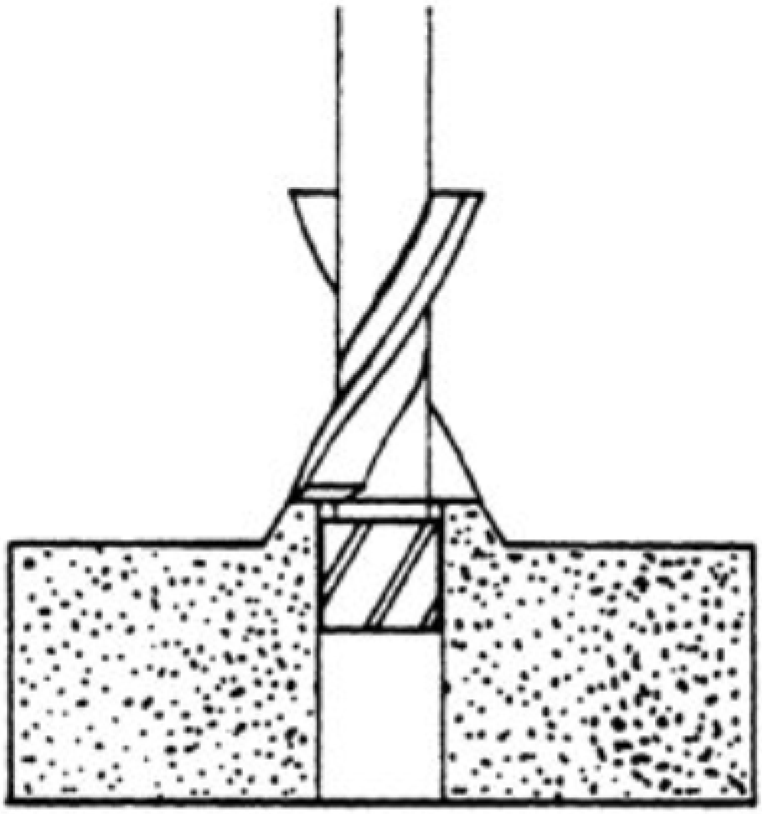
Center Drilling

- **Drilling**: Producing a hole given size and depth.
- **Boring**: Enlarging an existing hole to a given size and depth.
- **Counterboring**: Enlarging a hole with a flat bottom for a screw head to set in below the surface
- **Countersinking**: Producing a tapered surface in a hole so a flat head screw will be flush with the top surface of the part.
- **Tapping**: Producing a crew thread in a hole that has been drilled to a specific size.
- **Drilling a pilot hole**: Producing a small hole that is used to guide a larger drill and reduce the feed pressure of the larger drill. (**Note**: The pilot hole is drilled no larger than the web of the larger drill.)



Example of Drilling a Pilot Hole

- **Spot facing**: Making a flat surface so a bolt head or nut will seat properly.



Spot facing

Reaming: Enlarging a hole a small amount to make it true to size.

Chamfering: Making a small angular surface at the top of a hole.

✅ Week 4 - Cutting Speeds, RPM Calculations, and Machine Formulas

Concept Goals:

By the end of this week, you should:

- Calculate speeds and feeds accurately (SLO 3)
- Calculate RPM needed for milling/lathe operations accurately (SLO 3)

Concept Content:

This week we will discuss cutting speeds, rpm calculations, and machine formulas. In order to successfully use a milling or lathe machine, one must understand how to properly set the cutting speeds. If the speed is too low, the cutter won't work properly, but too high a speed can cause the machine to overheat and become damaged. It is not cheap to fix a damaged lathe or a mill. So, knowing how to properly calculate all of this out is vital to your success.

This Week's Material:

Lectures:

Milling Speeds and Feeds - 10 Slides

Speeds and Feeds - 15 Slides

Videos:

RPM Caculations - 2 Minutes

Cutting Speed and RPM on the Lathe and Mill - 10 Minutes

Reading:

Lathe Machine and Lathe Formulas: Embedded Below

Assignment:

Week 4 Quiz - 5 Questions - Located under the assignments tab

Milling Machine & Lathe Formulas

RPM = 4 x CS ÷ Diameter ()

4 = constant; does not change

CS = cutting speed [Tool Steel (**A2, D2**, **S7**, **O1** etc.) = **60**], [CRS (Cold Rolled Steel) = **80**],

[Aluminum = **200**]

Diameter = diameter of cutting tool being used (on mill) / diameter of work piece **<u>or</u>** hole (on lathe)

<u>End Mills:</u> RPM = 4 x CS/Diameter of End Mill

(Example: .250 **HSS** (High Speed Steel) End Mill, Material = CRS)

4 x CS ¸ .250 = 4 x 80 ¸ .250 = 320¸.250 =

<u>= 1280 RPM</u>

**** **IF USING A CARBIDE END MILL = RPM x 2** ****

** (DOUBLE THE RPMS IF USING CARBIDE TOOLING) **

(Ex: .250 End Mill (**CARBIDE**), Matl. = CRS)

RPM = 1280 RPM x 2 <u>= 2560 RPM</u>

ê<u>Drilling:</u> *** RPM = 4x CS/Diameter of Drill

ê<u>Reaming:</u> 1/3 RPM OF *<u>DRILL SPEED</u>* ****

****** DETERMINE DRILL SPEED, THEN DIVIDE DRILL RPM BY **3** *******

(**4 x CS** ¸ = RPM, THEN RPM **4 3**)

(Example: .250 drill, CRS) **4 x CS / .250** = 4 x 80 / .250 = 320/.250 = **1280 RPM**

1280 RPM 4 3

= 426 REAMING RPM

**********Drill pilot hole (thru hole) undersize before reaming**********

(FOR HOLE DIAMETERS OF .000" - .499" = Drill undersize by 1/64",

(FOR HOLE DIAMETERS OF .500" – 1.000" = Drill undersize by 1/32"

EX: .2500" REAMED HOLE (DRILL 1/64" under **.250")**

[USE 15/64" DRILL (.2344")]

Counter-Boring: **1/3 RPM** (*Based on Drill Size) **[Use the same math as used for Reaming**]

Boring Head (or Boring Bar): **500 – 1000 RPM** (**Based on diameter of hole) **

Drill pilot hole undersize by 1/16" (**4 x CS** ¸ for **HSS** tool) [**DOUBLE** the **RPM'S** for **CARBIDE**]

Counter-Sink: **80-100 RPM**

êPower Tapping: **50 RPM**

êChasing-Threads: **175 RPM** (*ACER* Handout sheet suggests **125 – 250** RPM)

Grooving Tool [(Carbide) Lathe]: **500 RPM**

êCenter Drill: **1000 RPM*** (ONLY FOR MANUAL LATHES & MILLS)**

Edge-Finder: **1000 RPM**

Face Mill (carbide-insertable cutter): **900-1500 RPM (DEPENDING ON) @ 15 – 20 IPM**

êCarbide Parting Tool (Lathe): **200-500 RPM**

êKnurl [Lathe]: **72 RPM** & **.009 IPR** Feed Rate**)**

****Cut undersize by .015 before knurling (for collet) ** **1/2 turn after hand tight****

êT-Slot Cutter: **250 RPM** at **1.0" IPM** (Inches per minute) feed on the **Proto-Trak or ACER Mills**

êHSS Forming Tool (Contour Tool for Forming Radii) [Lathe]: **250 RPM**

êSlitting Saw – Based on diameter of saw blade (**USE 4 x CS** ¸)

ê INDICATES CUTTING FLUID IS REQUIREDê

***** ***THREAD DEPTH – OF - CUT FORMULA*** *****

60° SHARP "V" THREADS – SET COMPOUND AT 29° from ⊥ (OR 61°)

*******THREAD DEPTH OF CUT =** *****

***** ***ACME THREAD*** *****

29° ACME THREADS – SET COMPOUND AT 14° from ⊥ (OR 76°)

****** TO DETERMINE DEPTH OF CUT =** ****

N = NUMBER OF THREADS PER INCH (TPI)

_____MILLING MACHINE FEED RATES__________

IPM = RPM x # FLUTES (OF TOOL) x FPT

RPM'S ARE DETERMINED BY THE FORMULA

4xCS/Diameter

***IPM = INCHES PER MINUTE OR FEED RATE**

***RPM = DETERMINED BY THE CUTTING TOOL**

BEING USED

***FPT = FEED PER TOOTH**

*********FPT FOR SPECIFIC MATERIALS*********

TOOL STEEL = .001"

CRS = .003"

ALUM. = .005"

LATHE MACHINE FEED RATES

FEED RATE ON A MANUAL LATHE IS

EXPRESSED IN INCHES PER REVOLUTION (IPR)

****WITH EACH REVOLUTION OF THE MACHINE SPINDLE, THE**

CARRIAGE MOVES A SET DISTANCE THAT IS BASED ON THE

SELECTIONS MADE ON THE GEAR BOX**

IPR FOR ROUGHING CYCLE = .006” - .008”

IPR FOR FINISHING CYCLE = .003” - .005”

***** *INCREASE THE RPM’S WHEN FINISH CUTTING******

–

HOLE MAKING ON A MANUAL LATHE

- **RPM’s for Drilling on a manual Lathe is determined by the**

  diameter () of the *drill !!*

- **Boring RPM’s is based on the of the existing hole**

Week 5 - Overview of Milling Machines

Concept Goals:

By the end of this week, you should:

- Properly identify the components of a milling machine (SLO 3)
- Properly identify machining accessories (SLO 3)
- Define how drilling, tapping, and boring works (SLO 3)

Concept Content:

This week we will do an overview of milling machines. It is important to know the basics of a milling machine before operating one and using it to create machine parts. Milling machines can cause injury if one is not careful. We will review the hazards of milling machines, the types of tools used on the milling machine, and how to square a part.

This week's material:

Videos:

Milling Machine Overview - 10 Minutes

Crash Course in Milling: Choosing & Using Endmills - 3.5 Minutes

Crash Course in Milling: Drilling, Tapping, and Boring - 4 Minutes

How to Square a Part - 5 Minutes

Reading:

Embedded Below

Assignment:

Hazards of Milling Machines

Electric milling machines cut metal using a rotating cutting device called a milling cutter. These machines cut flat surfaces, angles, slots, grooves, shoulders, inclined surfaces, dovetails, and recessed cuts. Cutters of different sizes and shapes are available for a wide variety of milling operations.

Milling machines include knee-and-column machines, bed-type or manufacturing machines, and special milling machines designed for special applications. Typical milling operations consist of selecting and installing the appropriate milling cutter, loading a work-piece on the milling table, controlling the table movement to feed the part against the rotating milling cutter, and callipering or measuring the part. (See Figure 41.)

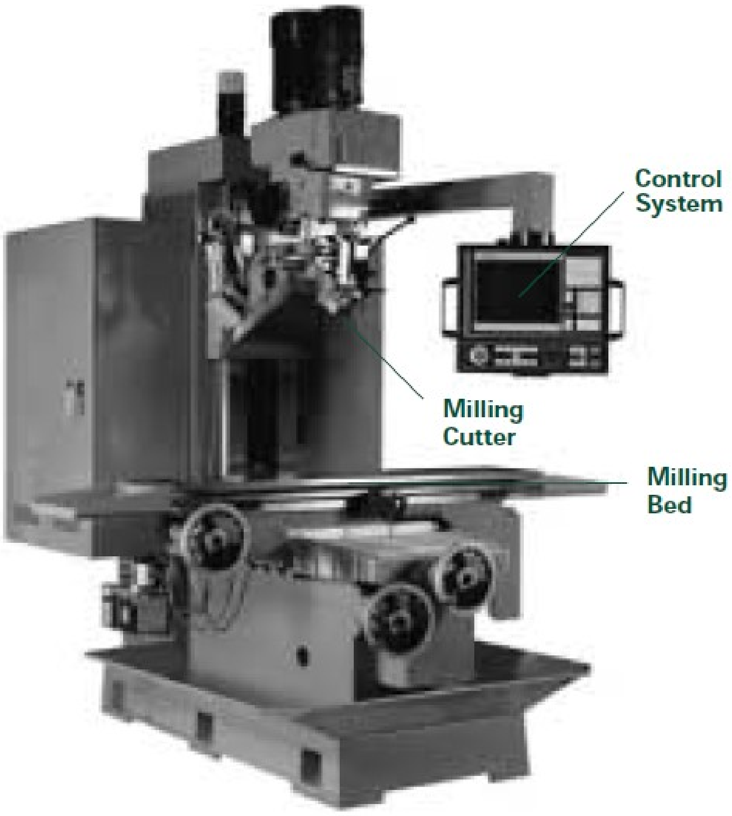


Figure 41 Bed Mill

Some frequent causes of amputation from milling machines include:

- Loading or unloading parts and callipering or measuring the milled part while the cutter is still rotating;
- Operating milling machines with the safety door selector switch on bypass;
- Inspecting the milling machine gearbox with the machine still operating;
- Manually checking the machine for loose gears (by removing the gearbox cover) while computerized cutting software program was operating;
- Performing servicing and maintenance activities such as setting up the machine, changing and lubricating parts, clearing jams, and removing excess oil, chips, fines, turnings, or particles either while the milling machine is stopped but still energized, or while the cutter is still rotating;
- Getting jewelry or loose-fitting clothing entangled in the rotating cutter.

Case History #22

While replacing parts on a horizontal milling machine, an employee shut off the machine, which put the revolving cutter in a neutral position. The employee, however, did not disengage the clutch to stop the cutter and proceeded to replace parts while the cutter was still moving. He amputated three fingers.

Case History #23

An employee was using a milling machine to cut metal samples to length. After a part had been cut, the employee needed to gauge the part size. While he was checking the edge of the sample, the blade caught the tip of his glove, pulled his hand into the cutting area, and amputated his right ring finger and part of his middle finger.

Source: OSHA IMIS Accident Investigation Database.

Safeguarding and Other Controls for Milling Machines

The following primary safeguarding methods will help protect you from point-of-operation and other milling machine hazard areas:

- Install guards (fixed, movable, and interlocked) that enclose the milling cutter's point-of-operation;
- Install properly applied safeguarding devices, such as presence-sensing devices and two-hand control methods;
- Install guards around the machine's power transmission components (such as drive mechanisms).

The following are some secondary safeguarding methods, work practices, and complementary equipment that may be used to supplement primary safeguarding or alone or in combination when primary safeguarding methods are not feasible:

- Use other safeguarding devices such as splash shields, chip shields, or barriers if they provide effective protection to the operator and when it is impractical to guard cutters without interfering with normal production operations or creating a more hazardous situation.
- Install awareness devices, such as barriers and warning signs, around the milling table.
- Instruct operators not to use a jig or vise (workholding equipment) that prevents the point of operation guard from being adjusted appropriately.
- Develop and implement safe (operating) work procedures for machine operators, such as safe work procedures for installing and using fixtures and tooling.
- Instruct operators to place the jig or vise locking arrangement so that force must be exerted away from the cutter.
- Ensure that all operators receive appropriate safe work procedure training by experienced operators until they can work safely on their own.
- Instruct operators to move the work-holding device back to a safe distance when loading or unloading parts and callipering or measuring the work and not to perform these activities while the cutter is still rotating unless the cutter is adequately guarded.
- Instruct employees not to wear gloves, jewelry, or loose-fitting clothing while operating a milling machine and to secure long hair in a net or cap.
- Prohibit operators from reaching around the cutter or hob to remove chips while the machine is in motion or not locked or tagged out.
- Conduct periodic inspections to ensure compliance.
- Perform servicing and maintenance under an energy control program in accordance with the Control of hazardous energy (lockout/tagout), 29 CFR 1910.147, standard.

Minor Servicing

At times, OSHA recognizes that some minor servicing may have to be performed during normal production operations, so a lockout/tagout exception is allowed. See the 29 CFR 1910.147(a)(2)(ii) Note, for details. For example, minor milling machine tool changes and adjustments may be performed without lockout/tagout if the machine's electrical disconnect or control (on/off) switches control all the hazardous energy and are:

1. properly designed and applied in accordance with good engineering practice;
2. placed in an off (open) position; and
3. under the exclusive control of the employee performing the minor servicing task.

Source: 29 CFR 1910.147(a)(2)(ii) Note.

Applicable Standards

- 29 CFR 1910.147, Control of hazardous energy (lockout/tagout)
- 29 CFR 1910.212, General requirements for all machines
- 29 CFR 1910.219, Mechanical power-transmission apparatus

Sources of Additional Information

- OSHA Publication 3067, Concepts and Techniques of Machine Safeguarding (http://www.osha.gov/Publications/Mach_Safeguard/toc.html)
- OSHA Machine Guarding eTool (http://www.osha.gov/SLTC/etools/machineguarding/index.html)
- OSHA Lockout/Tagout Interactive Training Program (http://www.osha.gov/dts/osta/lototraining/index.htm)
- National Safety Council, Accident Prevention Manual for Industrial Operations: Engineering and Technology. 10th Ed. Itasca, IL
- ANSI B11.8-2001, Safety Requirements for Manual Milling, Drilling and Boring Machines with or without Automatic Control

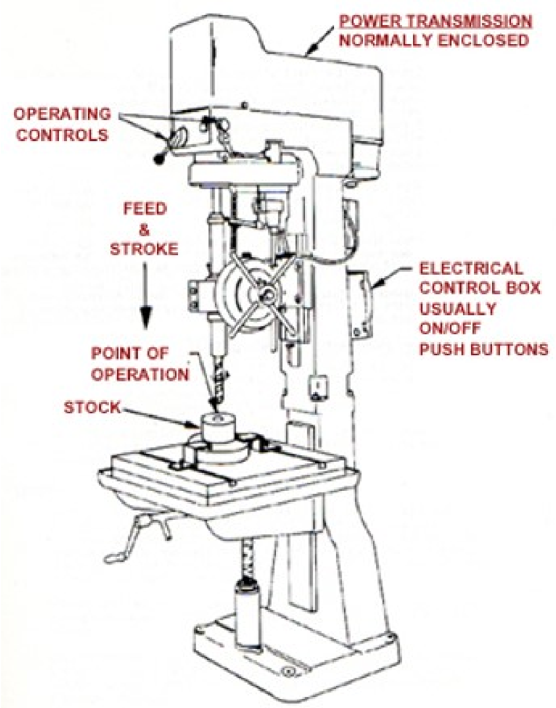


figure: Drilling and Milling

Drilling

- Shield, telescopic shield
- Production machines barrier guarding/shields
- Fixed guards for motor, pulley, belts
- Spring loaded chuck key
- Training
- No gloves, jewelry, or loose-fitting clothing
- Secure hair
- Use vice to secure work to drill table
- Replace projecting chucks and set screws
- Cover operator controls
- Shut off when not in use
- Eye protection
- Lockout

Milling

- Interlocked barrier guard
- Do not bypass interlock
- Splash shields, chip shields
- Safe work practices
- Training by experienced operators
- Move the vice or clamp away from tool to load
- Do not load or take measurements when unguarded tool is turning
- Do not clean chips or adjust coolant while running
- Use a brush to remove chips
- Place the vice or clamp so force is away from tool
- Do not leave tool exposed

- Turn off when not in use or unattended
- No gloves, jewelry, or loose-fitting clothing
- Secure long hair
- Eye protection
- Lockout

CNC Machine

figure: CNC Machine

ST-55 Turning Center Haas Automation
http://metalworkingnews.info/new-machines-from-haas-automation/

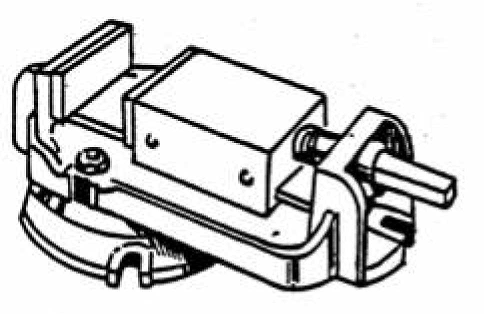
Milling Machine Safety Guidelines

- Safety Glasses and Safety Toe Shoes are to be worn at all times.
- Shirt sleeves must be short, or rolled up past the elbows.
- Long Hair must be tied back and restrained.
- Remove all items of Jewelry.
- Do Not Wear Gloves while operating machinery.
- Always return “Drawbar Wrench” to the tool box after use. Never leave it on the draw bar nut. “Keep it in your hands” at all times until it is returned to tool box.
- When installing or removing milling cutters, always hold them with a rag to prevent cutting your hands.
- You must always check direction of cutter rotation before cutting.
- Always check that vise is straight and securely clamped to the table.
- Always removes the cutter from machine before removing work piece.
- Always use a chip brush to remove chips from work area, never use your hand, a rag or compressed air.

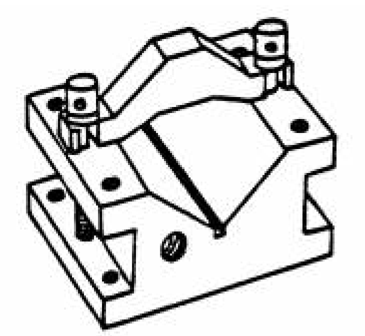
- Never touch the part to check the finish while cutter is rotating.
- Always shut off the machine before inspecting the part or making any adjustments.
- While setting up work, install the cutter last to avoid being cut.
- Always use a chip guard to avoid getting hit my flying chips or cutting fluid.
- Keep floor clean of oils to prevent any slippery condition that could result in injury.
- Always remove vise handle after securing the work piece and return it to the tool box (handle can wedge against the saddle while axis is moving)
- Never hold end milling cutter or taper shank tooling in a drill chuck.
- Always engage the machine way oil pump before starting any work.

Milling Machine Parts and Accessories

Precision Vise



Vee block and clamp



Precision Parallels

Dead Blow Hammer

Milling Machine Parts

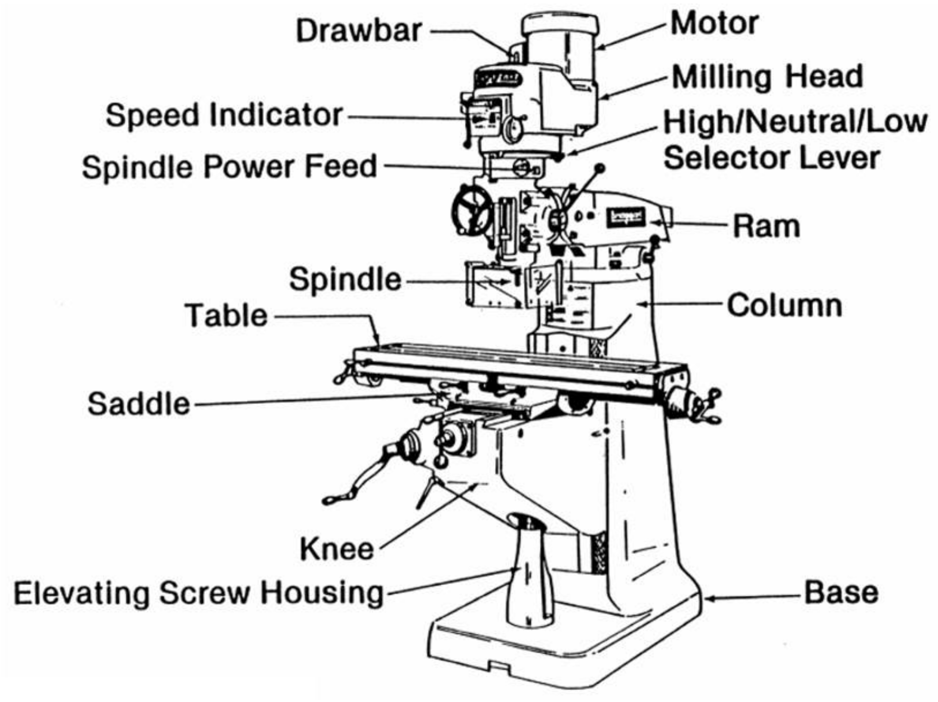


figure: Milling Machine Parts

Rotary table

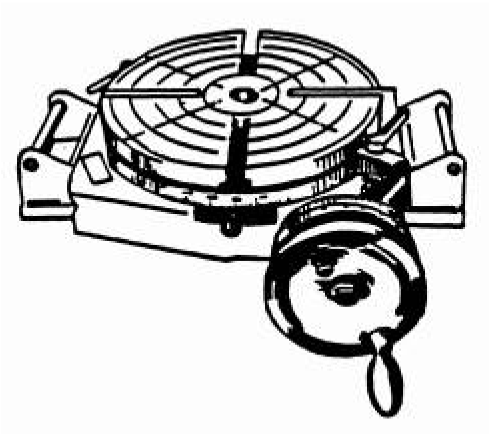


figure: Rotary table

Mill Holders

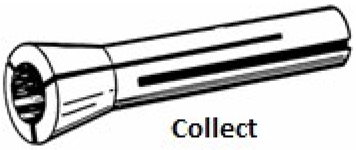


figure: Mill Holders

Hold-down clamp

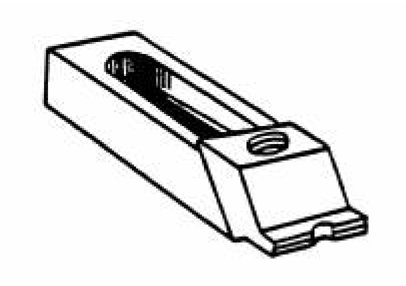


figure: Hold-down clamp

Angle plate

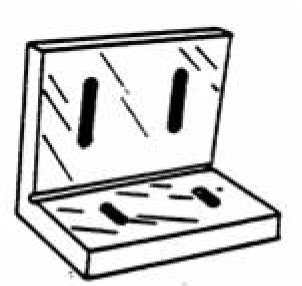


figure: Angle plate

Cutting Tools

Single End

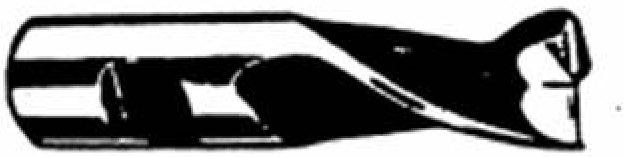


figure: Single End

Double End

figure: Double End

Four-flute end mill

figure: Four-flute end mill

Ball-nose end mill

figure: Ball-nose end mill

Roughing end mill

figure: Roughing end mill

Woodruff keyseat cutter

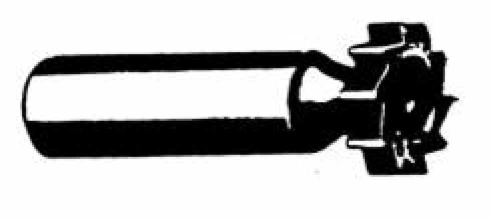


figure: Woodruff keyseat cutter

Countersink

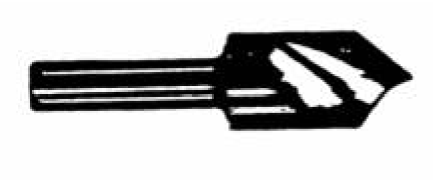


figure: Countersink

Counterbore with pilot

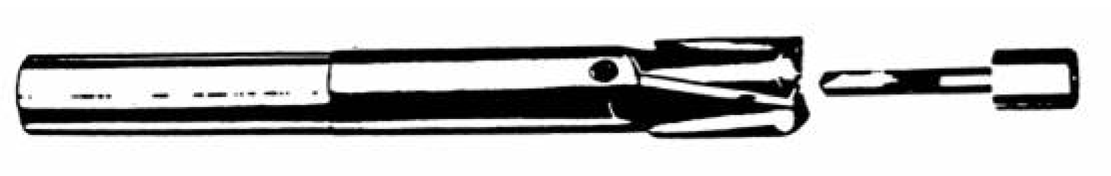


figure: Counterbore with pilot

Parts of the Milling Head

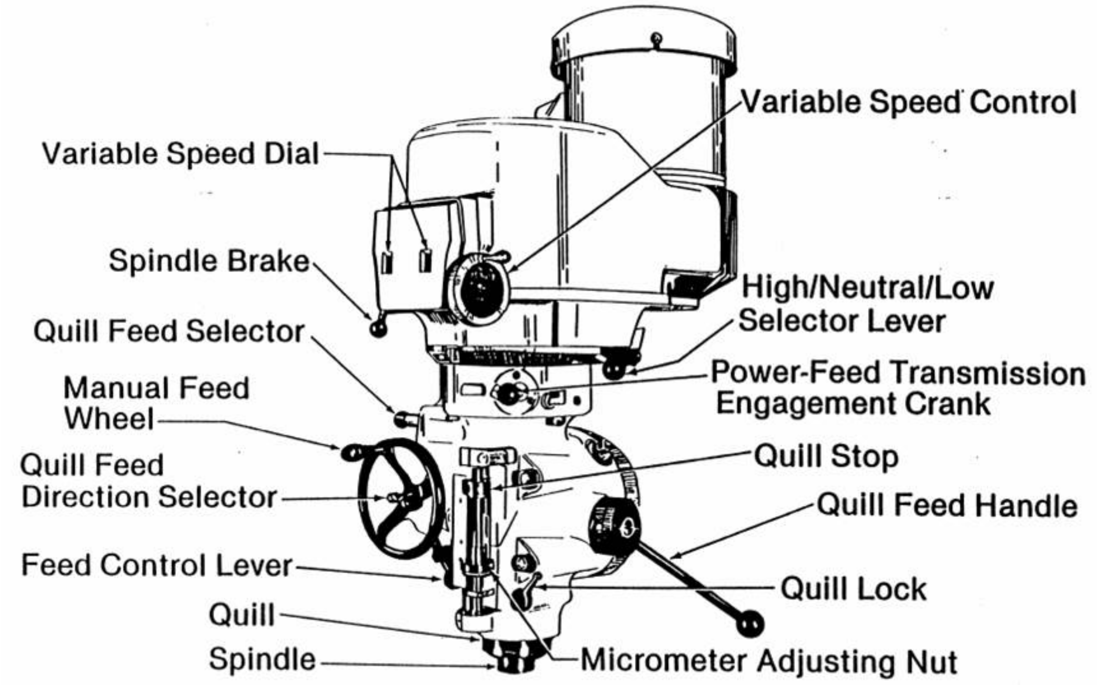


figure: Parts of the Milling Head

Milling Machine Operations - Demonstration

Instructor will:

- Show and explain how to articulate the head to different angles.
- Show and explain the use of the ram and turrent rotation.
- Show and explain the use of the quill feed.
- Show and explain the spindle gear ranges how to adjust RPM in both low and high ranges.
- Show and explain the spindle brake.
- Show and explain the orientation of the 3 Axis's X,Y,Z
- Show and explain the use of the table power feed.
- Show and explain the digital readout.
- Show and explain use of an edge finder and locating up your part.
- Show and explain machinability of different material types
- Show and explain different ways to square up a part.

Week 6 - Overview of Lathes

Concept Goals:

By the end of this week, you should:

- Correctly identify parts of a lathe machine (SLO 3)
- Correctly define/describe basic lathe operations (SLO 3)
- Understand basics of thread cutting (SLO 3)

Concept Content:

This week we will have an overview of Lathes. Lathes are the other type of machine you will work with in this course. They work differently than milling machines. They come with a different set of tools and techniques to work with.

This week's material:

Videos:

Dies and Threading Video - 9 Minutes

Thread Cutting on a Lathe - 34 Minutes

Reading:

Embedded Below

Assignment:

Week 6 Quiz - 3 Questions - located under the assignments tab

Rules for Safe Use of The Engine Lathe

- **Eye protection**: Wear approved safety glasses with side shields.
- **Watches and rings**: Remove before operating machinery.
- **Clothing**: Wear close-fitting clothes with shirttail tucked into pants; roll up long sleeves past elbow, or button.
- **Horseplay**: Is strictly prohibited in shop area.
- **Measuring, adjusting, cleaning, or oiling**: Stop Lathe.
- **Hands**: Never use hands to try to stop the lathe spindle or chuck, to grab chips, or to remove hot work from workholding device.
- **Rags**: Never use around revolving or moving parts.
- **Guards**: Never operate a machine with guards removed.
- **Chuck Wrench**: Remove immediately; never leave in chuck.
- **Floor**: Keep clean and free of chips and oil to eliminate slipping or tripping hazards.
- **Workholding Devices**: Always check to make sure that they are mounted securely.
- **Tools**: Never leave lying on machine.
- **Chucks**: Always clean before mounting on spindle; never set directly on the ways (use a wooden chuck cradle).
- **Large or oddly shaped parts that are chucked**: Rotate work a complete revolution by hand to make sure jaws and work clear the ways and carriage.
- **Sharp edges**: Remove all sharp edges and burrs from work.

Basic Lathe Operations

Turning: Removing material from outside surface of part.

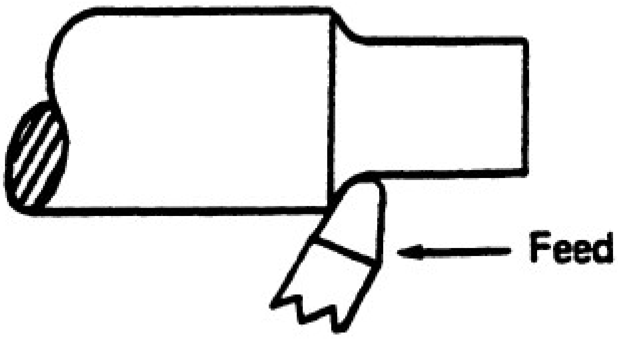


figure: Turning

Facing: Removing material from end surface of part

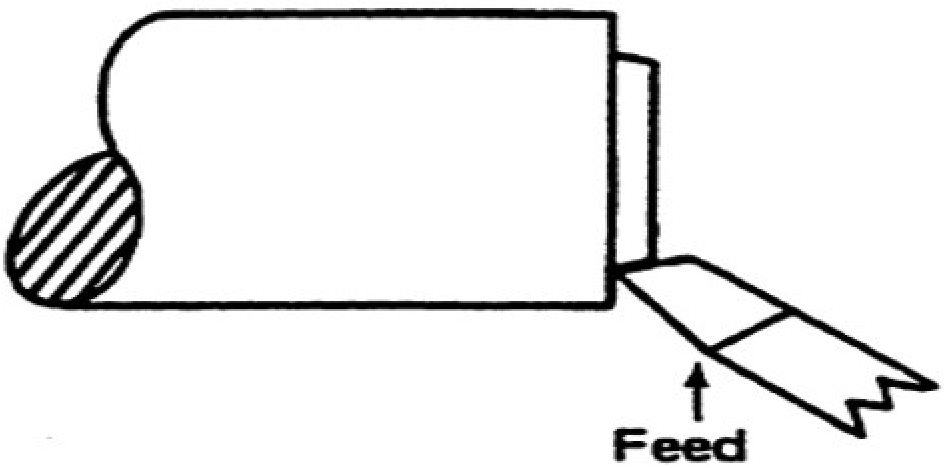


figure: Facing

Grooving: Cutting a recess in work.

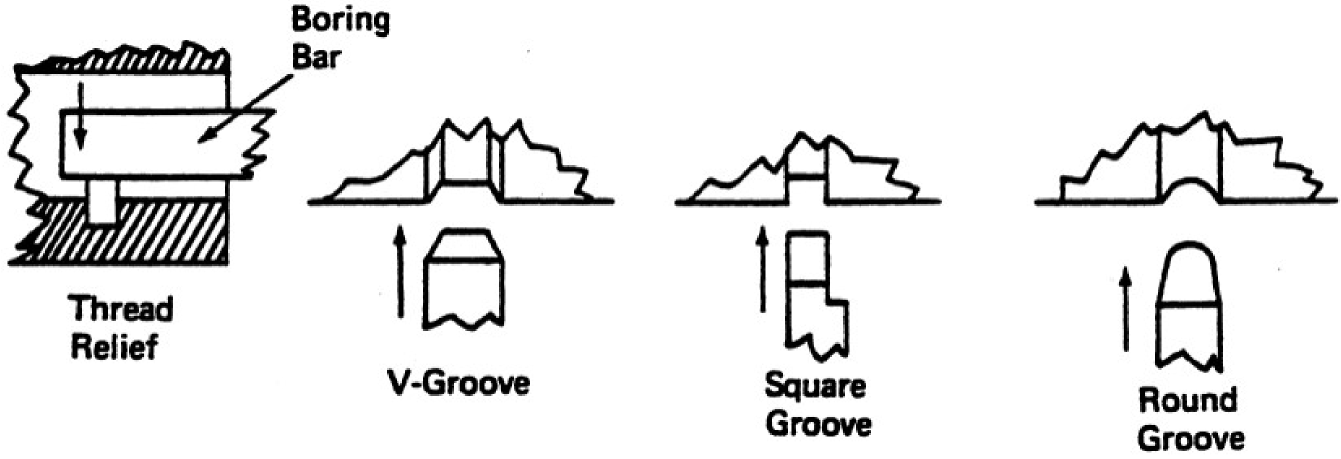


figure: Grooving

Note

Arrows indicate feed direction

Boring: Enlarging an existing hole.

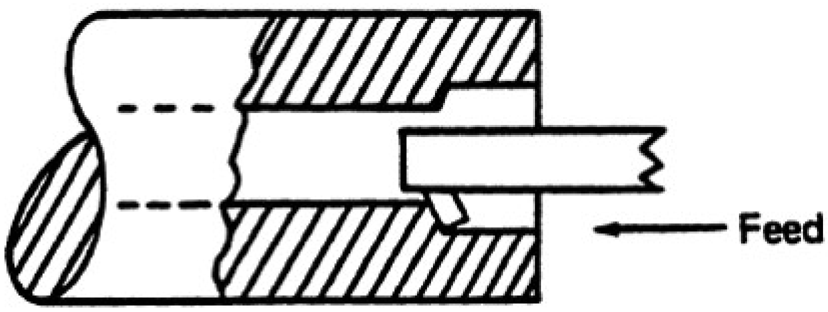


figure: Boring

Chamfering: Producing a flat, angular surface on the edge of a machined part.

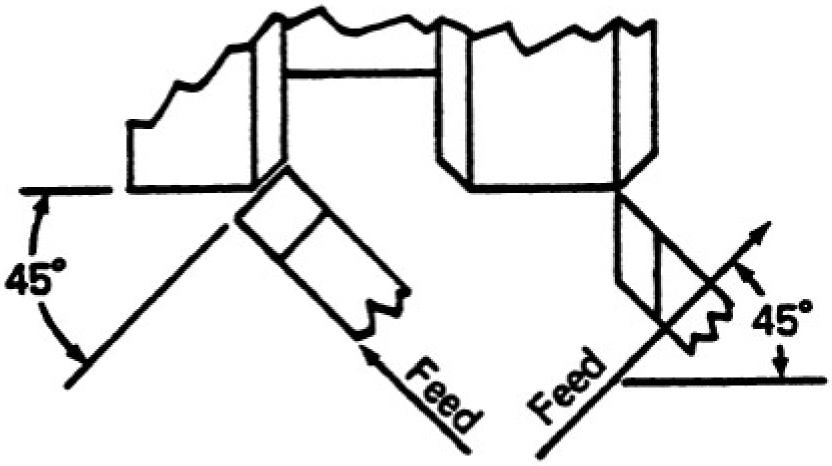


figure: Chamfering

Knurling: Producing a raised surface of work to improve grip or appearance or to increase diameter.

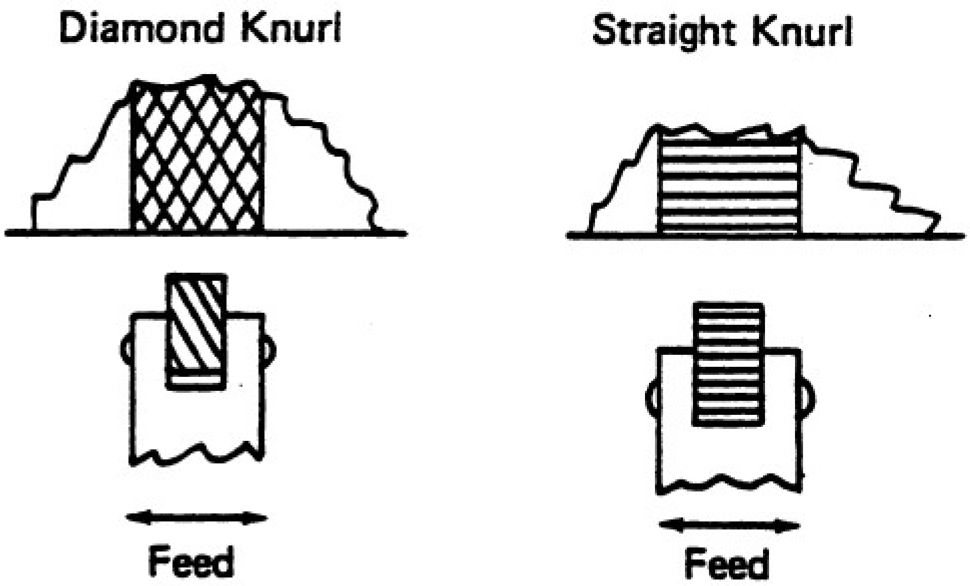


figure: Knurling

Threading: Forming internal or external threads with a single-point tool.

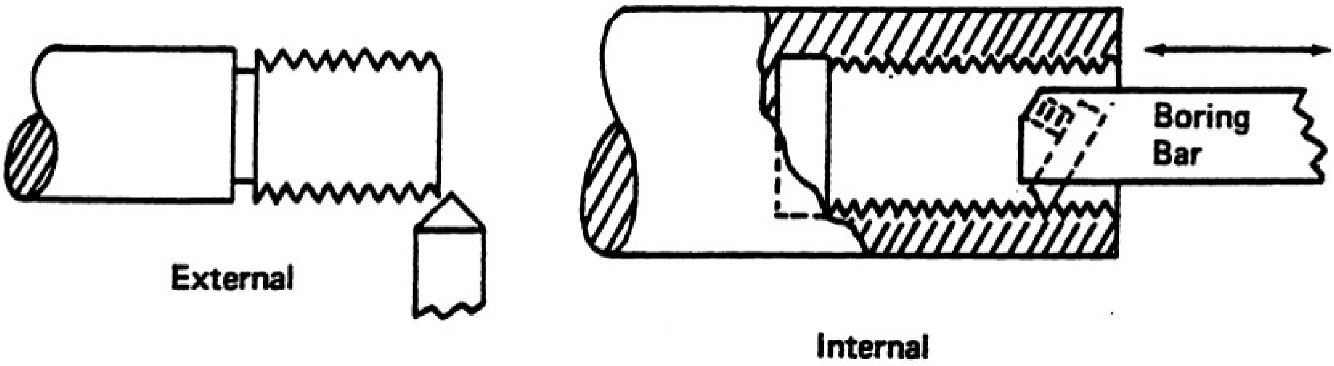


figure: Threading

Drilling: Producing a hole with a drill.

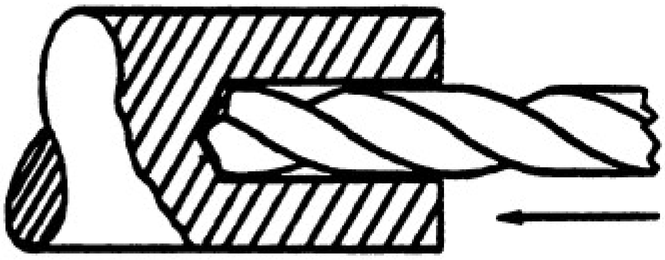


figure: Drilling

Reaming: Enlarging a hole slightly with a multi-fluted cutter.

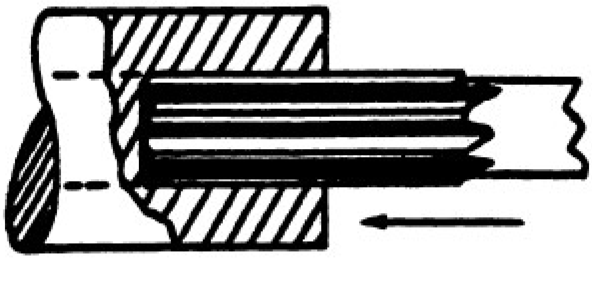


figure: Reaming

Forming: Producing a desired shape by using tools ground to that shape.

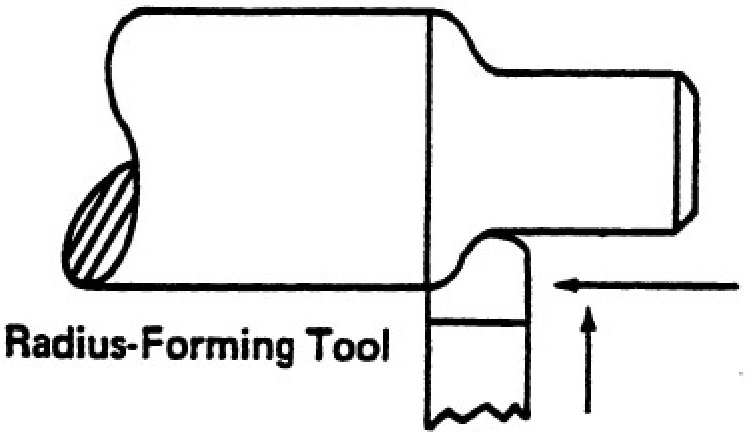


figure: Forming

Shouldering: Finishing surface where two diameters or steps meet.

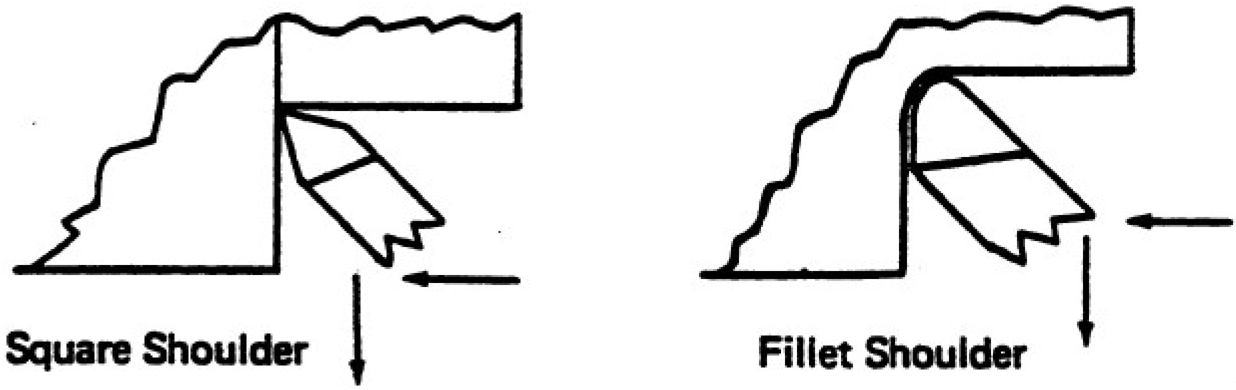


figure: Shouldering

Tapering: Producing uniform change in diameter of a part as measured along its axis.

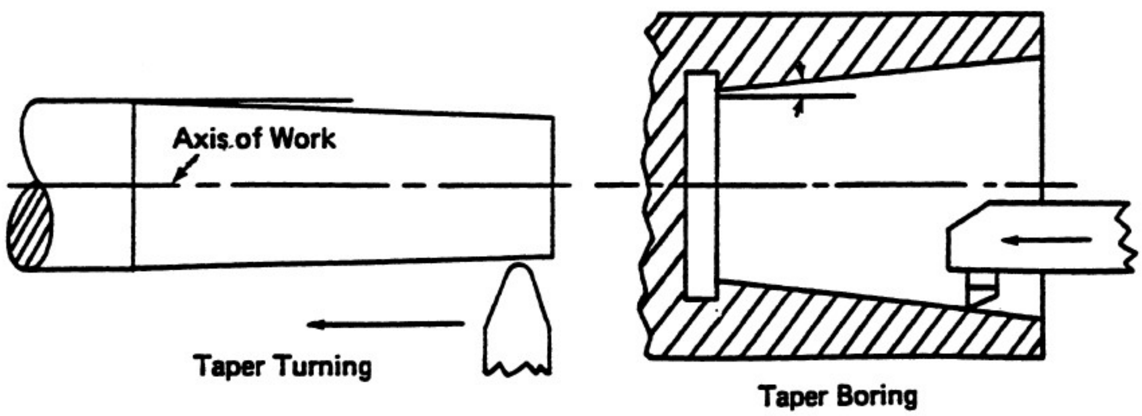


figure: Tapering

Filling: Chamfering or reducing diameter of work with a file while work is rotating

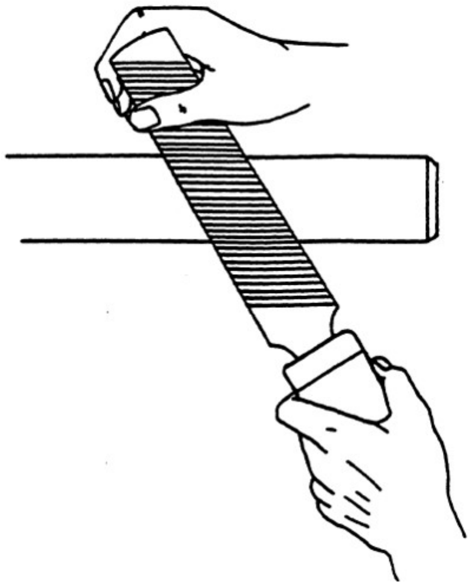


figure: Filling

Polishing: Improving surface of part with abrasive cloth while work is turning.

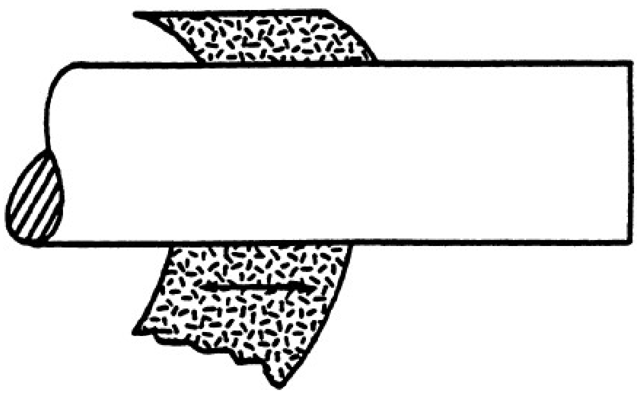


figure: Polishing

Cutoff: Cutting a part from work with a thin tool while work is rotating. Cutoff operations should never be done on work that is held between centers or supported with a center.

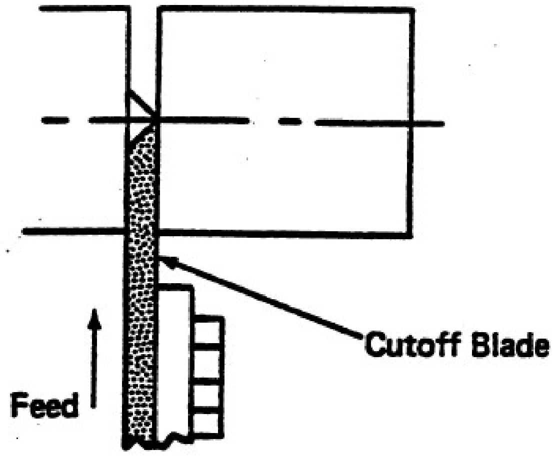


figure: Cutoff

Tapping: Producing internal threads with a tap, using the lathe tailstock to guide tap. Power is off when machinist performs this operation, and lathe is set in low range to prevent spindle from turning.

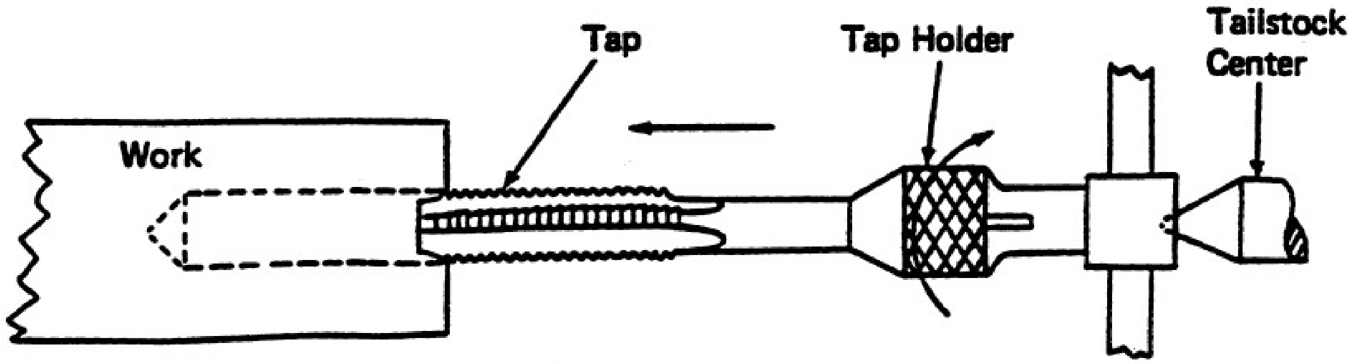


figure: Tapping

Center Drilling: Producing a tapered hole in end of work so that part can be held between centers or be used as starting hole for drilling operation.

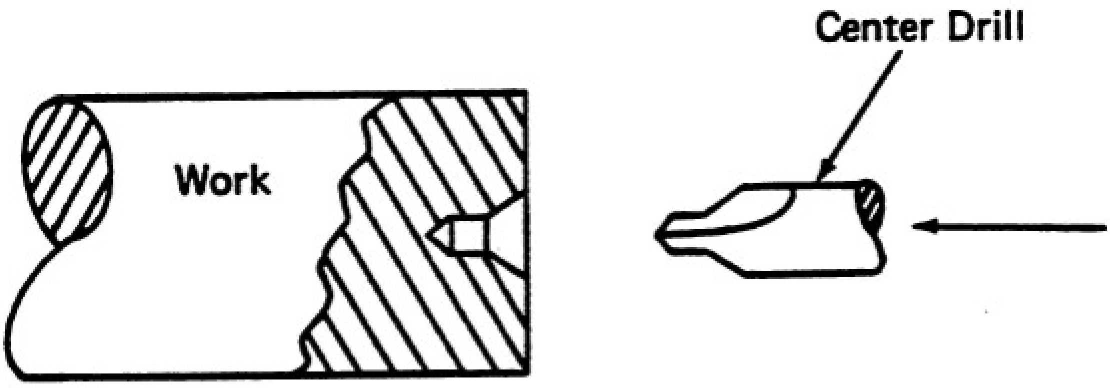


figure: Center Drilling

Types of Tool Posts and Toolholders

Tool posts and holders come in a number of designs. Some designs are combination posts and holders.

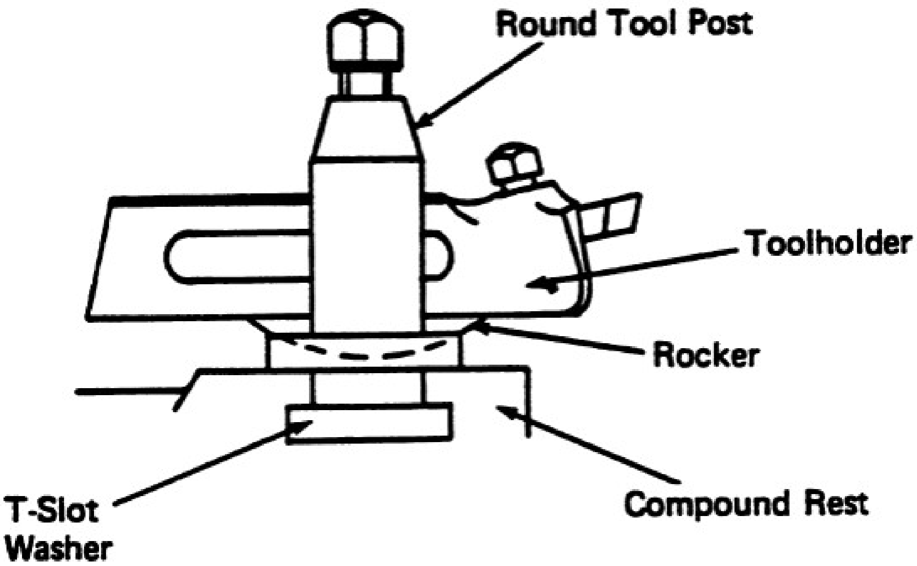


figure: round tool post and toolholder

Shape of Standard Lathe Tools

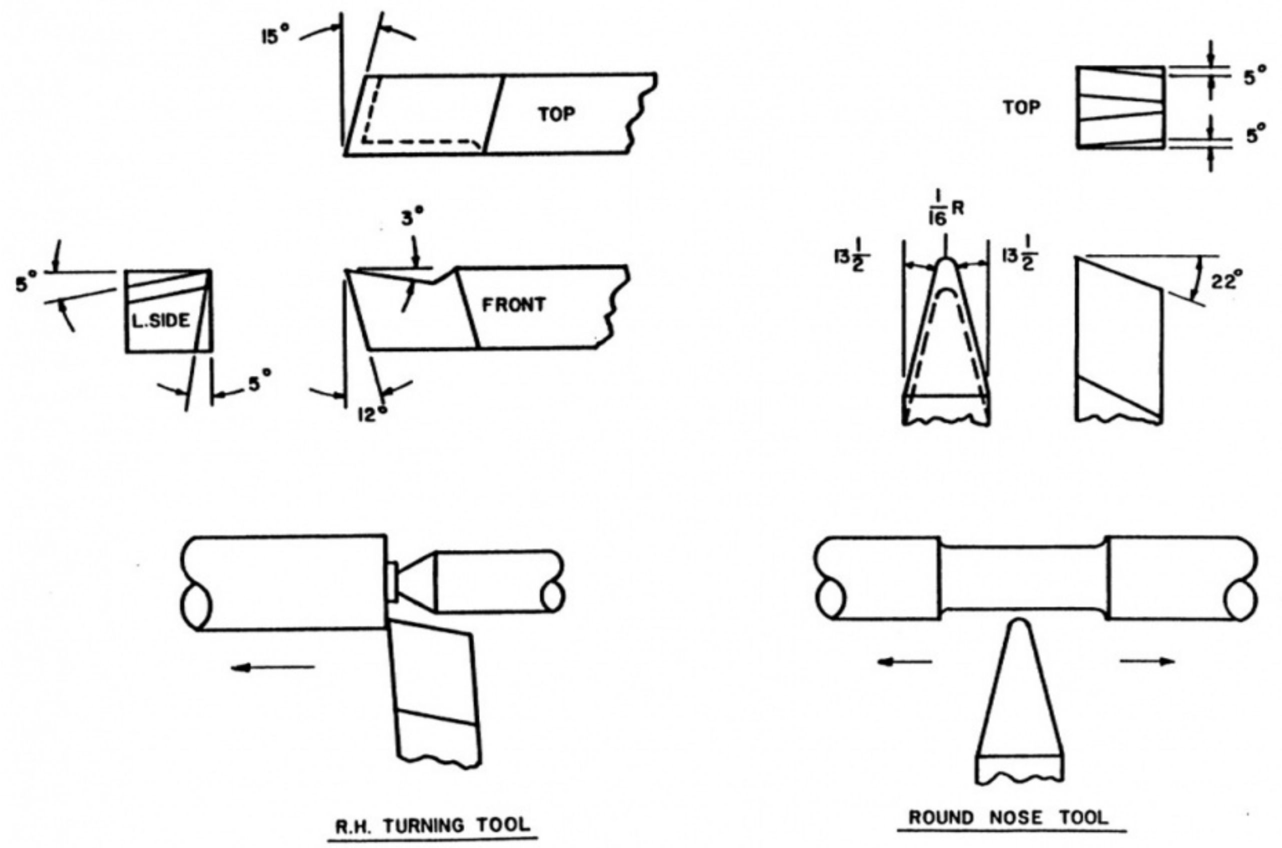


figure: Shape of Standard Lathe Tools

Major Parts of an Engine Lathe

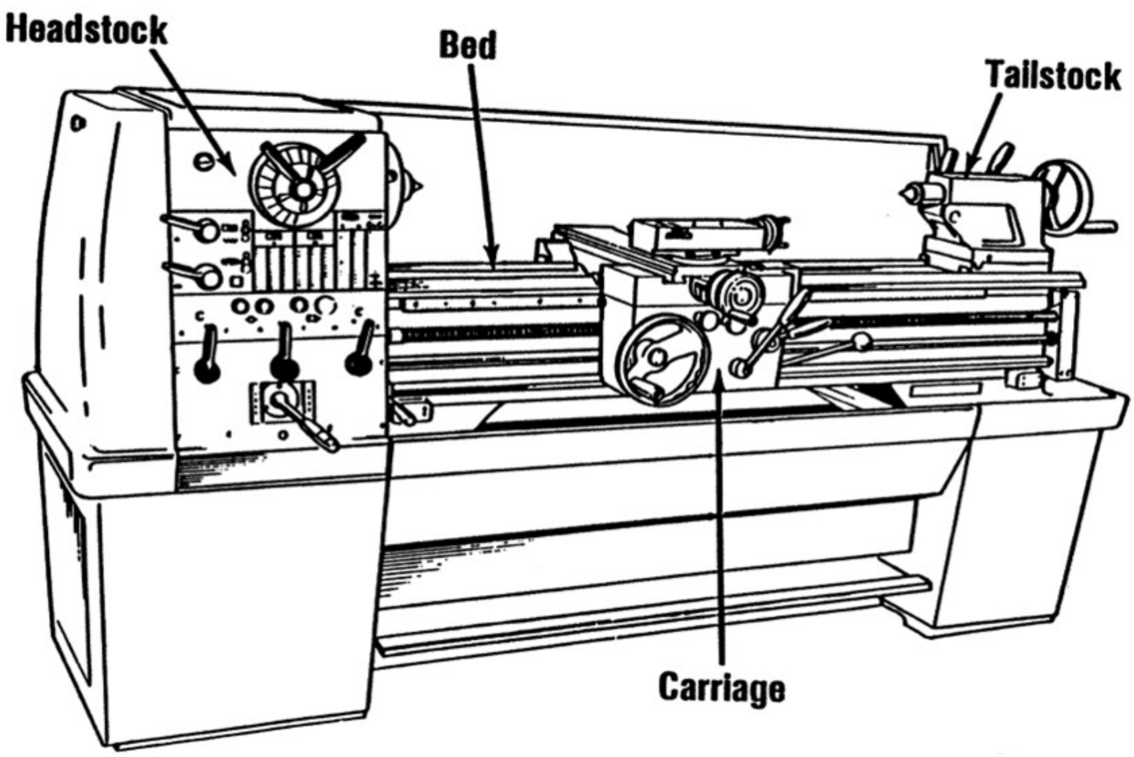


figure: Major Parts of an Engine Lathe

Lathe Headstock

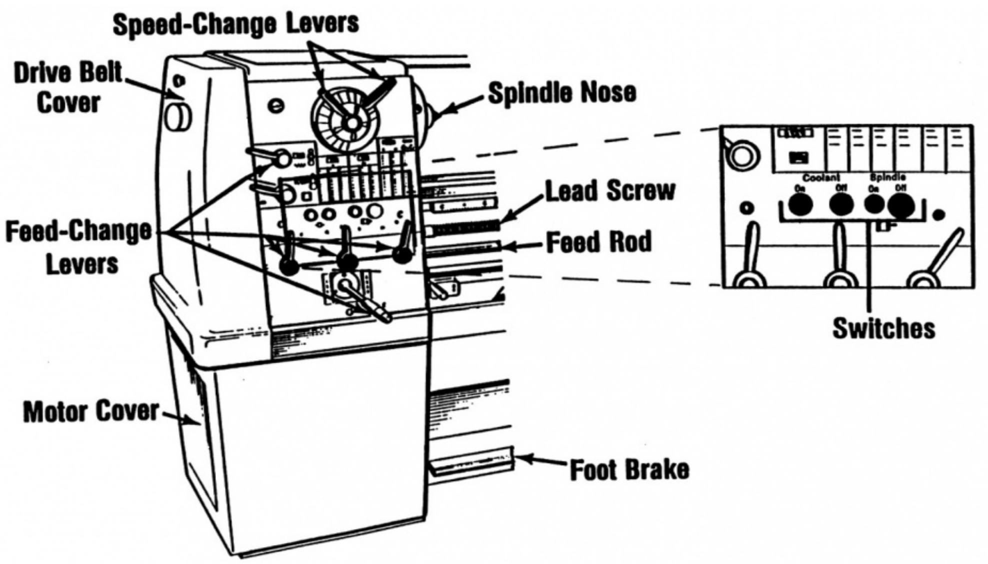


figure: Lathe Headstock

Parts of the Lathe Carriage

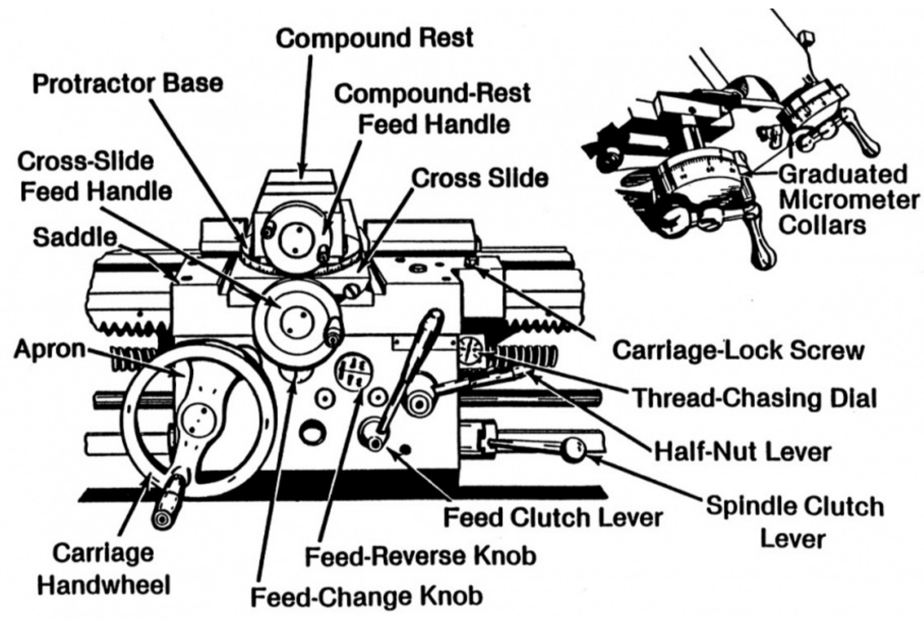


figure: Parts of the Lathe Carriage

Parts of the Lathe Tailstock

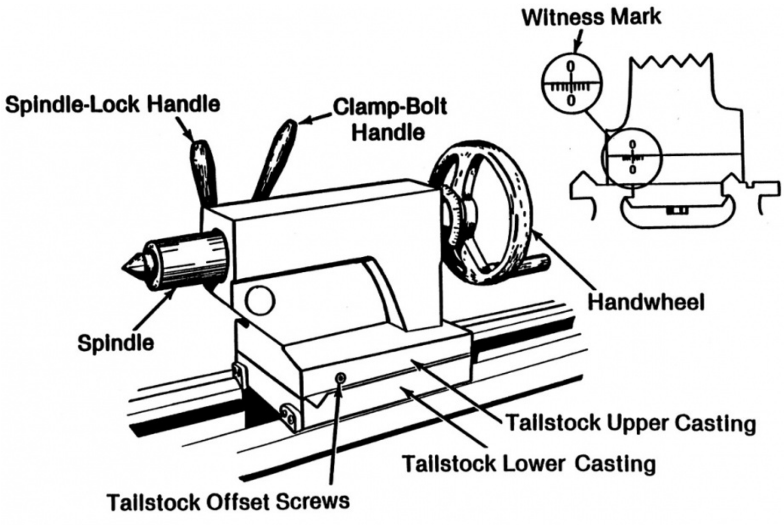


figure: Parts of the Lathe Tailstock

Lathe Accessories

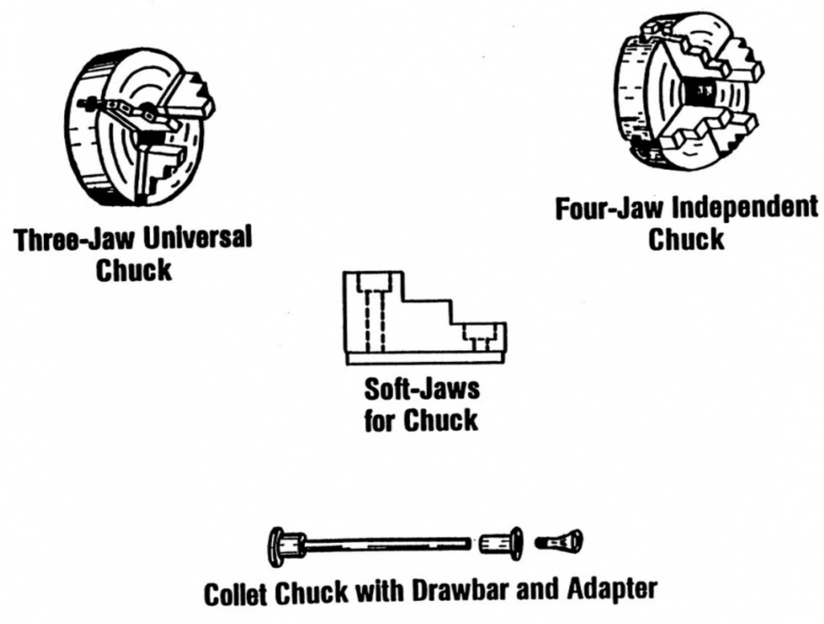


figure: Lathe Accessories

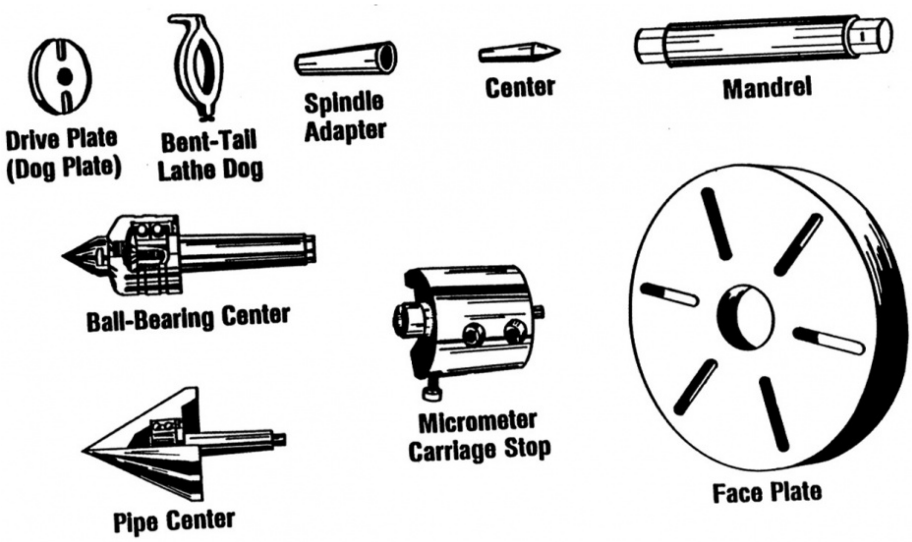


figure: Lathe Accessories

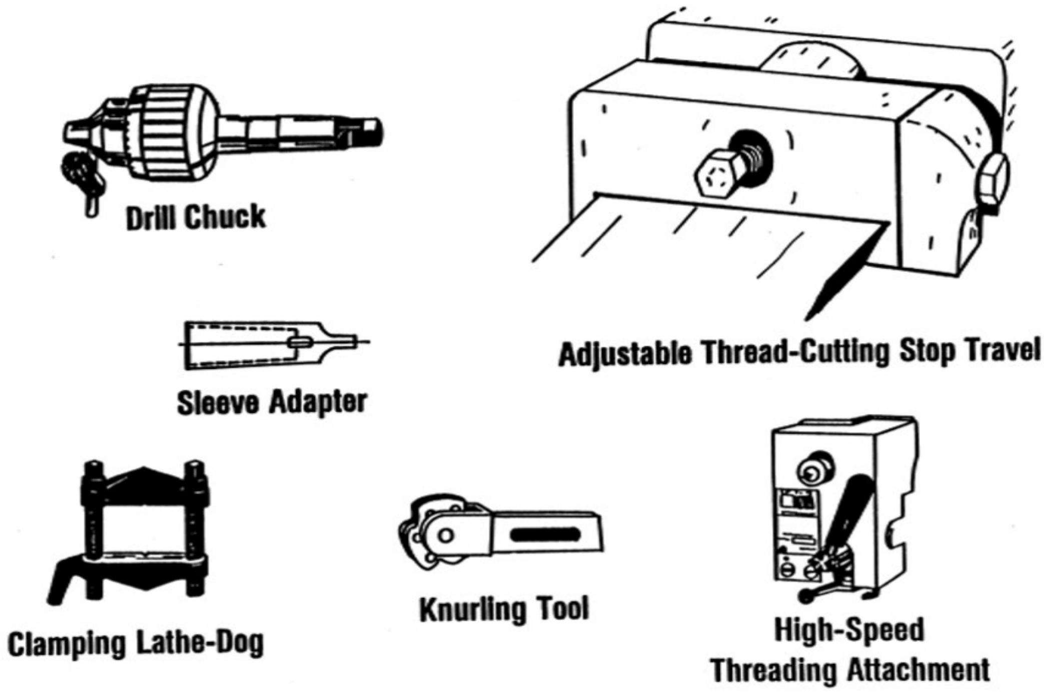


figure: Lathe Accessories

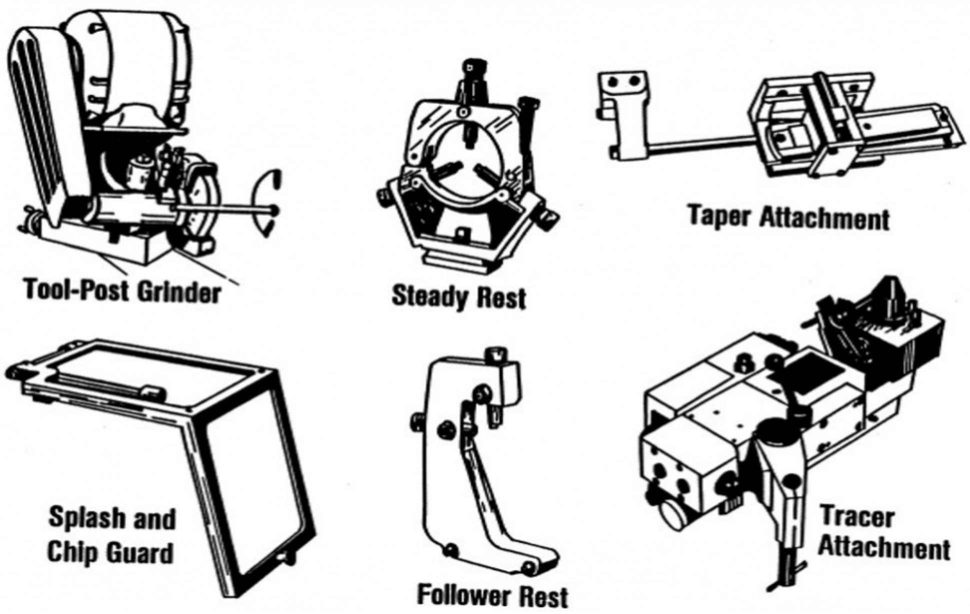


figure: Lathe Accessories

Lathe Spindle Drives

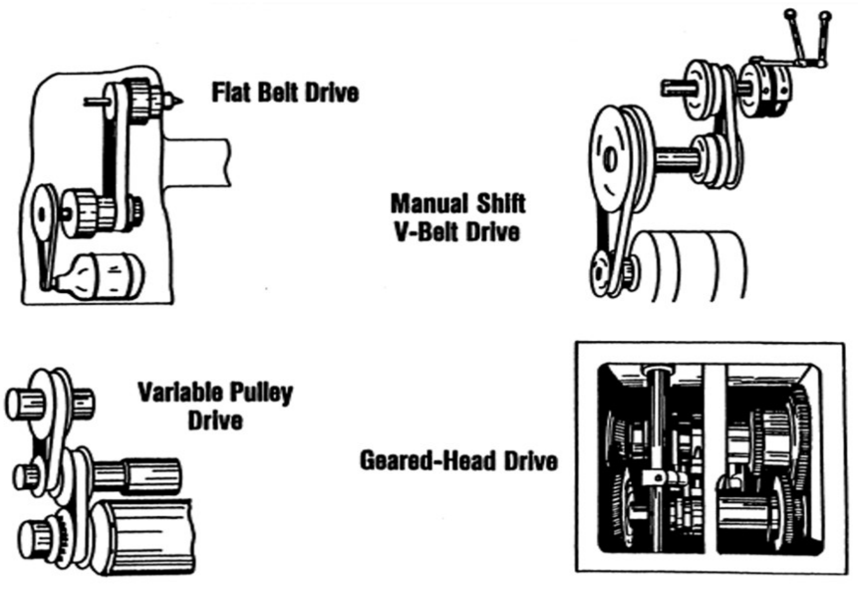


figure: Lathe Spindle Drives

Unit 2 - Mid-Term Exam

2.1 - Module Overview

Concept Goals:

By the end of this module, you should:

- Demonstrate an understanding of this week's material

Concept Content:

This week we will take our mid-term exam. It is located in the assignments tab under test.

This exam has 28 questions. Instructor Note: you can adjust the number of exam questions by either adding your own or marking the live button off on the existing bank of questions.

2.2 - Module Wrap-Up

Concept Content:

Thank you all for your work thus far in this course. Next week we will begin our project-focused part of the semester.

Unit 3 - Projects (Weeks 8-14)

Unit 3 Overview

Concept Goals:

By the end of this module you should:

- Utilize milling and lathe machines to create basic projects (SLO 3)

Concept Content:

Instructor Note: For this unit you can assign the projects as needed among the students. The next module over will have a bank of projects for you to pick and choose from. Given how students will move at their own pace, there are some more advanced projects in there for those who have the time. You will be responsible for selecting which projects to work on for each student in the order that makes the most sense for them.

This section will have learning materials related to the various projects and what students will be learning from them. There are here in a bank for you to go through with the students as they make sense.

Welcome students to the second part of this class. With the first few weeks of orientation and orientation with machines complete, it is time to work on projects. From here to the end of the semester, we will be tackling various projects in class. They are projects for both the mill and the lathe machines. As there are not enough of either machine for all students to work on a singular project, you will each be assigned projects to work on individually. Some may start with a lathe project, some may start on the mill. This will be at my discretion.

See the next module for the project blueprints.

Below are materials related to tapering and turning. **Instructor Note: This is material that will need to be taught in class. It is up to you when this mateiral is taught.**

Videos:

Taper Turning - 2.5 Minutes

Reading:

Terms and Definitions

Interior angle: Angle that lies inside and between two adjacent lines.

figure: **Interior angle**

Included angle: Sum of two equal angles whose common side is center axis of work or a part of work.

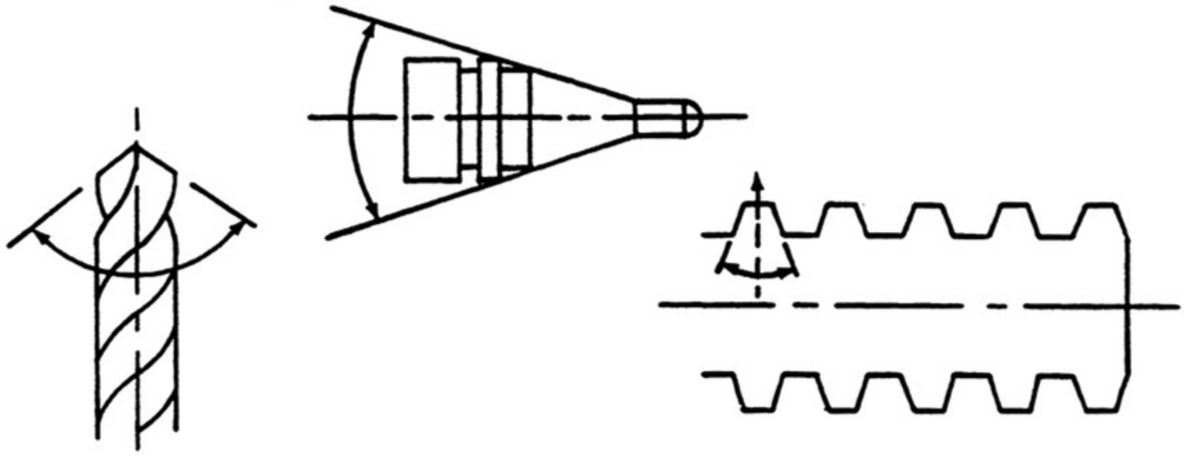


figure: **Included angle**

Right angle: Angle of 90°.

Right triangle: Triangle with two sides at 90° to each other.

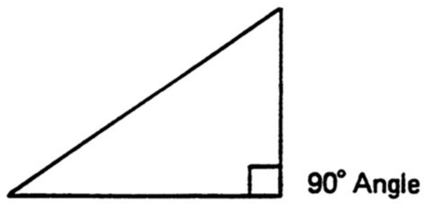


figure: **Right triangle**

Side adjacent: Side of right triangle that forms one side of reference angle and one of the sides of right angle.

Side opposite: die of a right triangle opposite a designates reference angle; forms one side of right angle.

Hypotenuse: Side of a right triangle opposite the right angle.

Sine: Ratio of length of side opposite the hypotenuse.

Cosine: Ratio of length of side of side adjacent to the hypotenuse.

Tangent: Ratio of length of side opposite to length of side adjacent.

Reference angle: Any angle used to define a dimension or give a location.

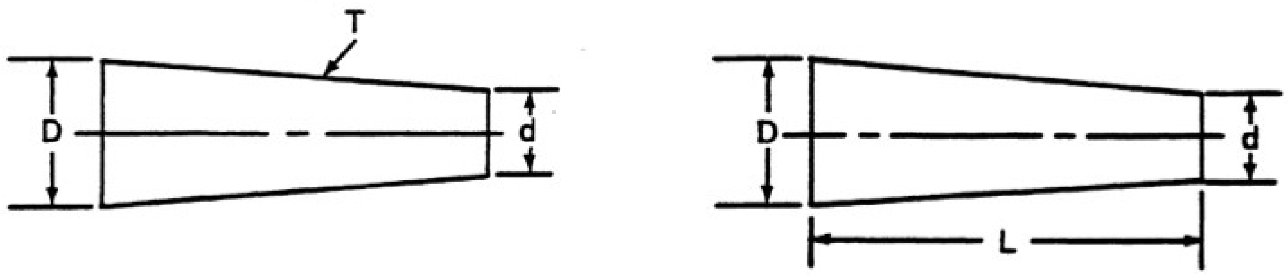
Trigonometric function: Ratio of lengths of two sides of a triangle expressed as a decimal.

Tolerance: Permissible deviation from a design dimension.

Limits: Maximum and minimum dimensions allowed.

Applications of Taper Formulas

T = D – d - Used to determine total taper of a part. To find total taper (T), subtract small diameter (d) from large diameter (D).



tpi = (D- d)/L - Used to determine taper per inch of a part. To find taper per inch (tpi), subtract the small diameter (d) from the large diameter (D) and divide by the length (L) in inches of the taper parallel to the axis

tpf = (D -d)/L x 12 or tpf=tpi x 12 - Used to determine taper per foot of a part. To find taper per foot (tpf), subtract the small diameter (d) from the large diameter (D), divide by the length (L) of taper in inches, and then multiply by 12; or multiply the tpi by 12. The tpi equals tpf divided by 12.

D = (tpi x L)+d - Used to determine large diameter of a part if taper per inch and small diameter are known.

d = D - (tpi x L) - Used to determine small diameter of a part if taper per inch and large diameter are known.

TO = (tpi x Overall Length)/2 - Used to determine tailstock offset.

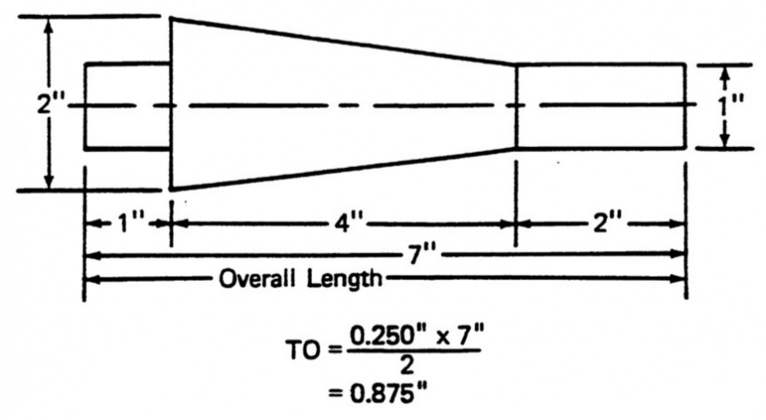
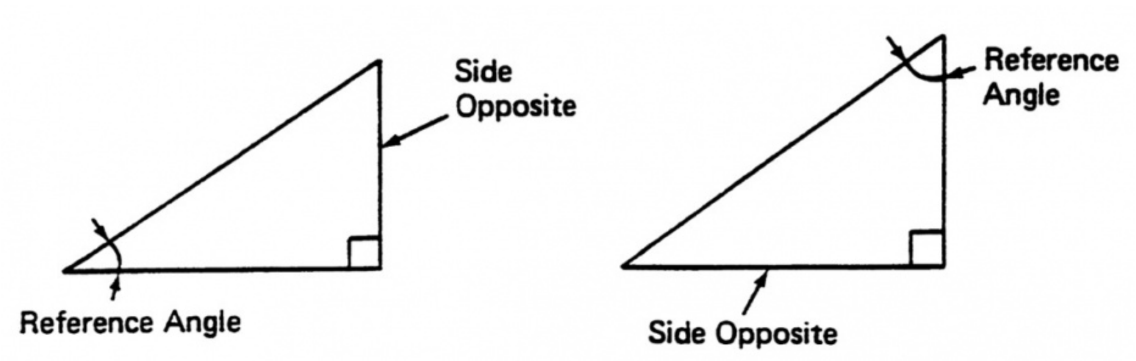


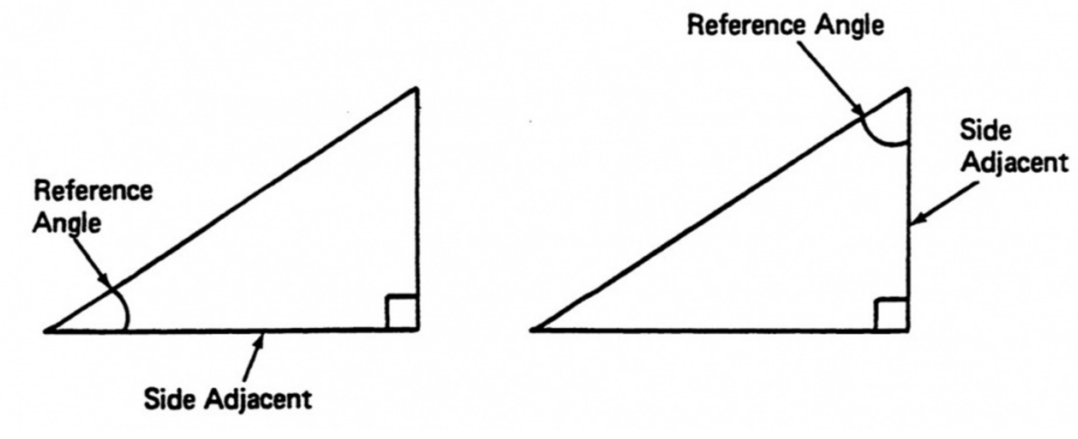
figure: **tailstock offset**

Sides of Right Triangles

Side Opposite

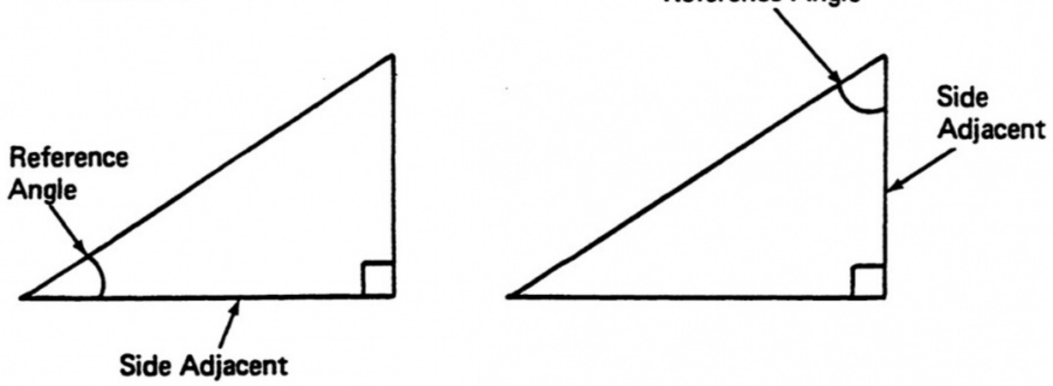


Side adjacent



Hypotenuse

FIGURE 11



Unit 3 Projects

Concept Content:

Here are the blueprints for machining projects for this course. **(Instructor note: this is a bank of potential projects, you can pick and choose which ones you like. There are more projects there than most students would be able to do in one semester).**

Your instructor will assign the projects from this bank of projects.

Projects:

Project 1

Project 2

Project 4

Project 5

Plumb Bob

C Clamp

Glock Hammer

Edge Clamp

Unit 4 - Final Exam

15.1 Final Exam

Concept Goals:

By the end of this module, you will:

- Demonstrate understanding of course material

Concept Content:

This week is our final exam. It is located in the assignments tab under test.

This exam has 34 questions. **Instructor note: you can adjust the number of questions by either adding in questions or setting the current questions to not live.**

15.2 Course Wrap-Up

Concept Content:

Thank you all for taking the final exam. Also, thank you all for your work in the course this semester. Best of luck as you move forward in the program.

Faculty Resources (For Instructor Only, Do Not Publish Live)