MAC-112, Machining Technology II

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.

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.

Course Syllabus

Concept Goals:

Insert the student learning outcomes for the course here.

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 Goals:

You can leave this section blank provided you uploaded the student learning outcomes to the previous section.

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 the basics of speeds and feeds
2. Understand the use of specific cutting tools
3. Understand the basics of how to set up and run a milling machine and a lathe machine.
4. Understand and utilize basic safety protocols in the machine shop such as proper use of personal protective equipment, and other guides to OSHA standards.

Concept Content:

This course introduces machining operations as they relate to the metalworking industry. Topics include machine shop safety, measuring tools, lathes, drilling machines, saws, milling machines, bench grinders, and layout instruments. Upon completion, students should be able to safely perform the basic operations of measuring, layout, drilling, sawing, turning, and milling.

Module	Module Learning Objectives
Unit 1 - Week 1 - Safety	• Describe the lockout/tagout process (SLO 4) • Demonstrate the ability to properly clean up the machine shop (SLO 4) • Describe the types of PPE and their uses (SLO 4) • Describe the uses of various machine guards (SLO 4)
Unit 1 - Week 2 - Grinders	• List and describe the different types of grinding machines (SLO 2) • Understand and describe the surface grinding process and how it works (SLO 2)

Unit 1 - Week 3 - Lathe and Milling Machine Review	• Describe the parts and functions of a milling machine (SLO 3) • Describe the parts and functions of a lathe machine (SLO 3) • Demonstrate adherence to proper safety protocols in the machine shop (SLO 4)
Unit 1 - Week 4 - Workholding Devices	• Identify machining tool holding devices (SLO 2) • Describe the difference between different types of chucks (SLO 3)
Unit 1 - Week 5 - Feeds and Speeds	• Demonstrate understanding of Feeds and Speeds by calculating them based on materials presented (SLO 1) • Define key terms such as RPM, IPT, IPR, etc. (SLO 1)
unit 1 - Week 6 - Coolants	• Describe the basics of maintaining CNC coolant levels and quality (SLO 3, SLO 4)
Unit 2 - Week 7 - Mid-Term Exam	• Demonstrate understanding of course material.
Unit 3 - Week 8 - Projects	• Utilize milling and lathe machines to create basic projects (SLO 3)
Unit 3 - Week 9 - Projects	• Utilize milling and lathe machines to create basic projects (SLO 3)
Unit 3 - Week 10 - Projects	• Utilize milling and lathe machines to create basic projects (SLO 3)
Unit 3 - Week 11 - Projects	• Utilize milling and lathe machines to create basic projects (SLO 3)
Unit 3 - Week 12 - Projects	• Utilize milling and lathe machines to create basic projects (SLO 3)
Unit 3 - Week 13 - Projects	• Utilize milling and lathe machines to create basic projects (SLO 3)
Unit 3 - Week 14 - Projects	• Utilize milling and lathe machines to create basic projects (SLO 3)
Unit 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

Week 1 - Safety

Concept Goals:

By the end of this week, you should:

- Describe the lockout/tagout process (SLO 4)
- Demonstrate the ability to properly clean up the machine shop (SLO 4)
- Describe the types of PPE and their uses (SLO 4)
- Describe the uses of various machine guards (SLO 4)

Concept Content:

Welcome to MAC 112. This first week we will have an overview of machine shop safety. We will cover some familiar topics such as personal protective equipment (PPE) and machine shop clean up. We will also cover electrical safety, lockout tagout procedures, and machine guarding. All of this is foundational knowledge to be as safe as possible in the machine shop.

This Week's Material:

Lectures:

PPE OSHA Presentation - 36 Slides

Machine Shop Clean Up - 4 Slides

Lockout Tagout Presentation - 8 Slides

Electrical Safety Presentation - 27 Slides

Machine Guarding Presentation - 32 Slides

Videos:

Machine Safeguards: The Basics - 6.5 Minutes

Assignment:

Week 1 Quiz -18 Questions

Week 2 - Grinders

Concept Goals:

By the end of this week, you should:

- List and describe the different types of grinding machines (SLO 2)
- Understand and describe the surface grinding process and how it works (SLO 2)

Concept Content:

This week we will discuss grinding and grinders. In machining, these tools are utilized often so knowing how they work is important for your success in the industry.

This week's material:

Reading:

Machining 101: What is grinding

Dorin, E. (2021, July 3). *Machining 101: What is grinding?*. Modern Machine Shop. https://www.mmsonline.com/articles/machining-101-what-is-grinding

19 Types of Grinding Machines and Their Uses

Xometry, T. (2023, November 8). *19 types of grinding machines and their uses*. Xometrys RSS. https://www.xometry.com/resources/machining/types-of-grinding-machines/

Videos:

Surface Grinding Machine Working and Classification - 4 Minutes

How Surface Grinding Works - 6 Minutes

Assignment:

Week 2 Quiz - 9 Questions

Week 3 - Lathe and Milling Machine Review

Concept Goals:

By the end of this week, you should be able to:

- Describe the parts and functions of a milling machine (SLO 3)
- Describe the parts and functions of a lathe machine (SLO 3)
- Demonstrate adherence to proper safety protocols in the machine shop (SLO 4)

Concept Content:

This week we will review Milling Machines and Lathes. We will cover topics including machine parts, operations, types of machines, and safety.

This Week's Material

Videos:

What is Milling? Parts, Questions, and Types of Machines - 15.5 Minutes

Lathe Machine: Parts, Function, Working, Operations & Types of Lathes - 14.5 Minutes

Millin Machine Safety Overview - 6.5 Minutes

Lathe Fundamentals 101: Lathe Safety - 12.5 Minutes

Reading:

Embedded Below

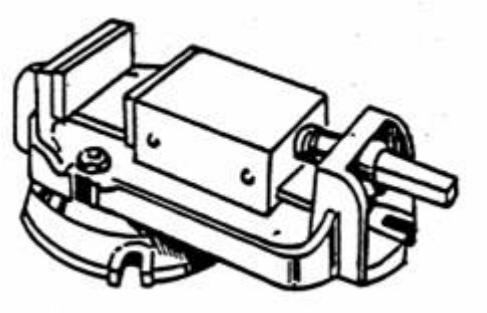
Assignment:

Week 3 Quiz - 10 Questions

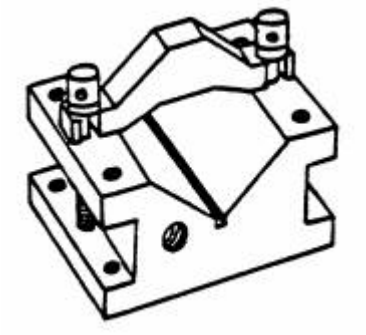
As a reminder, here are parts and accessories of Milling and Lathe Machines:

Milling Machine Parts and Accessories

Precision Vise



Vee block and clamp



Precision Parallels

Dead Blow Hammer

Milling Machine Parts

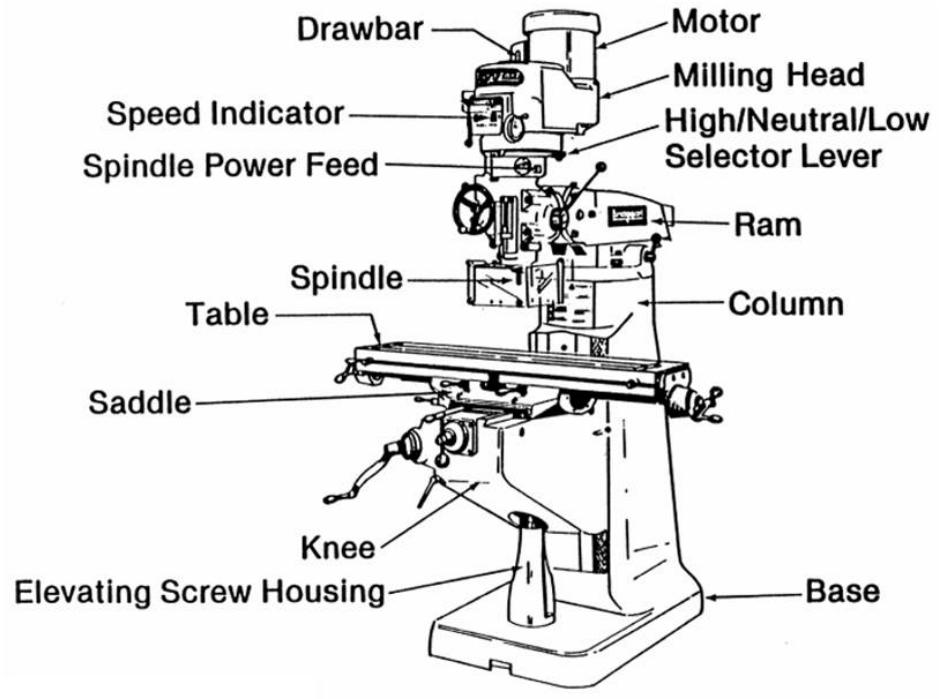


figure: Milling Machine Parts

Rotary table

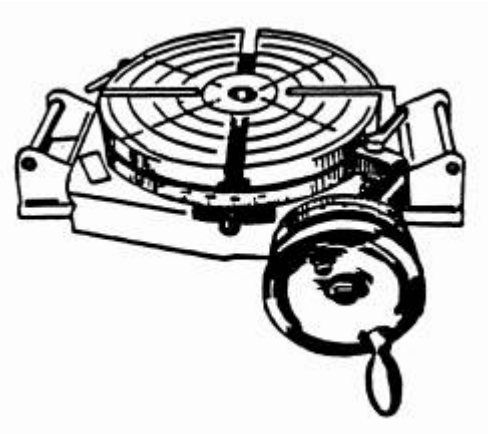


figure: Rotary table

Mill Holders

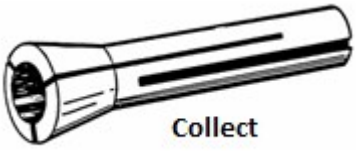


figure: Mill Holders

Hold-down clamp

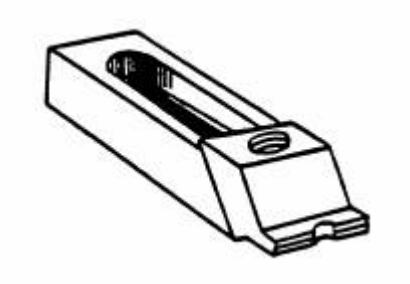


figure: Hold-down clamp

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

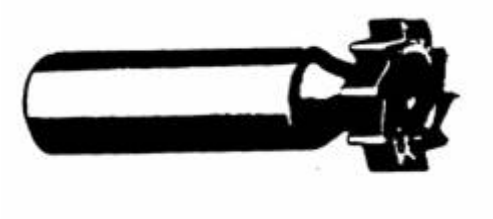


figure: Woodruff keyseat cutter

Countersink

figure: Countersink

Counterbore with pilot

figure: Counterbore with pilot

Parts of the Milling Head

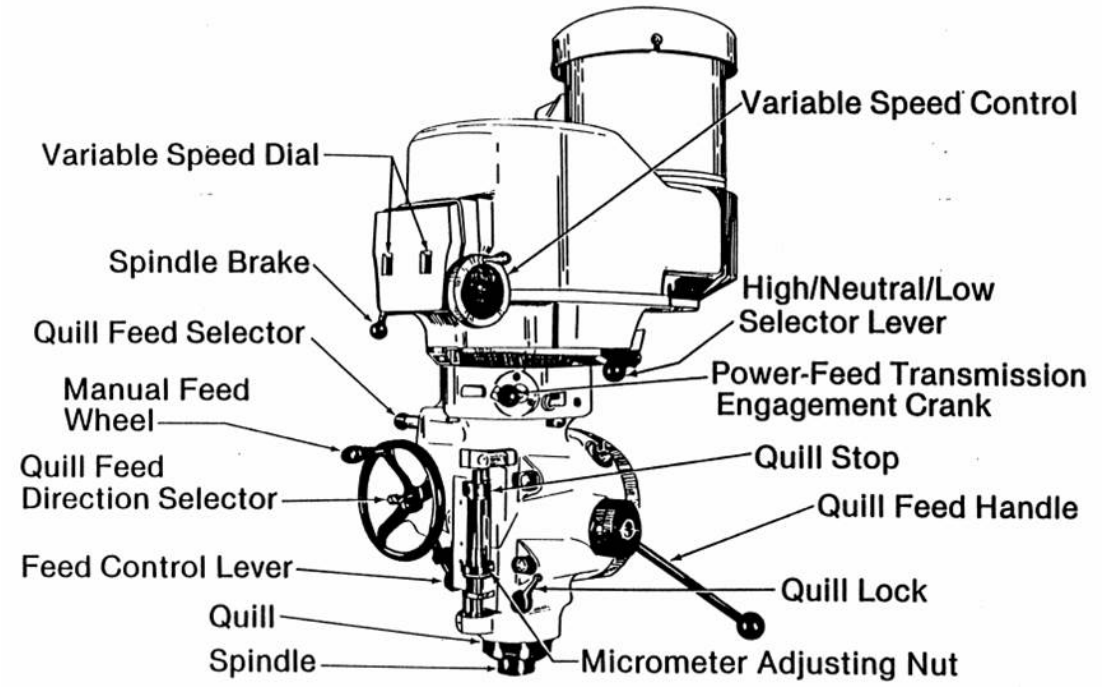


figure: Parts of the Milling Head

Basic Lathe Operations

Turning: Removing material from outside surface of part.

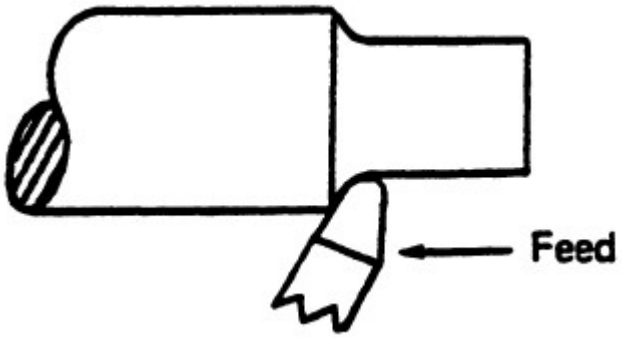


figure: Turning

Facing: Removing material from end surface of part

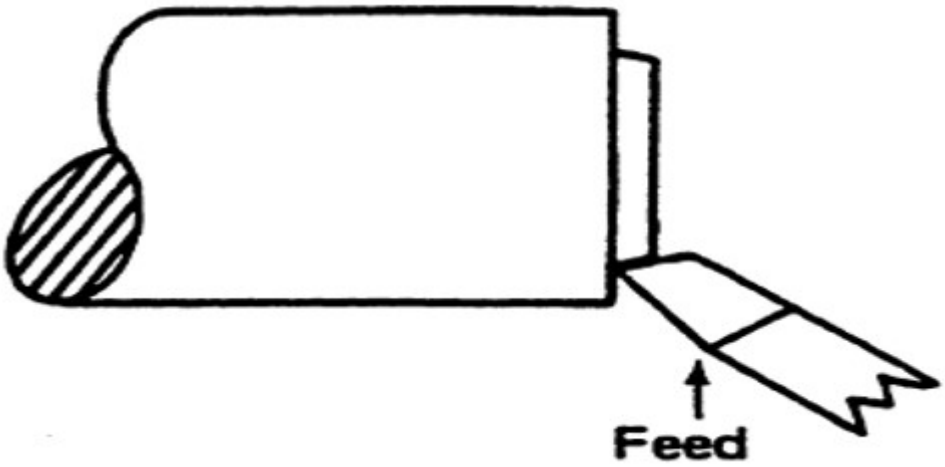


figure: Facing

Grooving: Cutting a recess in work.

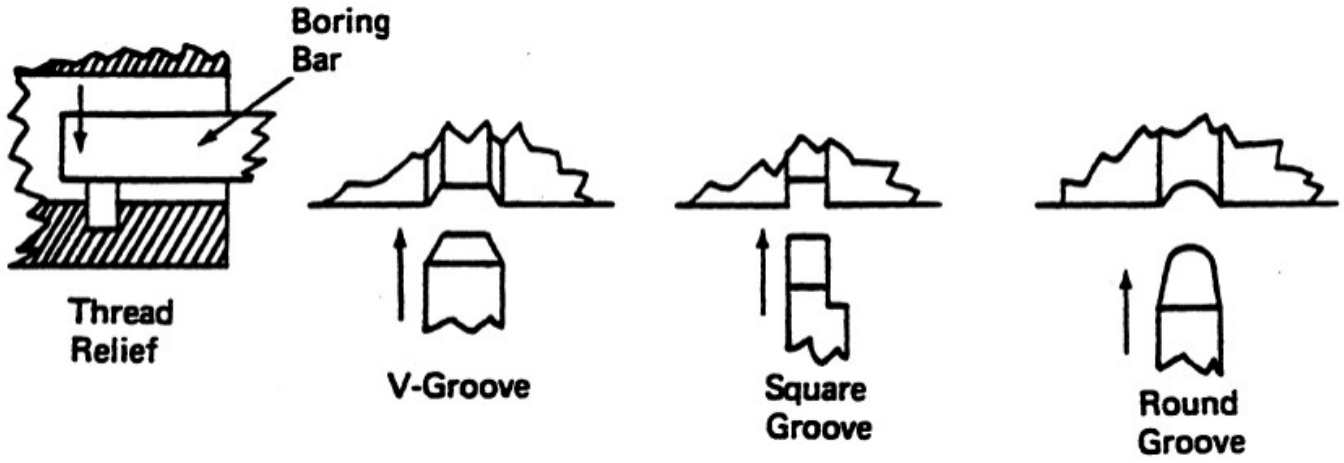


figure: Grooving

Note

Arrows indicate feed direction

Boring: Enlarging an existing hole.

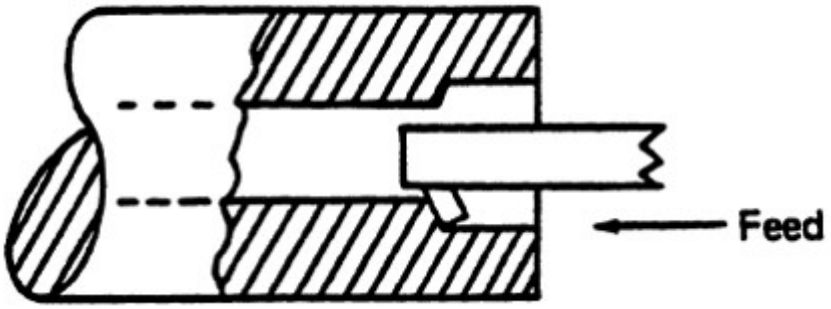


figure: Boring

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

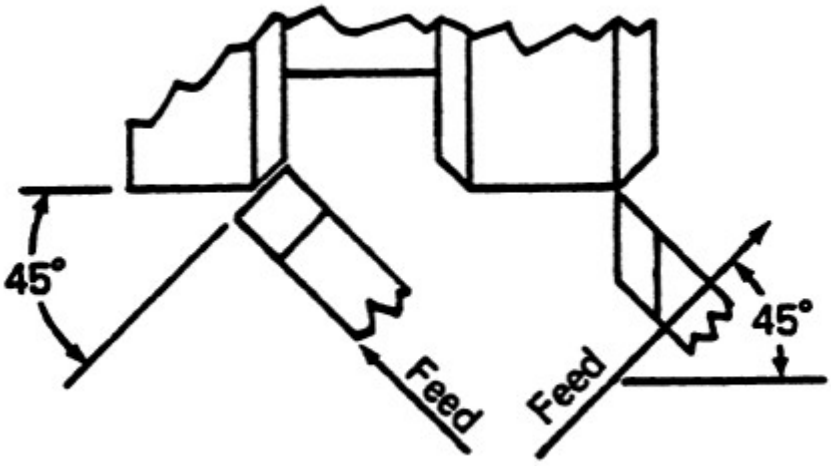


figure: Chamfering

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

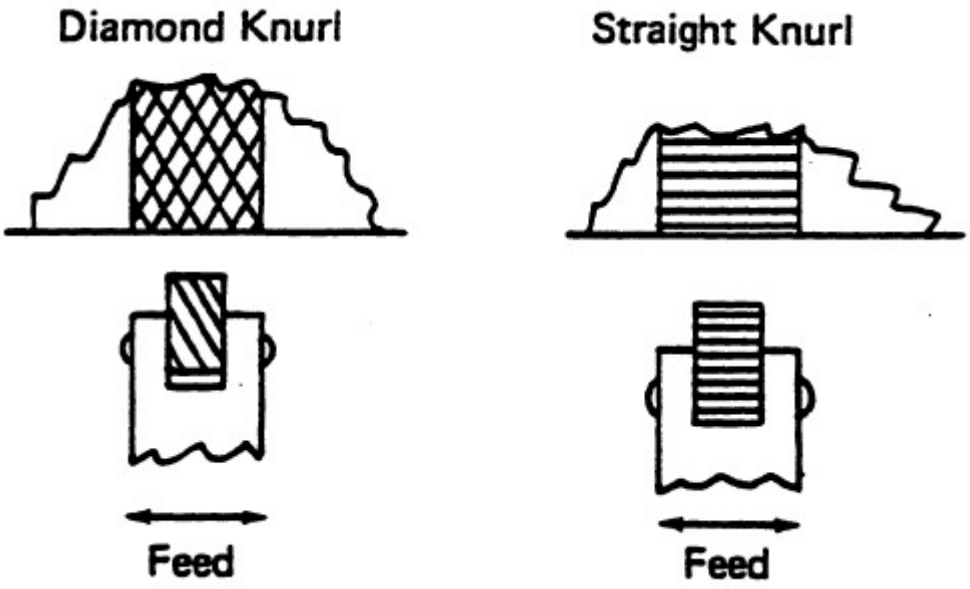


figure: Knurling

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

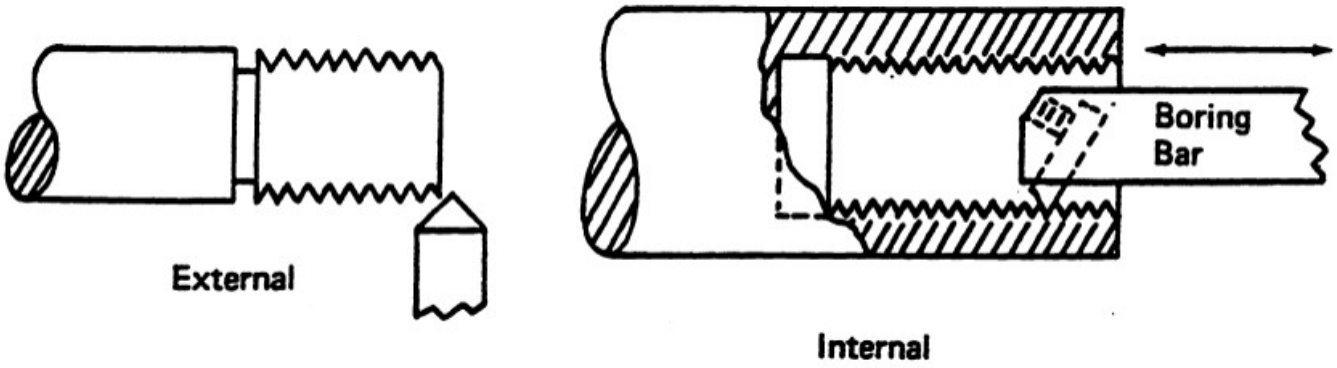


figure: Threading

Drilling: Producing a hole with a drill.

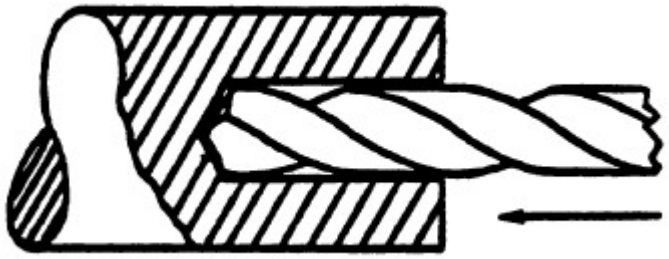


figure: Drilling

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

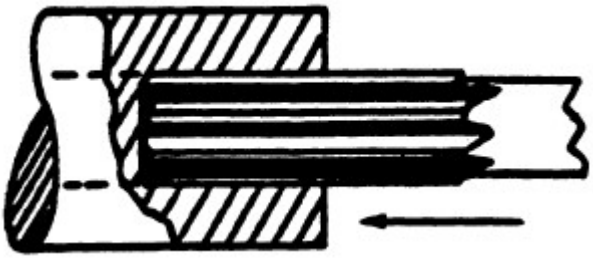


figure: Reaming

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

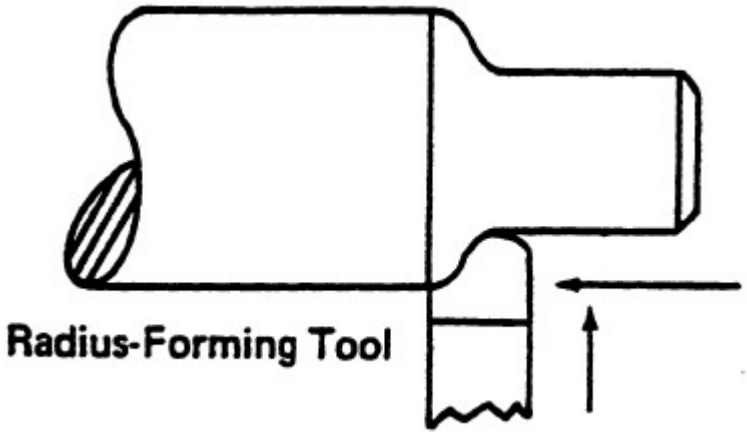


figure: Forming

Shouldering: Finishing surface where two diameters or steps meet.

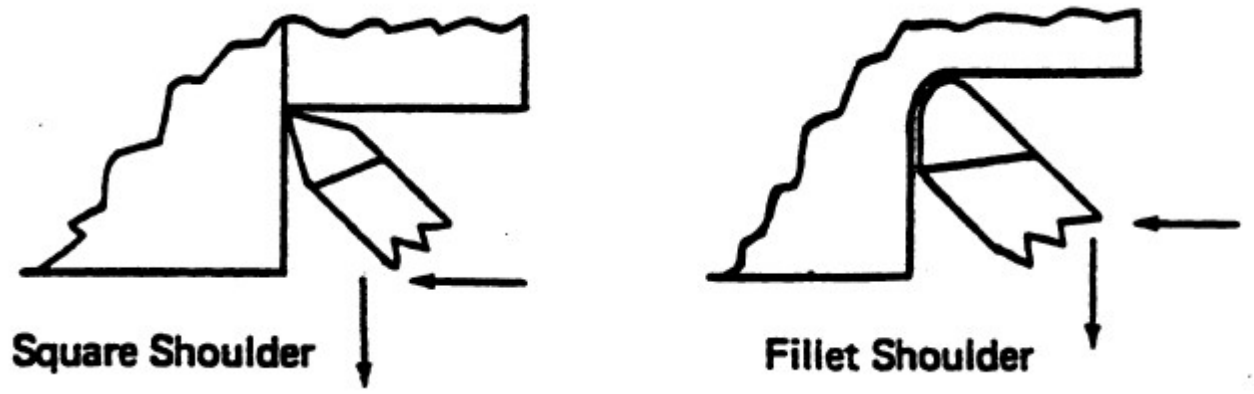


figure: Shouldering

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

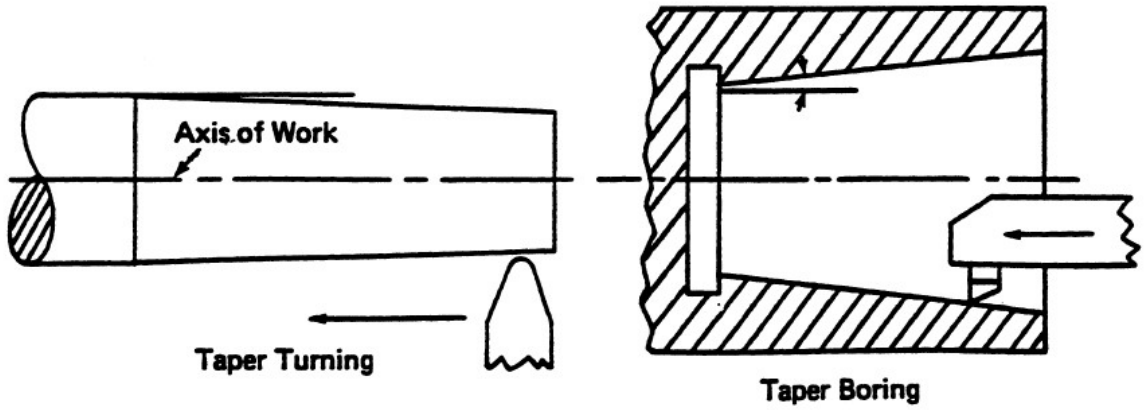


figure: Tapering

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

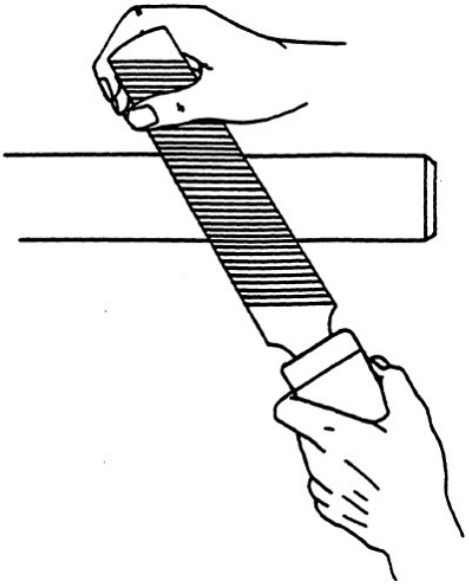


figure: Filling

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

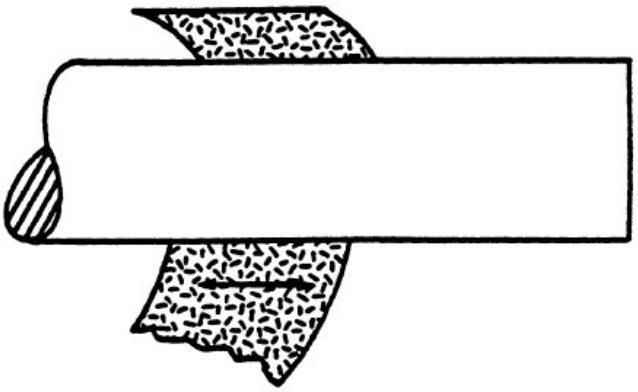


figure: Polishing

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.

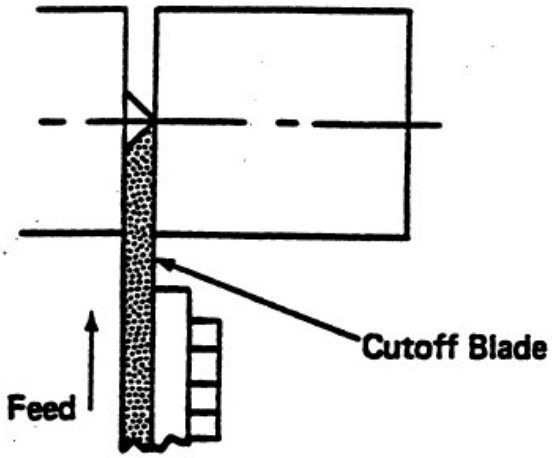


figure: Cutoff

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.

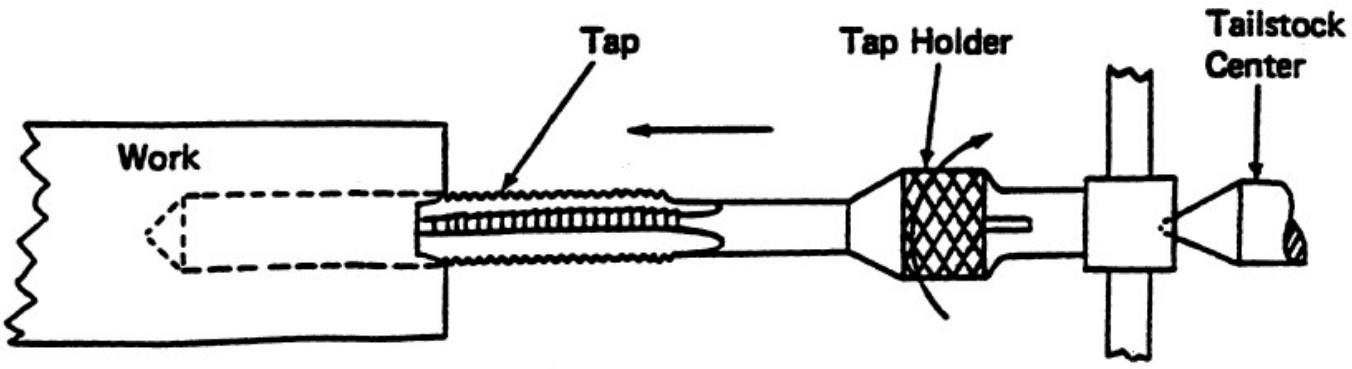


figure: Tapping

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.

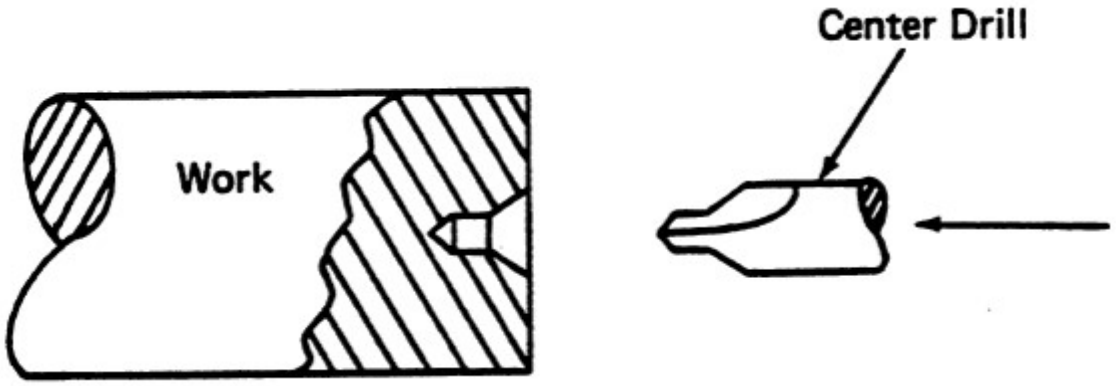


figure: Center Drilling

Types of Tool Posts and Toolholders

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

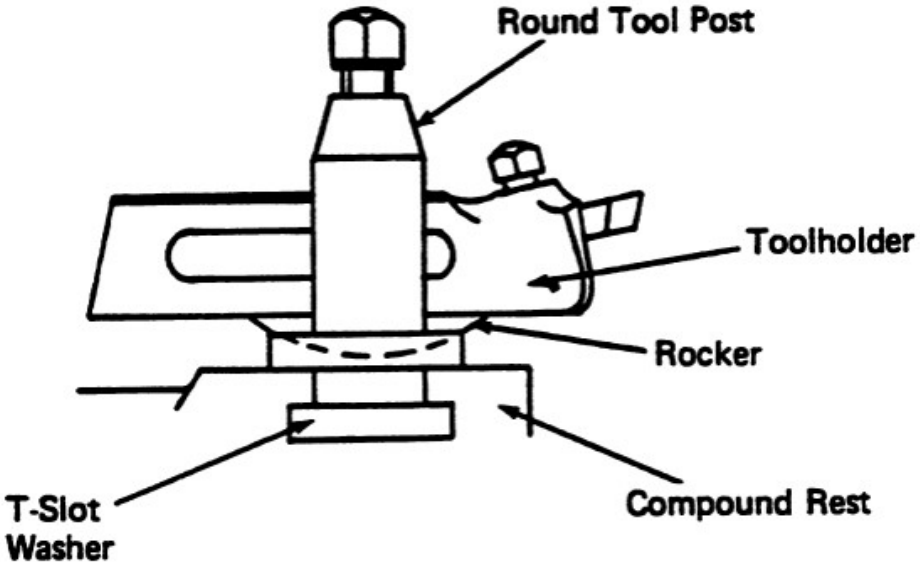


figure: round tool post and toolholder

Shape of Standard Lathe Tools

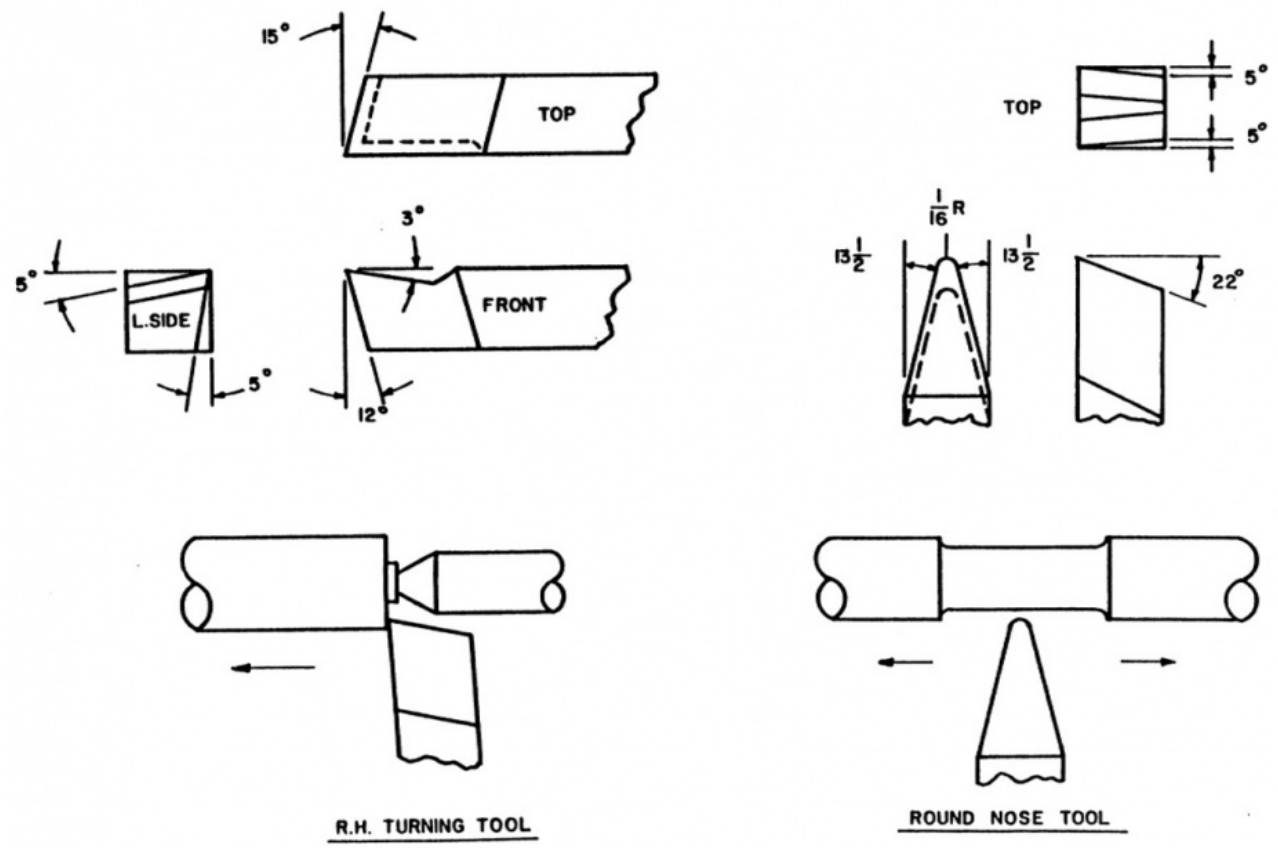


figure: Shape of Standard Lathe Tools

Major Parts of an Engine Lathe

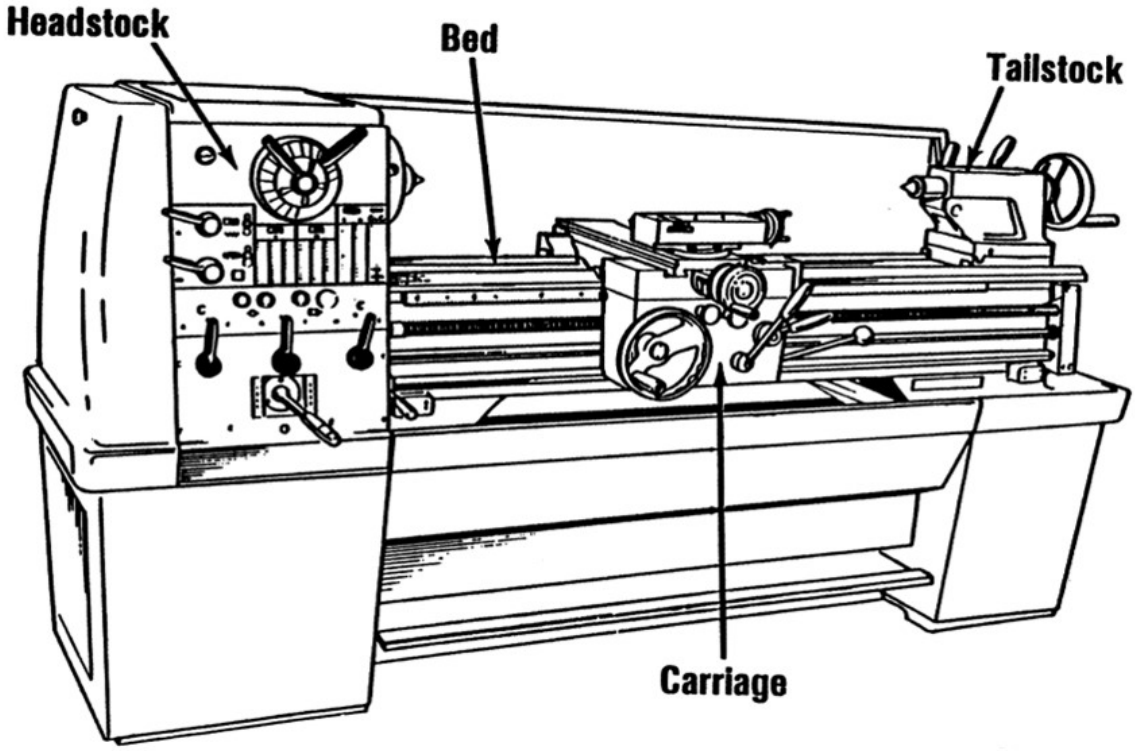


figure: Major Parts of an Engine Lathe

Lathe Headstock

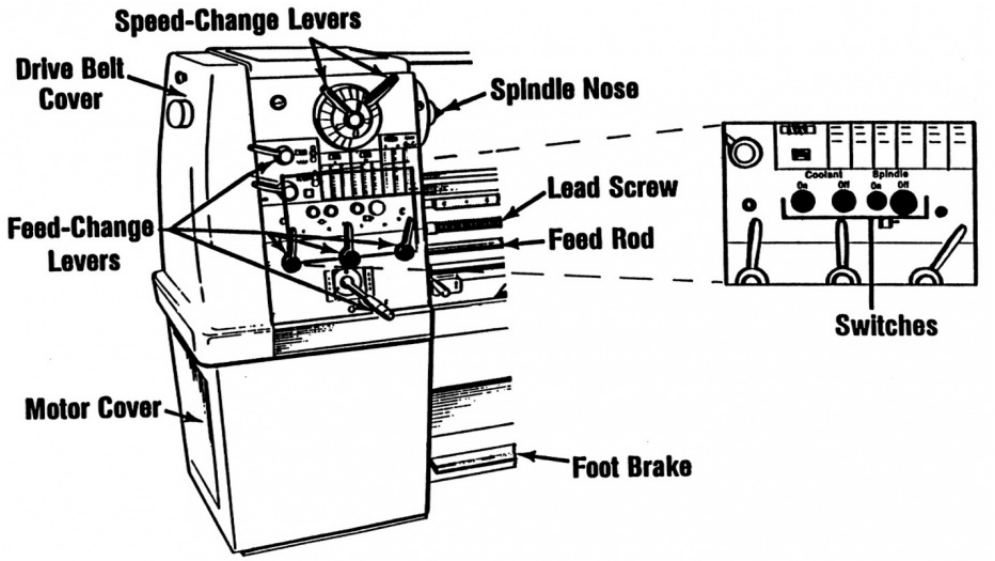


figure: Lathe Headstock

Parts of the Lathe Carriage

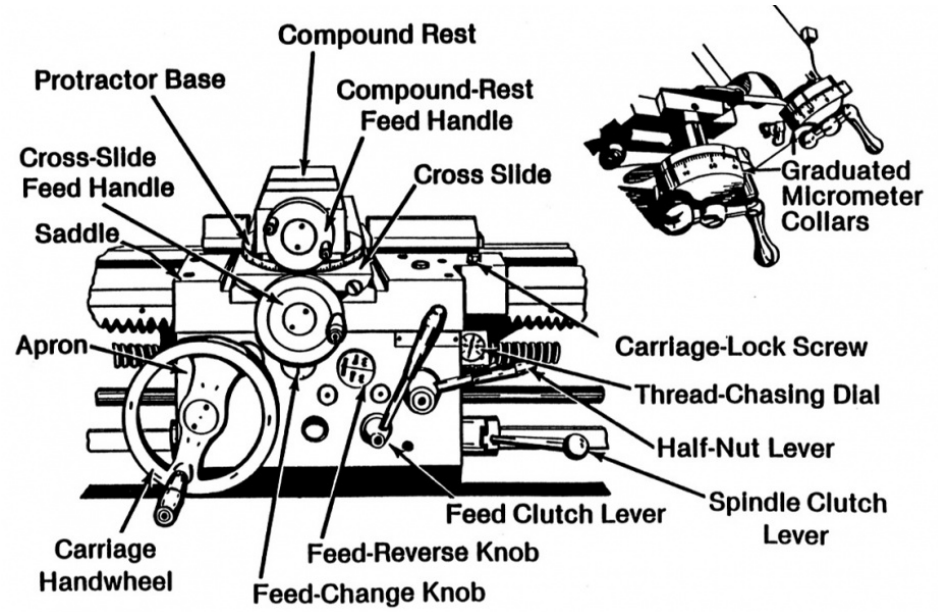


figure: Parts of the Lathe Carriage

Parts of the Lathe Tailstock

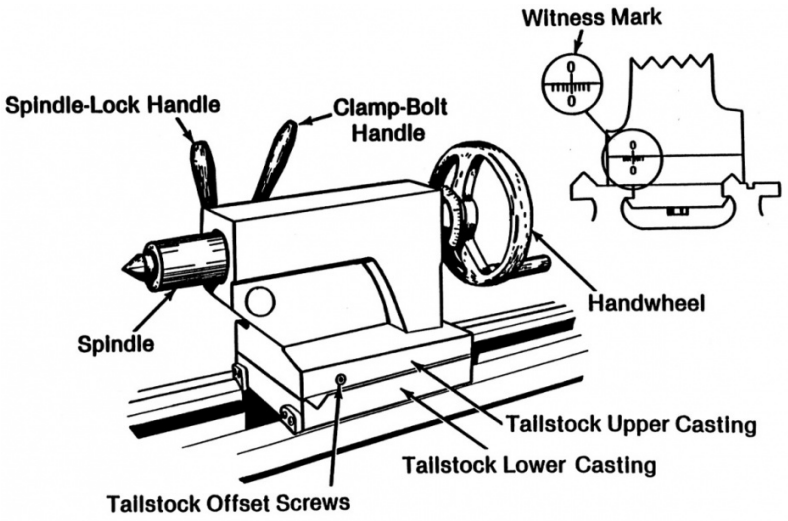


figure: Parts of the Lathe Tailstock

Lathe Accessories

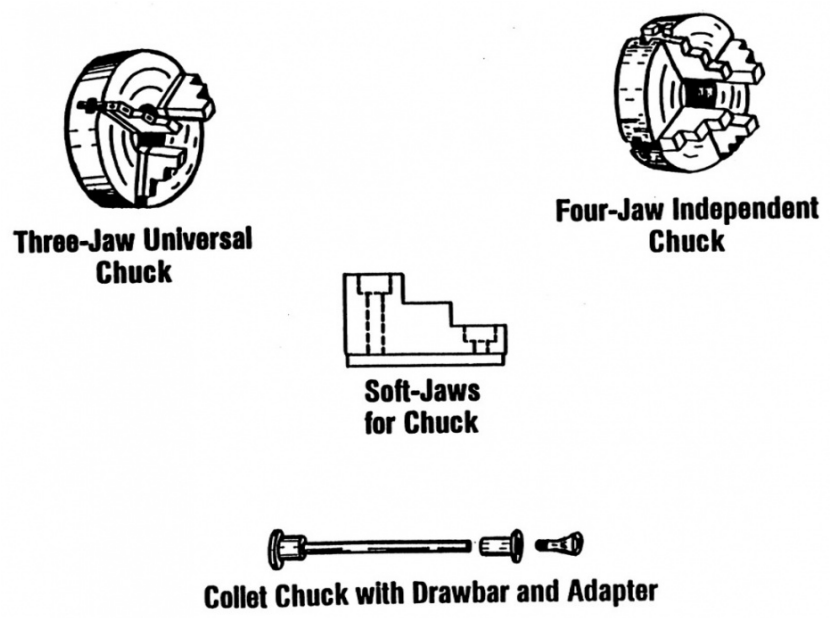


figure: Lathe Accessories

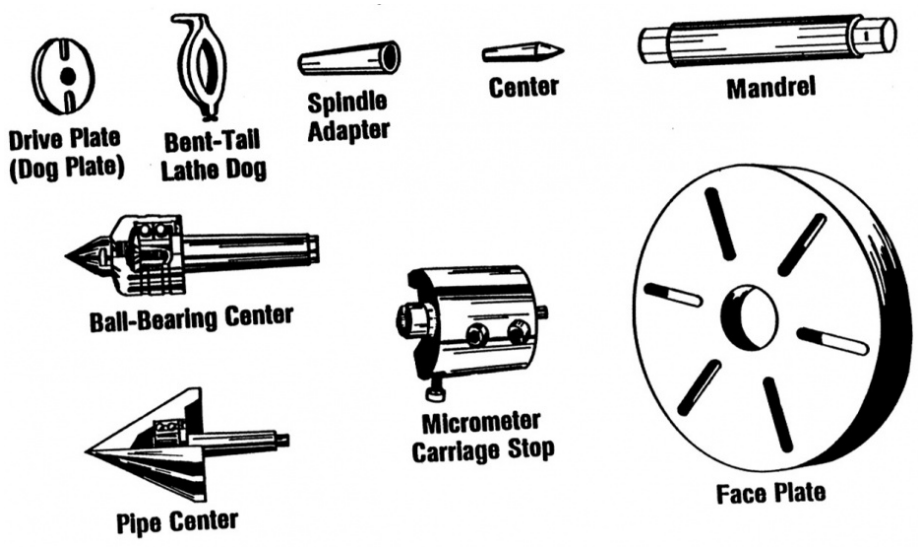


figure: Lathe Accessories

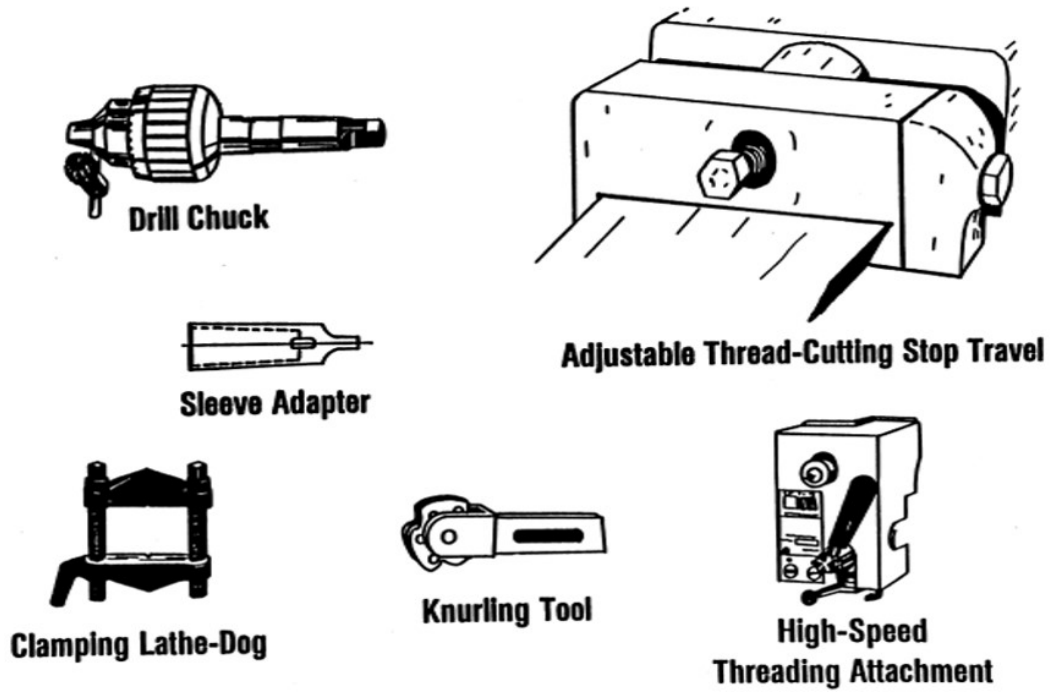


figure: Lathe Accessories

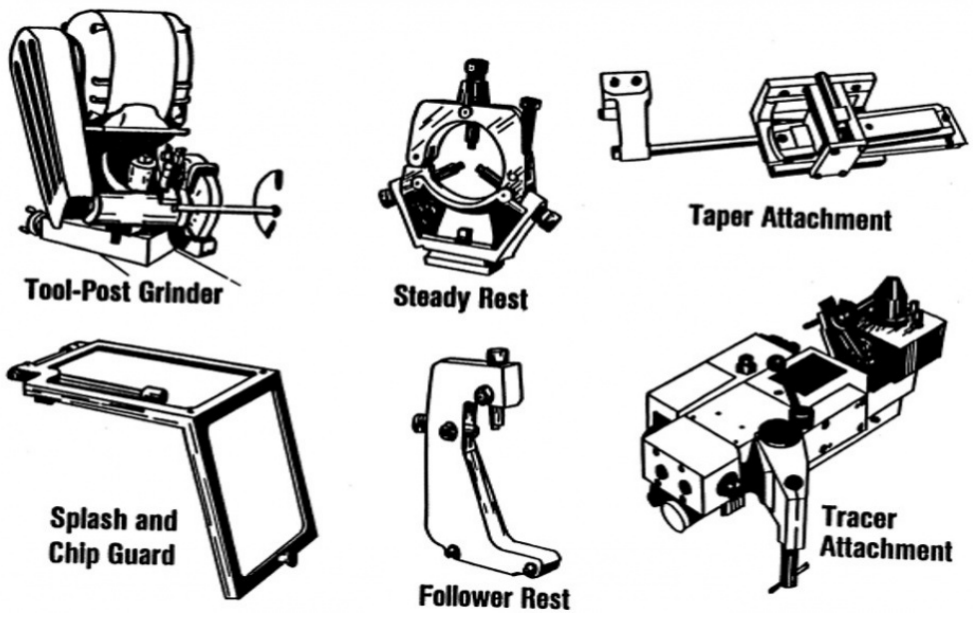


figure: Lathe Accessories

Lathe Spindle Drives

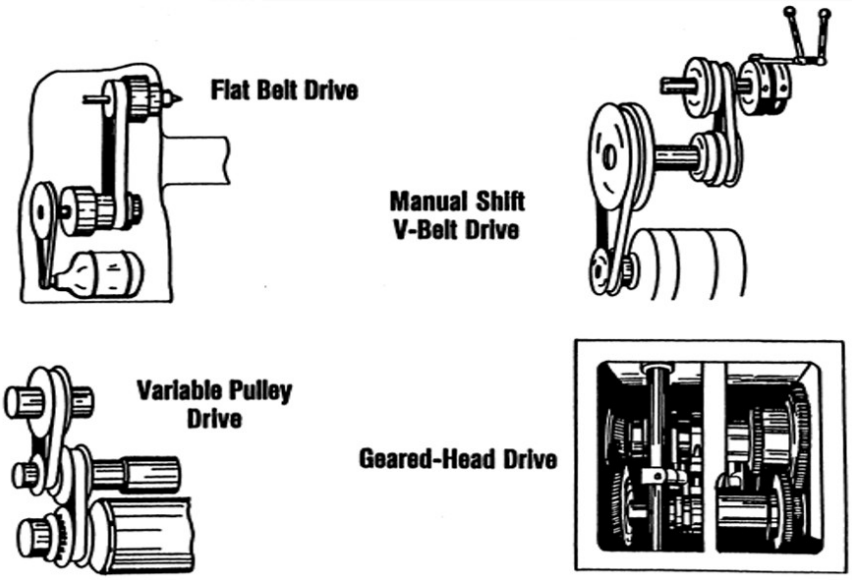


figure: Lathe Spindle Drives

Week 4 - Workholding Devices

Concept Goals:

By the end of this week, you should be able to:

- Identify machining tool holding devices (SLO 2)
- Describe the difference between different types of chucks (SLO 3)

Concept Content:

This week we will go over tool and workholding devices for both lathes and milling machines. It is important to know which tools to use for what jobs and how to properly attach them to the machine.

Videos:

Milling - Tool and Workholding Devices - 3.5 Minutes

Work and Tool Holding Devices for Lathes - 12 Minutes

Handouts:

Attaching the chucks to workholding devices/machines - 5 Pages

Identifying 3-Jaw and 4-Jaw Chucks - 3 Pages

Assignments:

Week 4 Quiz - 5 Questions

Week 5 - Feeds and Speeds

Concept Goals:

By the end of this week, you should:

- Demonstrate understanding of Feeds and Speeds by calculating them based on materials presented (SLO 1)
- Define key terms such as RPM, IPT, IPR, etc. (SLO 1)

Concept Content:

This week we will discuss feeds and speeds. You will need to understand how to calculate them in order to successfully cut materials while using either a lathe or milling machine. We will discuss how to run those calculations.

This week's material:

Lecture:

CNC Milling Feeds and Speeds - 7 Slides

Reading:

Embedded Below

Assignment:

Week 5 Quiz - Download and complete the quiz and upload the completed copy to the quiz section under the assignments tab.

SPEEDS, FEEDS AND TIME

FOR THE MANUFACTURING TRADES

Speeds and Feeds refer to two separate velocities in machine tool practice, ***cutting speed*** and ***feed rate***. They are often considered as a pair because of their combined effect on the cutting process.

Cutting Speed: For milling it is the circumferential speed for the milling cutter, and it expressed as surface feet per minute (sfpm). It is the distance which the outer cutting edge of the mill cutter tooth travels in one minute. Cutting speed can be visualized as the distance the cutter would roll on the floor in one minute.

Feed: Feed is the rate at which the tool is moved into the part or the part into the tool. Feed is measured in feet, inches or millimeters per time period.

Key terms:

- **SFM (*CS*)** = Surface Feet per Minute
- **RPM** = Revolutions Per Minute
- **IPT** = Inches Per Tooth
- **IPM** = Inches Per Minute
- **IPR** = Inches Per Revolution
- **D** = Cutter Diameter in inches
- **RPM** = Revolutions per minute
- **F** = Feed in inches per minute
- **FTP** = Feed per tooth in inches
- **W** = Width of cut
- **d** = Depth of cut
- **N** = Number of teeth

Key equations *milling:*

Examples

RPM – *Milling*

EXAMPLE ONE: Calculate the **Spindle Speed** (RPM) when milling with a .375" diameter bit at a Cutting Speed of 320 sfm (surface feet per minute).

$$RPM = \frac{3.82 \times CS}{D}$$

$$RPM = \frac{3.82 \times 320}{.375}$$

$$RPM = \frac{1222}{.375}$$

$$RPM = 3260$$

IPM – Milling

EXAMPLE TWO: Calculate the (**IPM**) for a ¼ diameter 4-flute HHS endmill cutting brass at 210 **SFPM** with a 0.002 **FPT** and 3260 **RPM**

$$IPM = FTP \times N \times RPM$$

$$IPM = 0.002 \times 4 \times 3260$$

$$IPM = 26$$

SFPM – Milling

EXAMPLE THREE: Calculate the (**SFPM**) appropriate for cutting aluminum using a 6" diameter cutter and 1000 RPM.

$$CS = \frac{D \times RPM}{3.82}$$

$$CS = \frac{6 \times 1000}{3.82}$$

$$CS = 1570.8$$

IPM – Milling

EXAMPLE FOUR: Dertermine the feed rate for machining low-carbon steel at 80 (SFPM), 122 **RPM,** using a heavy-duty plain milling cutter which is 2½" in diameter with 8 teeth, and with 0.004" feed per tooth.

$$IPM = FTP \times N \times RPM$$

$$IPM = .004 \times 8 \times 122$$

$$IPM = 4" \, per \, minute$$

Milling: Feed, Cutting Speed, and chip load

Material	SFM (HSS Tools)	Chip Load per Tooth			
		1/8"	1/4"	1/2"	1"
Aluminum Alloys	600-1200	0.0010	0.0020	0.0040	0.0080
Brass	200-350	0.0010	0.0020	0.0030	0.0050
Bronze	200-350	0.0010	0.0020	0.0030	0.0050
Carbon Steel	100-600	0.0010	0.0015	0.0030	0.0060
Cast Iron	80-350	0.0010	0.0015	0.0030	0.0060
Cast Steel	200-350	0.0005	0.0010	0.0020	0.0040
Cobalt Base Alloys	20-80	0.0005	0.0008	0.0010	0.0020
Copper	350-900	0.0010	0.0020	0.0030	0.0060
Die Steel	50-300	0.0005	0.0010	0.0020	0.0040
Graphite	600-1000	0.0020	0.0050	0.0080	0.0100
Inconel/Monel	30-50	0.0005	0.0010	0.0015	0.0030
Magnesium	900-1300	0.0010	0.0020	0.0040	0.0080
Malleable Iron	200-500	0.0005	0.0010	0.0030	0.0070
Nickel Base Alloys	50-100	0.0002	0.0008	0.0010	0.0020
Plastic	600-1200	0.0010	0.0030	0.0060	0.0100
Stainless Steel - Free Machining	100-300	0.0005	0.0010	0.0020	0.0030
Stainless Steel - Other	50-250	0.0005	0.0010	0.0020	0.0030
Steel - Annealed	100-350	0.0010	0.0020	0.0030	0.0050
Steel - Rc 18-24	100-500	0.0004	0.0008	0.0015	0.0045
Steel - Rc 25-37	25-120	0.0003	0.0005	0.0010	0.0030
Titanium	100-200	0.0005	0.0008	0.0015	0.0030

Cutting Speed (CS): *Cutting Speed* may be defined as the rate at which a point on the work circumference travels past the cutting tool.

Feed: The *feed* of a lathe may be defined as the cutting tool advances along the length of the work for every revolution of the spindle.

Key terms:

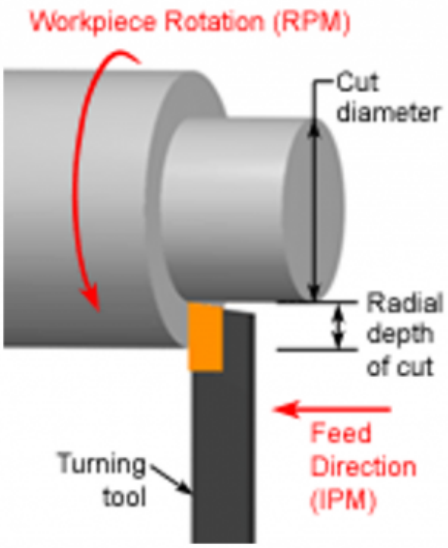
- **SFM (*CS*)** = Surface Feet per Minute
- **RPM** = Revolutions Per Minute
- **IPM** = Inches Per Minute
- **IPR** = Inches Per Revolution
- **D_1** = Diameter of work to be turned
- **RPM** = Revolutions per minute
- **F** = Feed in inches per minute
- **W** = Width of cut
- **d** = Depth of cut

Key equations *lathe:*

$$RPM = \frac{3.82 \times CS}{D1}$$

$$CS = D1" \times .2618 \times RPM$$

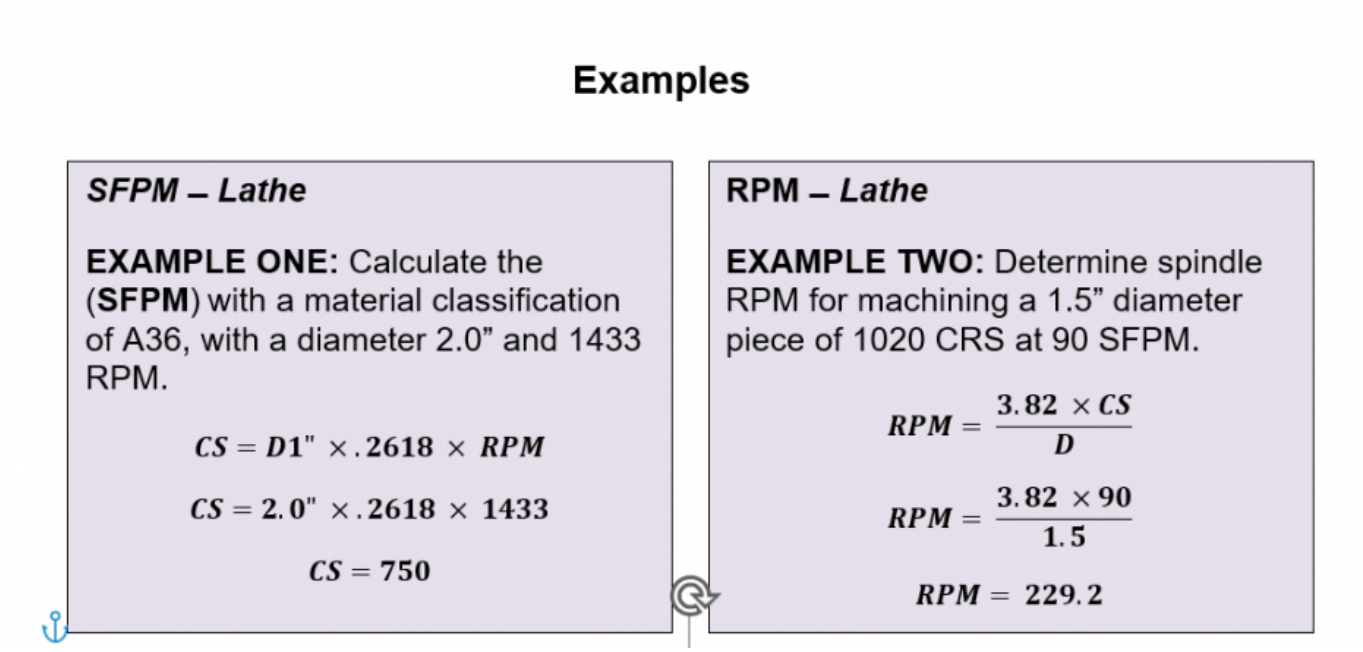
$$TIME = \frac{L}{RPM \times Feed\ Rate}$$



	Depth of Cut	Speed	Feed	Surface Finish
Roughing Operations	Deeper, 0.050–0.250	Slower	Higher, 0.010–0.040 IPR	Rougher
Finishing Operations	Shallower, 0.010–0.050	Faster	Lighter, 0.001–0.010 IPR	Smoother

Material	Brinell Hardness	Cutting Speed in SFPM	
		HSS	*Carbide*
Plain Carbon Steel: AISI/SAE 1006–1026, 1513, 1514	100–125	120	350–600
	125–175	110	300–550
	175–225	90	275–450
	225–275	70	225–350
Alloy Steel: AISI/SAE 1330–1345, 4032–4047, 4130–4161, 4337–4340, 5130–5160, 8630–8660, 8740, 9254–9262	175–225	85	250–375
	225–275	70	225–350
	275–325	60	180–300
	325–375	40	125–200
	375–425	30	90–150
Tool steel: AISI 01, 02, 06, 07	175–225	70	225–350
Tool steel: AISI A2, A3, A8, A9, A10	200–250	70	225–350
Tool steel: AISI A4, A6	200–250	55	175–275
Tool steel: AISI A7	225–275	45	125–225
Stainless steel: AISI 405, 409, 429, 430, 434, 436, 442, 446, 502	135–185	90	325–450
Stainless steel: AISI 301, 302, 303, 304, 305, 308, 309, 310, 314, 316, 317, 330	135–185	75	275–400
	225–275	65	225–350
Gray cast iron: ASTM A18, A278 (20 KSI TS)	120–150	120	240–600
Gray cast iron: ASTM A18, A278 (25 KSI TS)	160–200	90	200–450
Gray cast iron: ASTM A48, A278 (30, 35, & 40 KSI TS), A	190–200	80	175–400

Examples



Week 6 - Coolants

Concept Goals:

By the end of this week, you should:

- Describe the basics of maintaining CNC coolant levels and quality (SLO 3, SLO 4)

Concept Content:

This week we will discuss coolant for CNC machines. Coolant provides a vital role for machines beyond just keeping them cool. This week we will discuss just what those roles are and showcase how to change the coolant in a machine.

Videos:

CNC Coolant Basics - 22.5 Minutes

Coolant Simplified: 4 Steps To Filling the Tank on a CNC Machine - 5.5 Minutes - This video is a good example of the steps to change a coolant tank. This video may not contain all of the steps for your particular CNC machine in class. Be sure to listen to instructions carefully.

CNC Machine Coolant and Water Quality - 10 Minutes

Assignment:

Coolant Worksheet - Download the worksheet and upload it under the assignments tab under quiz. **(Instructor Note: the answer key to the assignment is located under instructor resources)**

Unit 2 - Mid-Term Exam

Unit 2 Overview

Concept Goals:

By the end of this module, you will:

- Demonstrate understanding of course material.

Concept Content:

This week is the mid-term exam. It is located under the assignments tab under test.

Mid-Term Exam - Questions - 30 **(Instructor Note: You can change the number of questions by either marking the questions not live so students won't see them, you can also add questions to the test as well. The 30 questions are a bank of questions for you to use as you see fit).**

Unit 2 Review

Concept Content:

Thank you for taking the mid-term exam and keeping with the course thus far. We will begin the 2nd half of our course next week. This part of the semester we will devote to doing in class projects so you get hands-on experience working with the machines.

Unit 3 - Projects

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.

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:

End Milling Project

Knight Chess Piece Project

Sphere with Curves Project

Lathe Tap Project

Mill Stop Base and Guage Project

Mill Stop Post and Arm Project

Parallel Clamp Project

Screw Jack Project

Unit 4 - Final Exam

Unit 4 Final Exam

Concept Goals:

By the end of this module, you will:

- Demonstrate understanding of course material.

Concept Content:

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

This exam has - 31 Questions **(Instructor Note: You can change the number of questions by either marking the questions not live so students won't see them, you can also add questions to the test as well. The 31 questions are a bank of questions for you to use as you see fit).**

This week is also your final week to complete any uncompleted projects.

Unit 4 Course Wrap-Up

Concept Content:

Thank you all for your efforts in this course. I hope it has been a good semester for you. Best of luck moving forward with your program of study.

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

Odigia Guide

Concept Content:

Click on the resources tab to find the guide sheet for instructors.

Week 4 Quiz Answer Key

Concept Content:

Week 4 Quiz Answer Key

Week 6 Answer Key

Concept Content:

Coolant Intro CNC Answer Key