Introduction to Machining

Objectives
The learner will be able to:

- Identify and define the machining terms
- Recognize and identify machine tools
- Assess the importance of machining in today’s society
- Examine the history of machining
- Describe careers in machining

Orienting Questions

✓ Can you explain the term machining and its meaning in today’s world?
✓ What are the common machine tools found in industry?
✓ Has the history of machining had any impact on the careers offered today?

Helpful Tips

✓ You can select the HIGHLIGHTED TERMS to read more about it.
✓ If needed, there are CLOSED CAPTION buttons on the YouTube videos that will enable you to read along while you watch. The Closed Caption buttons are located bottom right of the video screen.
✓ Take time and explore about the subject by selecting the EXPLORE links in each section of this module.
INTRODUCTION

MACHINING is a term that most people are not familiar with. We rely on machining to produce products and services we use every day. Products can range from automotive to medical and aerospace.

As society’s thirst for technology increases, the careers in the machining field are growing. This module covers the basic definition of machining and an introduction to the technical skills needed to be successful in many machining careers.

1.1. MACHINING EXPLAINED

Machining is a process used to shape raw materials into useful components through the use of machines.

In machining, specific equipment is used to perform turning, milling, drilling, and grinding operations. Specific machine tools perform specific tasks that are closely monitored by highly skilled workers that are referred to as Machinists.

1.1.1. MACHINE TOOLS

Machine tools perform the operations required to cut and shape the raw material. They employ such operations as turning, facing, milling, thread-making, grinding and hole-making.

TURNING, FACEING and BORING operations, as well as thread and hole-making, are done with a machine tool called a lathe. A LATHE is a motor driven machine that has a horizontal spindle. A spindle is a hollow tube that is belt or gear driven. A work-holding device is supported by the spindle. The raw material is then held in the work-holding device. The motor revolves the work-holding device at a specific RPM (Revolutions per Minute) while the cutting tool is applied to the spinning work piece to perform a specific operation.

A Lathe machine is a useful and valuable tool in the Industrial engineering field. The accuracy in grooving and cutting, to name a few, enables a lathe machine to produce materials used in every facet of society. Lathe machine comes in various shapes and
sizes. And dependent of the size of a lathe machine, the products being produced range from small threads on a screw to large machinery parts like a truck axle. Figure 1 shows the various styles of lathe machine used in industry.

**EXPLORE: Lathe Machines**

![Evolution of Lathe](image)

The first lathe was a simple lathe which was is now referred to as two person lathe. One person would turn the wood work piece using rope and the other person would shape the work piece using a sharp tool. This design was improved by Ancient Romans who added a turning bow which eased the wood work. Later a pedal (as in manual sewing machines) was used for rotating the work piece. This type of lathe is called “spring pole” lathe which was used till the early decades of the 20th century.

**Figure 1: All about Different Types of Lathe Machines** (Yash Machine, 2013)

Milling, thread-making, and hole-making operations are performed with a machine tool that is referred to as a milling machine (see Figure 2). **MILLING MACHINES** perform planning operations. Like the lathe, the milling machine has a spindle which revolves, but the spindle does not support the raw material. The spindle, in this case, secures the cutting tool. The raw material passes beneath the cutting tool through the use of a table. The raw material can be secured directly to the table or it can be mounted using a work-holding device.

**EXPLORE: Milling Machines**
GRINDING is an operation performed with a surface grinder. Like the milling machine the work is passed under the cutting tool through the use of a table and work-holding devices. The grinder (see Figure 3) is limited in the operations that can be performed. Lathes and mills are primarily used in the heavy removal of raw material to the desired shape and size, where a grinder can only remove small amounts at a time.

EXPLORE: Grinding

Figure 3: Grinding - 4 Surface Grinder (Virtual Machine Shop, 2013)
ACTIVITY #1

Watch the video titled: *Machine Tool Basics - Intro to Lathe Operations* provided below (see Figure 4). Write a summary explaining the lathe process.

Title: Machine Tool Basics - Intro to Lathe Operations -

![Video Thumbnail](image)

**Figure 4: Machine Tool Basics Volume 1 Lathe Operations Part 1** (SmithyCo., YouTube, 2013)

### 2.1. MACHINING HISTORY

In the beginning machine tools were powered by humans. To perform our machining processes, we have employed animal power, water power, steam, and electricity. The advancement in technology and increase supply of electrical powers has dramatically improved on the basic operations in machining tool (see Figure 5). Human involvement in the operation of machine tool operation is still prevalent in industry, however robotic technology and automation is becoming the norm.

**EXPLORE:** [Machining History](#)
2.1.1. FROM SIMPLE TO COMPLEX

From the Roman Empire until the 18th century, machine tools were simple in their form and use. They were not able to produce complex shapes and could not maintain the level of accuracy obtainable in today’s industrial world. The simplest and probably the first machine tool would be the bow drill. The basic operation of the bow drill is to perform hole-making operations. The bow was moved back and forth in a sawing motion that rotated the cutting tool to drill a hole. Today the bow drill is seen as a tool to start a camp fire.

Of course the bow drill was not the only machine tool development. The spring pole lathe was designed to produce cylindrical wood parts. Power for this early machine tool was produced by a foot pedal while the cutting tools were held against the material. However the spring pole lathe lacked one important quality, continuous motion. With the need for goods growing, the need for more accurate machine tools became a necessity. During the industrial revolution, machine tools evolved from man powered to steam powered and metal became the preferred raw material, over wood, to produce parts that would stand the test of time (see Figure 6 and 7).

During the 20th century, machine tools started to take the forms we recognize today (see Figure 8). We began using electricity instead of human or steam power. Machine tool movements became more automated through the use of gears and levers. Today, while we still use machines controlled by gears and levers, we also use computers to control machine operations. The CNC machine is a machine tool that is controlled by
numbers and programmed like a computer. The CNC machine is the innovation that enables us to maintain accuracy, repeatability, and high production levels.

**EXPLORE:** CNC Machine Overview

![Figure 6: Modern.Marvels - Machine.Tools part 2.avi (YouTube, 2013)](YouTube, 2013)

![Figure 7: Modern.Marvels - Machine.Tools part 3.avi (YouTube, 2013)](YouTube, 2013)

![Figure 8: Modern.Marvels.- Machine.Tools part 4.avi (YouTube, 2013)](YouTube, 2013)
3.1. ROLE PLAYING

The role that machining plays in today’s society is endless. From the bottles and aluminum cans that hold our favorite soda to the television we watch at home, machining operations have been performed to produce that product.

3.1.2. MANUFACTURING TODAY

When you picture manufacturing what do you think of? In most cases people tend to describe manufacturing as automobiles, televisions, appliances, etc. rolling off an assembly line. However, the term manufacturing refers to anything that is produced. Products can be as simple as nuts and bolts and as complex as jet engines. The end item that is produced is the final product the consumer will see or use.

**MACHINING** is a process that is sometimes involved in the manufacturing of consumable goods. In the machining industry parts are produced with high precision and with a high degree of accuracy. Tolerances, which are limits for the part size, are set by the company producing the final product. Tolerances will dictate if the final product will go out to the consumer.

**MACHINING** is heavily relied on by the aerospace industry. Machine tools are used to produce complex jet engine components, landing gear, and even some of the instrumentation. The machining of all these components is precise and closely examined to ensure that industry standards and tolerances are maintained.

The medical field is not an industry that would be seen as a field requiring machining. With the development of CNC technology we have seen innovations in joint replacement, surgical, and dental tools.

Plastics play an integral role in our world today. Especially in the manufacturing of electronic items but also in toys, bottles, cups, and all types of containers from big to small. Plastic parts that are manufactured in high numbers are usually made from a molding process where hot molten plastic is poured into a form. This type of process usually does not require a high level of precision; however the mold that the molten plastic is poured in to is made by machining processes. For plastic parts that require a high level of accuracy, a machining process may be required (see Figure 9).

**EXPLORE:** [Occupational Outlook Handbook](#)
ACTIVITY #2

Watch the video “How it’s Made: Toothpaste” (see Figure 10) and write a summary of the process of making a toothpaste. Pay attention to the steps, use of safety materials and machinery used throughout the procedure. Your summary report should be clear and at a minimum 2 paragraphs (a paragraph should consist of a minimum 3 sentences).

Title: How it’s made - Toothpaste

4.1. EQUIPMENT USED FOR MACHINING

There are some basic types of machine tools found in industry. Each machine is suited for a specific task or operation. These machine tools of today still closely resemble and
operate much in the same way as their early predecessors, but with technological advancements we have been able to improve machine tools dramatically.

4.1.2. SHOP SAWS

**SAWING MACHINES** use multi-tooth blades to perform their specific operation. Saws cut material to specific lengths and widths. They are the backbone of any machine shop or manufacturing facility. They can be seen as support equipment. The saw’s job is to prepare the material for further machining operations. Saws may cut in a horizontal position (see **Figure 11 and 12** or vertical position (see **Figure 13**). These are called band saws. You may also find circular style cutting saws called cold saws as well as abrasive saws called chop saws.

**EXPLORE: Band Saws**

![Figure 11: Basics: Horizontal Band Saw (YouTube, 2013)](image)
Figure 12: Parts of a BANDSAW MACHINE (American Machine Tool Company, 2013)

Figure 13: Parts of a Vertical Band Saw
(Canadian Centre for Occupational Health & Safety, 2013,)
4.1.3. DRILL PRESS

The **DRILL PRESS** is a machine that only performs the task of hole making operations (see Figure 14). It is not a precise machine tool and is usually used to drill holes that have been marked with a process called layout. In layout, machinist’s scratch lines on ink dyed surfaces to mark locations. These locations are used to guide the operator as to where to drill the holes. Other operations can be performed on the drill press such as spot facing, counter boring, and producing threads through tapping.

**EXPLORE:** [Drill Presses](#)

![Figure 14: Drill Press](AsktheBuilder, YouTube, 2013)

4.1.4. LATHE

The **LATHE** is a machine tool that is used to produce cylindrical parts (see Figure 15 and 16). It is a motor driven machine that has a horizontal spindle. A work-holding device is supported by the spindle. The raw material is then held in the work-holding device. The motor revolves the work-holding device at a specific rpm while the cutting tool is then applied to the spinning work piece to perform the specific operation. This particular machine tool can cut external and internal diameters, threading, hole making
operations, and grooves. The lathe can also perform grinding operations through the use of tooling attachments.

**EXPLORE:** [Lathe Machine Parts](#)

![Figure 15: Basics Engine Lathe Machine](YouTube, 2013)

Figure 15: Basics Engine Lathe Machine (YouTube, 2013)

![Figure 16: Mastering CNC Lathes Course 1 Lesson 1](MasterTask208, YouTube, 2013)

Figure 16:
Mastering CNC Lathes Course 1 Lesson 1
(MasterTask208, YouTube, 2013)

### 4.1.5. MILLING MACHINE

**MILLING MACHINES** primarily perform planning operations. Like the lathe, the milling machine has a spindle that revolves, but the spindle does not support the raw material. The spindle, in this case, secures the cutting tool. The raw material passes beneath the cutting tool through the use of tables. The raw material can be secured directly to the table or it can be mounted using a work-holding device.
The milling machine (see Figure 17) can also perform hole making operations as well as support thread making operations. There are two types of mills found in machining: the vertical mill and the horizontal mill. Both machines use coordinates from the Cartesian coordinate system. This system is based off the axis of X, Y, and Z, which enable these machine tools to locate features and positions of holes.

EXPLORE: Milling Machines Types

![Figure 17: Crash Course in Milling: Chapter 1 - Basic Machine Anatomy](GlacernMachineTools, YouTube, 2013)

4.1.6. PRECISION SURFACE GRINDERS

There are several different grinders found in manufacturing. GRINDERS (see Figure 18) are also referred to as abrasive machines and perform abrasive machining. The grinding wheel that is rotated by the horizontal spindle is an abrasive much like sandpaper could be thought of as an abrasive. Rather than removing large amount of material it removes small amounts of material and is primarily used for finishing operations and for obtaining precise and accurate measurements.

EXPLORE: Types of Grinder
5.1. CAREER PATHWAYS

Careers in machining (see Figure 19) require a great deal of hands-on skills and soft skills. These areas are also highly technical in nature and are now requiring some form of technical training to obtain a career in the field.

EXPLORERE: Pay Scale: Machinist

5.1.2. TYPES OF CAREERS

The most basic career in machining is the operator. Operator is an entry level career for employees who are entering the field of machining. This position requires that the employee be trained in running a machine in a specific area and is usually found in
large production based factories. The operator is only responsible for maintaining the part accuracy and quantity set by the company.

**SET-UP TECHNICIANS** are required to set the machine up to make the part that is required. This can include selection of cutting tools needed for specific operations, selection of work-holding devices, and running the first part. After the successful run of a first part, set-up technicians are required to check the part for inaccuracies and make the appropriate adjustments to ensure that the machine is safe and will produce consistent part sizes. Some set-up technicians are only required to set-up one style of machine but they can also be trained to set-up multiple machines. After the part has been checked thoroughly then and only then can the operator take control and begin production.

**CONVENTIONAL MACHINISTS** operate manual lathes, mills, and surface grinders. These machinists have honed their skills through years of experience and much start out in the field as operators or in apprentice positions. They do not specialize in one type of machine and can perform all of the operations to produce complete parts. While this type of career can still be found in large manufacturing facilities, they are more commonly found in small machine shops called “mom and pop” shops.

The **CNC MACHINIST** (see Figure 20) could be considered the machinist of today. CNC machines began as production machines that were set-up and only produced one kind of part to ensure repeatability and accuracy, and also a high volume of parts. Today CNC machines are not only used by manufacturing companies, but are also used by the small shops to produce one or two piece quantity jobs. Programming of these machines, in large companies may be done by an employee whose sole purpose is to program the CNC machine, however CNC machinists in small shops can be required to program, set-up, and operate the machine tool. This type of position is considered as highly skilled as a conventional machinist and can also take years of experience to master.

**EXPLORE:** Bureau of Labor Statistics
ACTIVITY #3

Job Hunting: Search for two job postings in the field of machining from SCWorks website. SCWorks is South Carolina’s online employment website (see Figure 21). List the two machining jobs that interest you and explain why you selected the jobs. Print your response and turn it in at next class session.

SCDEW: SCWorks
6.1. SKILLS FOR SUCCESS

All careers require you to have certain skills that will enable you to be successful (see Figure 22). These skills can be classified into two categories: **SOFT SKILLS AND TECHNICAL SKILLS**. Most careers require you to have both types of skills and machining careers are no different. An automotive mechanic is required to have knowledge that will enable that person to work on any type of automobile. That same
mechanic, while having excellent hands-on skills, also has to have excellent soft skills that will qualify that person to interact with customers.

Figure 22: 60 Minutes: Three million open jobs in U.S., but who's qualified? (www.cbsnews.com, November 11, 2012)

6.1.2. SOFT SKILLS

**SOFT SKILLS** are part of your personality. While some of your personality traits cannot be changed, they can be honed and perfected. In large manufacturing facilities, interaction with the customer is almost non-existent. The interaction between supervisor and fellow employees is crucial to teamwork and will make or break that team. Learning to get along with all types of people will help that team succeed in the face of adversity. The adversity that you may encounter is high volume production runs that have a short time to be completed and it takes everyone working as a team to complete that job. Machinists in small shops deal with customers on a daily basis from large companies to someone off the street. The crucial point to remember is that the customer is always right.

Patience may be a difficult quality to learn. This quality is something that every machinist must learn and the same holds true for any career. It takes years for some machinists to become proficient in machining processes. Taking your time and taking pride in your work should be the most important skill you should learn. Rushing to get the part finished can lead to a piece of scrap metal rather than a high precision part.
6.1.3. TECHNICAL SKILLS

**TECHNICAL SKILLS** are those which take the most patience to learn but they can be improved upon with practice and training. Technical skills are learned in three settings: secondary school programs (career centers), on-the-job training or post-secondary schools (technical schools). In the field of machining, the skills you will need to learn have to be obtained in one of these three places. Learning about the skills and tools you need is separate from hands-on training.

In machining, there are some skills that are of the upmost importance. Having mechanical aptitude is crucial because machinists must have the ability to disassemble and reassemble some parts prior to and after machining. Having a working knowledge of the relationship between the machine and the tools that are used to shape the material is crucial to the success of a machinist. Eye-hand coordination is a critical skill because in machining you sometimes have to make intricate movements and fine adjustments using machine tool controls. Machinists are required to have excellent **TROUBLESHOOTING SKILLS** which aid in their decision making process. With experience a machinist can decide what critical dimensions are to be maintained based on the tolerances of the part. Memorization of charts and formulas used in industry help in the decision making process. A supervisor or a shop foreman does not want to be asked how a basic formula is solved. They expect the machinist to be able to use technical reference materials to solve those problems.

The most important skill that you need to be successful in machining is the ability to read and interpret technical drawings. Technical drawings are two-dimensional representations of a three-dimensional part. Technical drawings are the “blueprints” that give the machinist the information to create the part represented. Drawings give the machinist the dimensions, tolerances, and important details about the operations required to effectively complete the part.

**MATH** is major component of machining. Trigonometry and geometry are used to solve accurate angles and aid in completing machining tasks. Basic addition and subtraction are utilized in the area of measuring instruments. Measuring instruments are tools that tell the machinist what size a measurement is and should be. It is not only important to hone your ability in machining operations but it is equally if not more important to understand the function of measuring instruments and become proficient in their use. As cutting tools have specific uses, so do measuring instruments.
MAJOR CONCEPTS

KEY CONCEPTS

Machining is a process where you must use equipment, which can be referred to as machine tools, to perform operations such as turning, shaping, planing, or milling. Specific machine tools perform specific tasks that are closely monitored by highly skilled workers that are referred to as Machinists.

Machine tools of the past were as simple as the bow drill. However, we were able to develop the technology for machining from human powered to electrical power with various innovations. Those innovations include the engine lathe, vertical and horizontal milling machine, drill press, and precision surface grinders. In recent history we have also developed the technology known as CNC (Computer Numeric Control). This basically translates to machines controlled by numbers.

Machining is no longer limited to one type of material. Machinists today are trained in the machining of plastic as well as metals. Career opportunities have increased with the development of CNC technology. In the past machinists were limited to conventional equipment and spent years mastering the trade. In today’s world conventional machines are still used. They require much training but this provides a basic understanding of machining processes. Manual machining can provide vital support to CNC machining in some instances.

While technical hands-on skills are extremely important, we should also focus great effort in the area of soft-skills development. Soft skills will secure the potential employee their job and give the lasting first impression that employers look for.

KEY TERMS

Machining  
Saws  
Drill Press  
Lathe  
Milling machines  
Grinders

LABS
MTT122 is the co-requisite lab for MTT121.

ASSESSMENTS

MODULE REINFORCEMENT

True or False: Read the following questions and determine whether the statement is true or false.

1. The drill chuck can be considered the first machine tool.
2. Processing means to produce something.
3. Manufactured items that are used by the consumer are called the end products.
4. Tolerances are defined as levels of accuracy.
5. The highly skilled workers that set-up and operate machine tools are called mechanics.
6. Technical drawings give the machinist important information required to produce a part.
7. Saws cut only in the horizontal position.
8. Plastic parts are only produced with molds.
9. Soft skills are not as important as technical skills.
10. Milling machines have spindles that hold the part for machining.
11. CNC machines are only used in high production situations.

Multiple Choice: Read the following questions or statements and select the best answer.

1. The most recent power supply advancement in machining is the use of ________.
   a. Animals
   b. Electricity
   c. Human
   d. Nuclear Power
   e. Steam

2. CNC machine tools are controlled by ________.
   a. Numbers
   b. Ball Screws
   c. Axis
   d. Computers
   e. Accuracy

3. ________ Machines are considered the backbone of any machine shop.
   a. Welding
   b. Drilling
   c. Milling
   d. Sawing
   e. Cutting
4. The drill press performs only ______ operations.
   a. Turning
   b. Milling
   c. Drilling
   d. Hole-making
   e. Thread-making

5. The most basic career in machining is the ________.
   a. Operator
   b. Set-up Technician
   c. Manual Machinist
   d. CNC machinist
   e. Programmer

6. ______ the outside/inside diameters of raw material is performed on a ______.
   a. Milling, milling machine
   b. Turning, milling machine
   c. Turning, lathe
   d. Drilling, lathe
   e. Drilling, drill press

7. Both the vertical and horizontal milling machines employ the use of the ________ to obtain feature positions.
   a. Cartesian Coordinate System
   b. ASME standards
   c. X,Y, and Z positions
   d. Work-holding Devices
   e. Coordinate Measuring Machine

8. The ________ is only responsible for maintaining part accuracy and quantity.
   a. Set-up technician
   b. Operator
   c. Machinist
   d. Programmer
   e. Engineer

9. Which operation is not performed on a lathe?
   a. Turning
   b. Threading
   c. Milling
   d. Grinding
   e. Drilling
## Answer Key

<table>
<thead>
<tr>
<th>True or False</th>
<th>Multiple Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. F</td>
<td>1. B</td>
</tr>
<tr>
<td>2. F</td>
<td>2. A</td>
</tr>
<tr>
<td>3. T</td>
<td>3. D</td>
</tr>
<tr>
<td>4. T</td>
<td>4. D</td>
</tr>
<tr>
<td>5. F</td>
<td>5. A</td>
</tr>
<tr>
<td>6. T</td>
<td>6. C</td>
</tr>
<tr>
<td>7. F</td>
<td>7. A</td>
</tr>
<tr>
<td>8. F</td>
<td>8. B</td>
</tr>
<tr>
<td>10. F</td>
<td></td>
</tr>
<tr>
<td>11. F</td>
<td></td>
</tr>
</tbody>
</table>

### Answer Keys to Activities

#### Answer to Activity #1

Student response must entail the terms Turning, Facing and Boring processes.

#### Answer to Activity #2

The summary report should explain the steps, use of safety materials and type of machines used to make the product shown in the video.

#### Answers to Activity #3

The two selected machining jobs are listed along with an explanation of why it was chosen as an ideal job.
DISCUSSIONS

QUESTION 1
What is your background in industry? How will your background influence your career path?

QUESTION 2
List your strengths and weaknesses in relation to soft and technical skills. How do you intend on honing your weaknesses?
CRITICAL THINKING

PUTTING NEW KNOWLEDGE TO WORK

<table>
<thead>
<tr>
<th>Job Description #2</th>
<th>Immediate Supervisor</th>
<th>Task</th>
<th>Result of Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>You are a Machinist…</td>
<td>…your immediate supervisor, Mr. Humphries,...</td>
<td>…has asked you to use the Outside Caliper and convert the measurement from centimeter (cm) to inches...</td>
<td>…this will enable you to explain conversion measurement and demonstrate use of the Outside Caliper.</td>
</tr>
</tbody>
</table>

Student Instructions:

1. Locate job postings for machinists online.
2. Open a word document
3. Type the information for the job posting to include: the position of the job and the duties of that job.
4. Name the word document with your last name first and first name last with an underscore between, for example: Smith_John.
5. Save the word document on your personal computer.
6. Upload the document to the assigned class dropbox.
7. SMILE …You have completed two tasks and have successfully uploaded both screenshots documents to the assigned class dropbox.

RUBRIC SCALE

GRADING RUBRIC FOR INSTRUCTORS:

<table>
<thead>
<tr>
<th>Two Tasks: Outside Micrometer and Caliper</th>
<th>Excellent (60 points max)</th>
<th>Good (50 points max)</th>
<th>Fair (40 points max)</th>
<th>Additional Practice Needed (25 points)</th>
</tr>
</thead>
</table>
1. Locate job postings for machinists online

<table>
<thead>
<tr>
<th></th>
<th>Excellent (45 points max)</th>
<th>Good (35 points max)</th>
<th>Fair (25 points max)</th>
<th>Additional Practice Needed (10 point max)</th>
</tr>
</thead>
</table>

2. Open a word document

3. Type the information for the job posting to include: the position of the job and the duties of that job.

4. Save the word document in your personal files

5. Name the word document with your last name first and first name last with an underscore between, for example: Smith_John

6. Successfully uploaded the document to the assigned class dropbox

<table>
<thead>
<tr>
<th>Turned In On Time (5 points)</th>
<th>Turned in 1 day late (2 points)</th>
<th>Turned in 2 days late and gave reason to instructor on tardiness (1 point)</th>
<th>Turned in 3 days late or Did Not Turn In after day 2 tardiness (0 point)</th>
</tr>
</thead>
</table>

Total

Page 27
## ATTRIBUTION TABLE

<table>
<thead>
<tr>
<th>Author/s</th>
<th>Title</th>
<th>Source</th>
<th>License</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="http://www.yashmachine.com">www.yashmachine.com</a> YouTube</td>
<td>Figure 1: All about Different Types of Lathe Machines</td>
<td><a href="http://youtu.be/rJbEYursP6w">http://youtu.be/rJbEYursP6w</a></td>
<td>Public Domain</td>
</tr>
<tr>
<td>Ron Smith</td>
<td>Figure 3: Grinding - 4: Surface Grinder (Virtual Machine Shop)</td>
<td><a href="http://www.kanabco.com/vms/other_grinding/other_grinding_04.html">http://www.kanabco.com/vms/other_grinding/other_grinding_04.html</a></td>
<td>Author permission Contact: <a href="mailto:ronsmithut@yahoo.com">ronsmithut@yahoo.com</a></td>
</tr>
<tr>
<td>newtexas2006</td>
<td>Figure 6: Modern.Marvels.- Machine.Tools part 2.avi</td>
<td><a href="http://youtu.be/LZj-9g_Soxo">http://youtu.be/LZj-9g_Soxo</a></td>
<td>Public Domain</td>
</tr>
<tr>
<td>newtexas2006</td>
<td>Figure 8:</td>
<td><a href="http://youtu.be/6xu08Lwxp">http://youtu.be/6xu08Lwxp</a></td>
<td>Public Domain</td>
</tr>
<tr>
<td>Author</td>
<td>Figure/Link</td>
<td>Creative Commons License</td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------------------------------------------------------------</td>
<td>-----------------------------------</td>
<td></td>
</tr>
<tr>
<td>DCTTeacher1</td>
<td>Figure 9: CNC 3040 Milling Plastic Parts</td>
<td><a href="http://youtu.be/22olFh7RttQ">http://youtu.be/22olFh7RttQ</a></td>
<td>Public Domain</td>
</tr>
<tr>
<td>Moe Sal</td>
<td>Figure 10: How It’s Made: Toothpaste</td>
<td><a href="http://youtu.be/g9aD3BpxEAY">http://youtu.be/g9aD3BpxEAY</a></td>
<td>Public Domain</td>
</tr>
<tr>
<td>Ladell Humphries</td>
<td>Figure 11: Basics Horizontal Band Saw</td>
<td>creative commons attribution 3.0</td>
<td>Unported License.</td>
</tr>
<tr>
<td>Canadian Centre for</td>
<td>Figure 13: Parts of a Vertical Band Saw</td>
<td><a href="http://www.ccohs.ca/oshaanswers/safety_haz/woodwork/band_saw.html">http://www.ccohs.ca/oshaanswers/safety_haz/woodwork/band_saw.html</a></td>
<td>See Hyperlink</td>
</tr>
<tr>
<td>Occupational Health &amp;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>American Machine Tool</td>
<td>Figure 12: Parts of a Band Saw Machine</td>
<td><a href="http://www.americanmachinetools.com/how_to_use_bandsaw.htm">http://www.americanmachinetools.com/how_to_use_bandsaw.htm</a></td>
<td>See Hyperlink</td>
</tr>
<tr>
<td>Company:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AsktheBuilder</td>
<td>Figure 14: Drill Press</td>
<td><a href="http://youtu.be/tiHF1y3Dr6w">http://youtu.be/tiHF1y3Dr6w</a></td>
<td>Public Domain</td>
</tr>
<tr>
<td>Ladell Humphries</td>
<td>Figure 15: Basics Engine Lathe Machine</td>
<td>creative commons attribution 3.0</td>
<td>Unported License.</td>
</tr>
<tr>
<td>MasterTask208</td>
<td>Figure 16: Mastering CNC Lathes</td>
<td><a href="http://youtu.be/yN0ti6ek0">http://youtu.be/yN0ti6ek0</a></td>
<td>Public Domain</td>
</tr>
<tr>
<td>Course 1 Lesson 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>ManufacturingCareers</td>
<td>Figure 19: iExplore CNC Machining career video</td>
<td><a href="http://youtu.be/n8tnFvsKG1k">http://youtu.be/n8tnFvsKG1k</a></td>
<td>Public Domain</td>
</tr>
<tr>
<td>Geographic Solutions, Inc: SCWorks</td>
<td>Figure 21: SC Works Online Services</td>
<td><a href="https://jobs.scworks.org/vosnet/Default.aspx">https://jobs.scworks.org/vosnet/Default.aspx</a></td>
<td>See Hyperlink</td>
</tr>
</tbody>
</table>
This workforce solution was funded by a grant awarded by the U.S. Department of Labor’s Employment and Training Administration. The solution was created by the grantee and does not necessarily reflect the official position of the U.S. Department of Labor. The Department of Labor makes no guarantees, warranties, or assurances of any kind, express or implied, with respect to such information, including any information on linked sites, and including, but not limited to accuracy of the information or its completeness, timeliness, usefulness, adequacy, continued availability or ownership.

ASSIST Consortium Curriculum is licensed under a Creative Commons Attribution 3.0 Unported License.

Unless otherwise noted, this work was created by Ladell Humphries, Machine Tool Instructor, humphriesle@cctech.edu. The design layout was created by Lynda Marshall, marshalllc@cctech.edu and the template design was created by Clemson University Center for Workforce Development, frady@clemson.edu. ASSIST grant is licensed under the Creative Commons Attribution 3.0 Unported License. To view a copy of this license, visit http://creativecommons.org/licenses/by/3.0/ or send a letter to Creative Commons, 444 Castro Street, Suite 900, Mountain View, California, 94041, USA.