# MAC – 124, CNC Milling



## 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 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. Make use of precision instruments such as micrometers to properly measure out machine parts.
2. Study sample parts, blueprints, drawings, or engineering information to determine methods or sequences of operations needed for production.
3. Set up and operate a CNC mill correctly
4. Know how to set up and edit a program for a CNC milling operation
5. Know how to inspect simple machine parts

**Concept Content:**

This course introduces the manual programming, setup, and operation of CNC machining centers. Topics include programming formats, control functions, program editing, part production, and inspection. Upon completion, students should be able to manufacture simple parts using CNC machining centers.

| Module | Module Learning Objectives |
|---|---|
| Module 1 - Intro to CNC Week 1 | • Understand the different axes CNC mills use (SLO 3, SLO 4)<br>• Explain the difference between the two basic types of automatic tool changers (SLO 3)<br>• Explain the difference between the basic types of CNC machines (SLO 3) |
| Module 2 - Intro to CNC Week 2 | • Identify major components of a CNC milling machine (SLO 3)<br>• Identify workholding solutions for CNC mills (SLO 3)<br>• Identify basic CNC cutting tools (SLO 3) |
| Module 3 - Safety | • Understand how the Lock Out, Tag Out Process Works (SLO 3)<br>• Explain the different types of machine guards such as enclosure guards, etc. (SLO 3)<br>• Define pinch points and points of operation. (SLO 3) |

| | |
|---|---|
| Module 4 - CNC Trigonometry | • Understand basic trigonometry principles as related to CNC machine functions (SLO 4) |
| Module 5 - CNC Coordinates and Codes | • Understand how the X, Y, and Z axes work in a CNC coordinate system (SLO 4)<br>• Define the various types of coordinate systems used in CNC milling (SLO 4) |
| Module 6 - CNC Coordinates and Codes | • Understand how G and M codes work (SLO 4)<br>• Be able to create simple lines of programing using G and M codes (SLO 4) |
| Module 7 - Mid-Term Exam | • Demonstrate understand of course material thus far |
| Module 8 - Speeds and Feeds | • Understand how to calculate feeds and speeds for basic shop materials (SLO 4) |
| Module 9 - CNC Milling Programing | • Draft a basic CNC program (SLO 4)<br>• Understand the use of safety lines in CNC coding (SLO 4)<br>• Define what a canned cycle is (SLO 4) |
| Module 10 - CNC Milling Programing | • Demonstrate the ability to properly program simple CNC jobs based (SLO 4)<br>• Define what linear and circular interpolation are (SLO 4)<br>• Explain the difference between linear and circular interpolation (SLO 4) |
| Module 11 - CNC Milling Set Up and Operation | • Be able to list the parts of a CNC milling machine (SLO 3)<br>• Understand that cutting tools are used for milling operations (SLO 3)<br>• Create a small CNC part utilizing a blueprint (SLO 2) |
| Module 12 - CNC Milling Set Up and Operation | • Be able to complete circular pocket milling using a blueprint (SLO 2)<br>• Understand how conditional switches work (SLO 3 and SLO 4) |
| Module 13 - Project Work Week | • Utilize blueprints to create simple machine parts (SLO 2) |
| Module 14 - CNC Part Inspection | • Make use of precision instruments to gauge part quality (SLO 1 and SLO 5)<br>• Understand the purpose of quality inspection/improvement (SLO 5)<br>• Carry out a successful part inspection (SLO 5) |
| Module 15 - Final Exam | • Demonstrate understand 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.

# Module 1 - Intro to CNC Week 1

## 1.1 Module Overview

**Concept Goals:**

By the end of this module you should be able to:

- Understand the different axes CNC mills use (SLO 3, SLO 4)
- Explain the difference between the two basic types of automatic tool changers (SLO 3)
- Explain the difference between the basic types of CNC machines (SLO 3)

**Concept Content:**

Welcome to CNC 124 - CNC Milling. This week we will begin our introduction to CNC milling. Please see module 1.2 for more details regarding this week.

This week at a glance:

Articles:

Types of CNC Milling Machines

CNC Machine Axes

What is an Automatic Tool Changer of CNC Router

The Difference of Disc ATC CNC Router and Linear Type ATC CNC Router

Benefits of an automatic tool changer and how it works

Videos:

Automatic CNC Tool Change Example - 0.5 Minutes

CNC machines – The Types of CNC Machines Explained - 8 Minutes

CNC Machining 3, 4, & 5th Axes? Explained - 4.5 Minutes

Assignment:

Module 1 Quiz - 10 Questions

## 1.2 Module Content Resources

**Concept Content:**

This we will we discuss some of the basics of CNC milling machines. We will discuss the different types of CNC machines, the axes used in CNC milling, and going over automatic CNC tool changers and how they work.

This week's material:

Lecture:

What is Numerical Control? - 18 Slides

Articles:

Types of CNC Milling Machines

N.A. (2023, December 5). *Types of CNC milling machines*. Basilius Inc. https://www.basilius.com/blog/types-of-cnc-milling-machines/

CNC Machine Axes

Axsom, T. (2022, August 9). *3-axis to 12-axis: CNC milling machine capabilities compared*. Fictiv. https://www.fictiv.com/articles/3-axis-to-12-axis-cnc-milling-machine-capabilities-compared

What is an Automatic Tool Changer of CNC Router

N. A. (2023, October 12). *Benefits of an automatic tool changer and how it works*. ShopSabre CNC. https://www.shopsabre.com/benefits-of-an-automatic-tool-changer-and-how-it-works/

The Difference of Disc ATC CNC Router and Linear Type ATC CNC Router

N.A. (2022, May 25). *The Difference of Disc ATC CNC Router and Linear Type ATC CNC Router* . upgoalcnc.com. https://www.upgoalcnc.com/news/detail/The_Difference_of_Disc_ATC_CNC_Router_and_Linear_Type_ATC_CNC_Router

Benefits of an automatic tool changer and how it works

N.A. (2023, October 12). *Benefits of an automatic tool changer and how it works*. ShopSabre CNC. https://www.shopsabre.com/benefits-of-an-automatic-tool-changer-and-how-it-works/

Videos:

Automatic CNC Tool Change Example - 0.5 Minutes

CNC machines – The Types of CNC Machines Explained - 8 Minutes

CNC Machining 3, 4, & 5$^{th}$ Axes? Explained - 4.5 Minutes

## 1.3 Module Assessment/Assignment

**Concept Content:**

This Week's Assignment:

Module 1 Quiz -10 Questions - Located in quizzes under the assignments tab.

## 1.4 Module Reflection

**Concept Content:**

This is a completely optional section. The purpose of this section is to ask your students to reflect on the material they have learned in this course. Or, if there is a specific area of the content you wanted to make sure students understood, you could guide them to discuss that in their response to your reflection question(s). You could also use this section to discuss case studies related to the content this section went over. However, if you feel that this would not be an appropriate assignment/task for your specific subject, please feel free to delete this section from your class.

## 1.5 Module Discussion Board

**Concept Content:**

This is a completely optional section. The prupose of this section is to invite your students to discuss the week's content and what they learned from it with each other. If you feel this would not be approriate for your class or at least this week's content, feel free to delete it. If you are interested in doing a discussion board, a good idea would be to come up with a question related to the week's content for the students to answer. From there, require them to answer the quesion and respond to a least one other student's answer to foster discussion.

## 1.6 Module Wrap-Up

**Concept Goals:**

Module Learning Objectives:

- Understand the different axes CNC mills use (SLO 3, SLO 4)
- Explain the difference between the two basic types of automatic tool changers (SLO 3)
- Explain the difference between the basic types of CNC machines (SLO 3)

**Concept Content:**

This week in review:

Articles:

Types of CNC Milling Machines

CNC Machine Axes

What is an Automatic Tool Changer of CNC Router

The Difference of Disc ATC CNC Router and Linear Type ATC CNC Router

Benefits of an automatic tool changer and how it works

Videos:

Automatic CNC Tool Change Example - 0.5 Minutes

CNC machines – The Types of CNC Machines Explained - 8 Minutes

CNC Machining 3, 4, & 5$^{th}$ Axes? Explained - 4.5 Minutes

Assignment:

Module 1 Quiz - 10 Questions

# Module 2 - Intro to CNC Week 2

## 2.1 Module Overview

**Concept Goals:**

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

- Identify major components of a CNC milling machine (SLO 3)
- Identify workholding solutions for CNC mills (SLO 3)
- Identify basic CNC cutting tools (SLO 3)

**Concept Content:**

This week is the second week of our CNC milling introduction section. See module 2.2 for more details.

This week at a glance:

Articles:

What are the vital parts of a CNC milling machine?

Parts of a CNC milling machine: Visual Guide

Total Guide to CNC Milling Machine Workholding

Videos:
What is Milling? Parts, Operations and Types of Milling Machines - 15.5 Minutes.

Crash Course in Milling: Chapter 6 - Tool Holding - 3.5 Minutes

Types of Milling Cutter - 8 Minutes

Assignment:

Module 2 Quiz -10 Questions

## 2.2 Module Content Resources

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

This week we will continue discussing CNC milling machines. We will cover the parts of a CNC mill and discuss the various tools and workholding solutions that go along with a CNC mill.

This week's material:

Articles:

What are the vital parts of a CNC milling machine?

Roberson, B. (2023, August 10). What are the vital parts of a CNC milling machine?: CNC machines: Roberson Machine Company. Roberson Tool. https://robersontool.com/what-are-the-vital-parts-of-a-cnc-milling-machine/

Parts of a CNC milling machine: Visual Guide

Leo, G. (2023, September 21). *Parts of a CNC milling machine: Visual guide: Aria manufacturing*. Aria. https://www.madearia.com/blog/parts-of-a-cnc-milling-machine/

Total Guide to CNC Milling Machine Workholding

N., A. (n.d.). *Total guide to CNC milling machine workholding*. CNC Cookbook. http://www.cnccookbook.com.s3-website-us-east-1.amazonaws.com/CCCNCMillingWorkholding.html

Videos:
What is Milling? Parts, Operations and Types of Milling Machines - 15.5 Minutes. The part from 1:10 - 3:30 is the revelant part for this week. However, the rest of the video is a good review of what we discussed last week.

Crash Course in Milling: Chapter 6 - Tool Holding - 3.5 Minutes

Types of Milling Cutter - 8 Minutes

## 2.3 Module Assessment/Assignment

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

This week's assignment:

Module 2 Quiz -10 Questions

## 2.4 Module Reflection

**Concept Content:**

This is a completely optional section. The purpose of this section is to ask your students to reflect on the material they have learned in this course. Or, if there is a specific area of the content you wanted to make sure students understood, you could guide them to discuss that in their response to your reflection question(s). You could also use this section to discuss case studies related to the content this section went over. However, if you feel that this would not be an appropriate assignment/task for your specific subject, please feel free to delete this section from your class.

## 2.5 Module Discussion Board

**Concept Content:**

This is a completely optional section. The prupose of this section is to invite your students to discuss the week's content and what they learned from it with each other. If you feel this would not be approriate for your class or at least this week's content, feel free to delete it. If you are interested in doing a discussion board, a good idea would be to come up with a question related to the week's content for the students to answer. From there, require them to answer the quesion and respond to a least one other student's answer to foster discussion.

## 2.6 Module Wrap-Up

**Concept Goals:**

Module Learning Objectives:

- Identify major components of a CNC milling machine (SLO 3)
- Identify workholding solutions for CNC mills (SLO 3)
- Identify basic CNC cutting tools (SLO 3)

**Concept Content:**

This week we finished our introduction to CNC milling. Next week we will discuss shop safety.

This week in review:

Articles:

What are the vital parts of a CNC milling machine?

Parts of a CNC milling machine: Visual Guide

Total Guide to CNC Milling Machine Workholding

Videos:
What is Milling? Parts, Operations and Types of Milling Machines - 15.5 Minutes.

Crash Course in Milling: Chapter 6 - Tool Holding - 3.5 Minutes

Types of Milling Cutter - 8 Minutes

Assignment:

Module 2 Quiz - 10 Questions

# Module 3 - Safety

## 3.1 Module Overview

**Concept Goals:**

By the end of this module, you should:

- Understand how the Lock Out, Tag Out Process Works (SLO 3)
- Explain the different types of machine guards such as enclosure guards, etc. (SLO 3)
- Define pinch points and points of operation. (SLO 3)

**Concept Content:**

This week we will discuss machine safety. See module 3.2 for details and this week's material.

This week at a glance:

This week's content is embedded in module 3.2.

Assignments:

Module 3 Quiz - 8 Questions

## 3.2 Module Content Resources

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

This week we will discuss safety in a machining setting. We will review machine guards, lock out tag out, among other safety topics below.

OSHA compiles the information about injuries resulting from industrial machinery.  Here is how they introduce the topic of Machine Safety:

Amputations are a common result to an injury that has been sustained due to improper guarding of machinery. Read the OSHA Fact Sheet concerning Amputation as a result of improper guarding and be prepared to submit a summary of the Fact sheet to your instructor. To access the fact sheet, please click on facts. (Reference 3, US Department of Labor, Public Domain)

Machine guarding is essential to protect the people from hazards created by machinery, such as pinch-points, cutting edges, and grinding surfaces. OSHA Standard 29 CFR 1910.212 covers Machine Guarding. To access this standard, please click on standards. (Reference 4, US Department of Labor, Public Domain)

In Figure 1, notice the various types of power tools and the presence or lack of presence of guards.

Figure 1 – Power Tools (by Tim Zim, CC BY – NC 2.0)

Image: Various power tools.  The table is missing it's guard, but all other tools have their guards in place.

## Safety Barriers for Avoidance of Accidents

There are different types of safety barriers.

OSHA defines Barrier Guards as follows:

Barrier Guards are appropriate safeguards for full revolution and part revolution mechanical power presses. They are designed to keep the operator's hands and arms from entering the "danger zone" as prescribed by the particular machine. Barrier guards are usually the first point-of-operation safeguard considered for machines.

*This passage was taken from*
*https://www.osha.gov/SLTC/etools/machineguarding/presses/barrierguards.html*

*Reference 5, US Department of Labor, Public Domain*

By accessing the site for Reference 5 (above), you can read much more about what OSHA has to say about Barrier Guards, including Barrier Guard Types and Regulations.

## Accidents

The Problem, Workers who operate and maintain machinery each year suffer approximately -18,000 amputations, lacerations, crushing injuries, and abrasions – 800 deaths

The importance of Machine Safety is simple: you get to keep your fingers and limbs, and you get to go home!

# Pinch Points and Points of Operation

What makes guards necessary – moving parts?  Moving parts have the ability to entangle, crush, or sever your body parts.  Even if your body is not directly in contact with moving parts, if your clothing or a tool you are holding makes contact with moving parts, the outcome could be the same.

## Definitions

**Pinch Point:** a location where it is possible for a body part to become injured between moving objects.
A pinch point could be as simple as your car door.

**Points of Operation:** the areas where work is performed on a machine.  Examples include: where material being cut meets the power tool doing the cutting, or where the punches driven by a punch press contact the material.

## Illustrations of Pinch Points


Figure 3 – 2010/365 – September 29 – Pinch Point (by Colin Jagoe, CC BY – NC – SA 2.0)

Image: Roller with a plate over the top and a pin in front.  On the plate the verbiage is “Warning: Pin Point Keep Hands Away.

Figure 4 – NJW_1763 (by Nick Winterhalter, CC BY – NC – ND 2.0)

Image: 3 Pulleys with rods to the right.

## Illustrations of Points of Operation

According to OSHA, the following conditions present points of operation which are the most common hazards:

- Cutting—action generated during sawing, boring, drilling, milling, slicing, and slitting.
- Punching—motion resulting when a machine moves a slide (ram) to stamp or blank metal or other material.
- Shearing—movement of a powered slide or knife during metal trimming or shearing.
- Bending—action occurring when power is applied to a slide to draw or form metal or other materials.

This passage is taken from
https://www.osha.gov/OshDoc/data_General_Facts/amputation-factsheet.pdf

(US Department of Labor, Public Domain)

Figure 5 – Trimming the edge (by Lewis Meyer, CC By – NC 2.0)

Image: Man pushing a metal rod into a trimming machine

# Enclosure Guards

**Enclosure Guards** are also often referred to as Barrier Guards by OSHA.


Figure 6 – Elevator equipment (by Tom Magliery, CC BY – NC – SA 2.0)

Image: Elevator equipment with a barrier guard present over the working parts.

OSHA defines four types of Barrier Guards as follows:

- Die enclosure Guards
- Fixed barrier Guards
- Interlocked Barrier Guards
- Adjustable Barrier Guards

All of them are listed in OSHA Standard 29 CFR 1910.217 (c)(2)(ii) – (vi). Take time to review each of them. The links are accessible from the link above.

## Safety

Safety.  Ultimately that is what this presentation and OSHA are all about: your safety in the workplace.  We have talked about Pinch Points, Points of Operation, and Guards.  All of those are intended to raise your awareness of hazards around machines which can injure or maim you.  Next we will present machine controls.

# Electrical Controls

While Electrical Controls are not what some may think of as typical guards, they can be incorporated in ways that increase safety.

## Interlocking Guards

**Interlocking guards** provide a safeguarding action that shuts off, or disengages power, and prevents the cycling of the machine when the guard has been opened. They stop the machine before the worker is able to reach into a hazardous area.  Typically they are used to permit access for the removal of jams without having to remove fixed guards.

## Automatic Guards

Automatic Guards fall into two types: self-adjusting and pullback.

**Self-adjusting guards** provide a barrier which moves as material of varying sizes enters the point of operation.  Figure 7 shows a woman using a radial saw.  Notice the retractable guard on the blade.

Figure 7 – Laura Sawing (by Ruthie Hansen, CC BY – NC – SA 2.0)

Image: Woman using radial saw

OSHA Standard 29 CFR 1926.304(d) covers the guarding requirements for all portable, power-driven, circular saws.

Pull-back Guards usually use a system of cables which attach to an operators hands, wrists, or arms. When machine action is safe (typically on the up stroke), the operator is afforded free access to the point of operation.  When machine action is hazardous (typically on the down stroke), mechanical linkage limits the reach of the operator, preventing the operator from having access to the point of operation. To view this standard, please click on standard. (Reference 11, US Department of Labor, Public Domain) This standard regulates the use of Pull-back devices.

If Pull back guards are not installed on a machine, it is essential that interlocked barrier guards are used on presses as a method that will prevent the press operation if the barrier guard is not present. OSHA defines an Interlocked Press Barrier Guard as:

An interlocked press barrier guard shall be attached to the press frame or bolster and shall be interlocked with the press clutch control so that the clutch cannot be activated unless the guard itself, or the hinged or movable sections of the guard are in a position to conform to the requirements

## Presence-sensing Guards

**Presence-sensing Guards** usually use a system of light emitters, receptors, and controls which interrupt the operating cycle of a machine if an operator or maintenance worker enters the zone which the sensors protect.  If the sensing field is broken by intrusion the machine stops and will not continue to cycle. To be effective, these types of controls depend on design factors that ensure the speed with which cycle interruption occurs is greater than the speed with which a worker can reach into the hazardous area.  A common type of presence-sensing guards is a **light curtain**.

# Lockout/Tag-out Procedures

One of the greatest invitations you can present for accident and injury is to service a machine while power is applied.  Is it enough to turn off the main power switch?  Then what is to prevent someone else from turning that switch back on?  And what about the energy stored within the machinery components?  What about compressed spring forces?  What about stored hydraulic or pneumatic energy?  What about stored electrical charges in capacitors?

Lock Out Tag Out Procedure Video - 6.5 Minutes

## Define Lockout

To protect workers from the hazards of energy, OSHA has established a Lockout/Tag-out Standard. The standard is 29 CFR 1910.147 and it states that equipment must be turned off, disconnected from any energy source, and relieved of any stored energy before the equipment is worked on.  It further requires employers to develop written procedures, to train their employees on those procedures, and to conduct inspections that ensure those procedures are being followed.

The **Lockout** portion of Lockout/Tagout establishes a zero energy state within the machine being worked on, and assures the zero energy state will continue during the work by securely fastening the sources that supply energy to the machine to an off position. A **zero energy state** is when all of the power sources (electricity, pressurized air or water or oil, vacuum, etc.) that supply a machine have been disconnected, and when all of the stored energy within the machine has been released.

## Steps for Lockout Procedure

OSHA has developed and published specific guidelines for the required content of Lockout Procedures, and requires employers to provide training and to ensure compliance.  Below is a summary of their required content for Energy Control Procedures.

OSHA Energy Control Procedures - Required Content

What specific elements must be documents in the employer's energy control procedures?

- The procedures must outline the scope, purpose, authorization, rules and techniques that the employer will use to control hazardous energy
- The procedures must state the means to be used to enforce compliance.

At a minimum, the procedures must include:

- A specific statement of the intended use of the procedure
- Specific procedural steps for shutting down, isolating, blocking, and securing machines or equipment to control hazardous energy
- Specific procedural steps for the placement, removal, and transfer of lockout devices or tagout devices, and a description of who has responsibility for them
- Specific requirements for testing a machine or piece of equipment to determine and verify the effectiveness of lockout devices, tagout devices, and other energy control measures

## Define Tagout

**Tagout** refers to the use of labels on machinery and on the energy sources supplying that machinery; those labels are required to provide a clear warning that the machine is being worked on and cannot be operated until the tag is removed by authorized personnel.

## Steps for Tagout

As should be expected, OSHA has specific requirements concerning Tag-out, and here is a summary version of what they specify:

Employers must train employees in the following limitations of tags:

- Tags are essentially warning devices affixed to energy isolating devices and do not provide the physical restraint on those devices that is provided by a lock
- When a tag is attached to an energy isolating means, it is not to be removed without authorization of the authorized person responsible for it, and it is never to be bypassed, ignored, or otherwise defeated
- Tags must be legible and understandable by all employees
- Tags and their means of attachment must be made of materials which will withstand the environmental conditions encountered in the workplace
- Tags may evoke a false sense of security and their meaning needs to be understood as part of the overall energy control program
- Tags must be securely attached to energy isolating devices so that they cannot be inadvertently or accidentally detached during use

Anytime a machine has a Tagout label applied:

- Do not remove the tag unless you are authorized
- Do not energize the machine
- Do not attempt to operate the machine

Figure 7 shows a lockout/tagout in process.  Notice the locks and the tags.

Figure 7 – DCP_2786 (by GCPLearning, CC BY – NC – SA 2.0)

Image: A person is adding a lock to tagged out box which has two locks on it currently.

# Safety Standards for Lockout/Tagout

The Safety Standards for Lockout/Tag-out are an important part of OSHA's work.  OSHA is very detailed in the standards they have developed, and in the compliance they require from employers. Employers, therefore, are very conscious of their responsibility to train their workers on those standards, to develop procedures, and to make sure their workers follow those procedures.

Videos:

CNC Mill Safety - 7.5 Minutes

## 3.3 Module Assessment/Assignment

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

This week's assignment:

Module 3 Quiz - 8 Questions

## 3.4 Module Reflection

**Concept Content:**

This is a completely optional section. The purpose of this section is to ask your students to reflect on the material they have learned in this course. Or, if there is a specific area of the content you wanted to make sure students understood, you could guide them to discuss that in their response to your reflection question(s). You could also use this section to discuss case studies related to the content this section went over. However, if you feel that this would not be an appropriate assignment/task for your specific subject, please feel free to delete this section from your class.

## 3.5 Module Discussion Board

**Concept Content:**

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a least one other student's answer to foster discussion.

## 3.6 Module Wrap-Up

**Concept Goals:**

Module Learning Objectives:

- Understand how the Lock Out, Tag Out Process Works (SLO 3)
- Explain the different types of machine guards such as enclosure guards, etc. (SLO 3)
- Define pinch points and points of operation. (SLO 3)

**Concept Content:**

This week we discussed safety in the machine shop. Next week we will discuss the trigonometry needed for CNC machining.

This week in review:

This week's content is embedded in module 3.2.

Assignments:

Module 3 Quiz - 8 Questions

# Module 4 - CNC Trigonometry

## 4.1 Moudle Overview

**Concept Goals:**

By the end of this module, you should:

- Understand basic trigonometry principles as related to CNC machine functions (SLO 4)

**Concept Content:**

This week we will cover trigonometry. Please view module 4.2 for more details.

This week at a glance:

Videos:

A Refresher on Trigonometry – 5 Minutes

Machining Math Fundamentals: Pythagoras Theorem – 6.5 Minutes

SOH COA TOA (Trigonometry) – 6 Minutes

Transposition – 7 Minutes

Activity:

Trig Exercises - 13 Slides

Assignment:

Module 4 Quiz - 4 Questions

## 4.2 Module Content Resources

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

This week we will go over trigonometry. Understanding of basic trig principles will help you better draft your programs for the CNC machines. Unless you understand how angles work and are calculated, it will be hard for you to accurately program the machine to cut at the right angles.

Videos:

A Refresher on Trigonometry – 5 Minutes

Machining Math Fundamentals: Pythagoras Theorem – 6.5 Minutes

SOH COA TOA (Trigonometry) – 6 Minutes

Transposition – 7 Minutes

Activity:

Trig Exercises - 13 Slides - We will work through these exercises in class together.

## 4.3 Module Assessment/Assignment

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

This week's assignment:

Module 4 Quiz - 4 Questions

## 4.4 Module Reflection

**Concept Content:**

This is a completely optional section. The purpose of this section is to ask your students to reflect on the material they have learned in this course. Or, if there is a specific area of the content you wanted to make sure students understood, you could guide them to discuss that in their response to your reflection question(s). You could also use this section to discuss case studies related to the content this section went over. However, if you feel that this would not be an appropriate assignment/task for your specific subject, please feel free to delete this section from your class.

## 4.5 Module Discussion Board

**Concept Content:**

This is a completely optional section. The prupose of this section is to invite your students to discuss the week's content and what they learned from it with each other. If you feel this would not be approriate for your class or at least this week's content, feel free to delete it. If you are interested in doing a discussion board, a good idea would be to come up with a question related to the week's content for the students to answer. From there, require them to answer the quesion and respond to a least one other student's answer to foster discussion.

## 4.6 Module Wrap-Up

**Concept Goals:**

Module Learning Objectives

- Understand basic trigonometry principles as related to CNC machine functions (SLO 4)

**Concept Content:**

This week in review:

Videos:

A Refresher on Trigonometry – 5 Minutes

Machining Math Fundamentals: Pythagoras Theorem – 6.5 Minutes

SOH COA TOA (Trigonometry) – 6 Minutes

Transposition – 7 Minutes

Activity:

Trig Exercises - 13 Slides

Assignment:

Module 4 Quiz - 4 Questions - Due by **(insert due date here)**

# Module 5 - CNC Coordinates and Codes Week 1

## 5.1 Module Overview

**Concept Goals:**

By the end of this module, you should:

- Understand how the X, Y, and Z axes work in a CNC coordinate system (SLO 4)
- Define the various types of coordinate systems used in CNC milling (SLO 4)

**Concept Content:**

This week we will start our discussion on CNC Milling Coordinates. See module 5.2 for more detail.

This week at a glance:

Lectures:

CNC Mill Coordinates Overview - 9 Slides

Reading:

Embedded in module 5.2

Video:

CNC Coordinate Systems - 5 Minutes - This is a good visual presentation for the coordinate systems we are talking about.

Assignment:

Absolute and Incremental Positioning Exercise - 1 Page

## 5.2 Module Content Resources

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

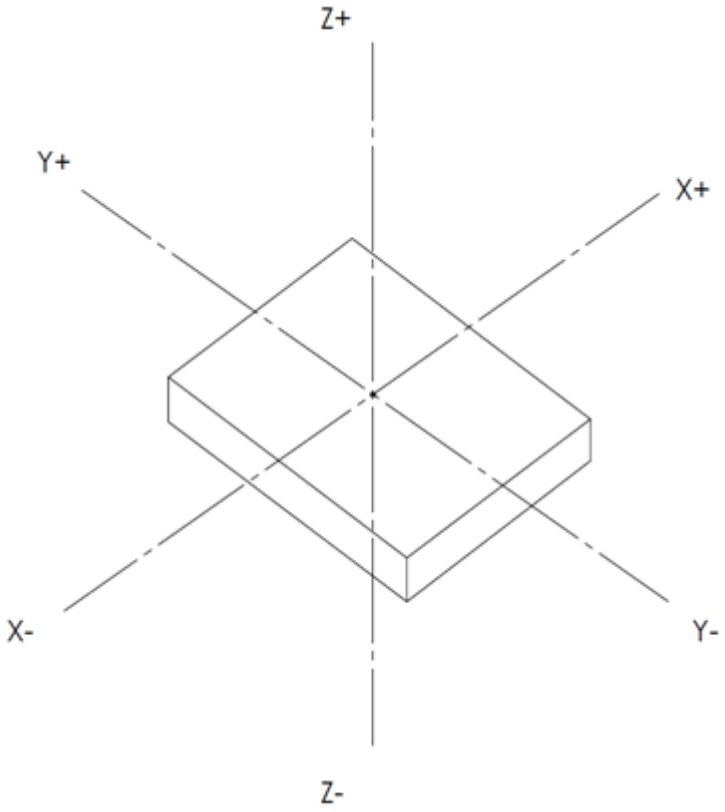
This week we will start going over CNC milling coordinates. We will discuss the basics of X, Y, and Z axes, how those axes are utilized, an overview of other types of coordinate systems, and going over the beginning of letter codes.

Lectures:

CNC Mill Coordinates Overview - 9 Slides

Reading:

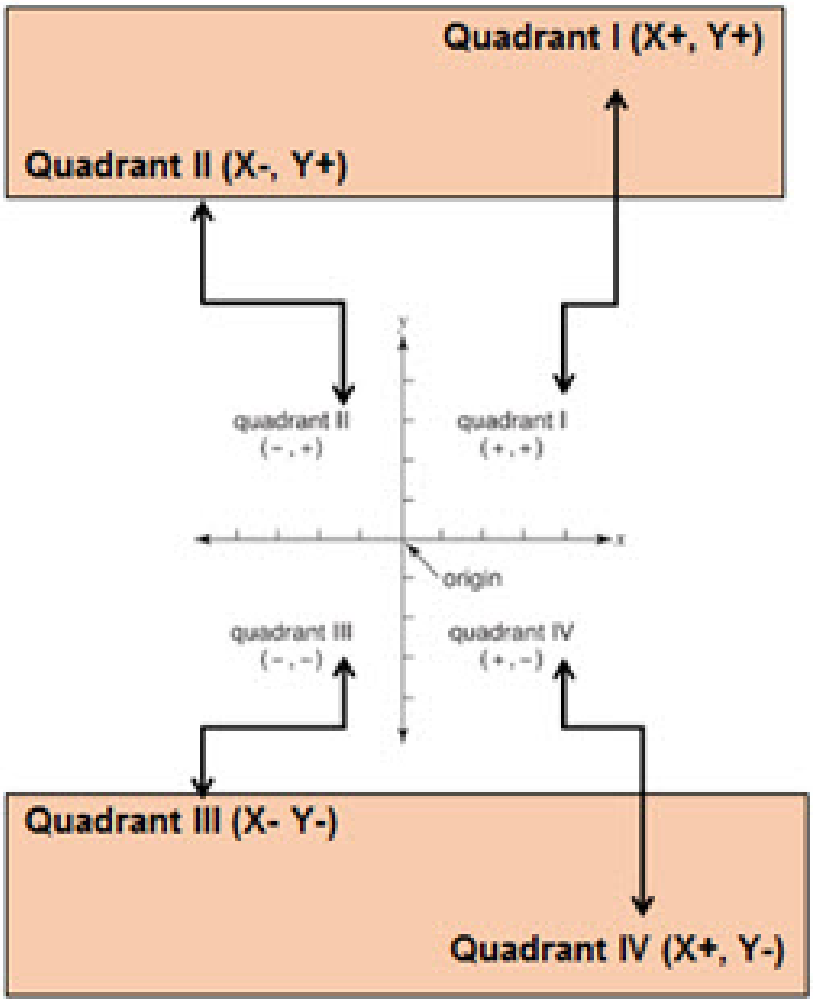
# CNC Milling Coordinate System




The CNC Vertical Machining Center uses three coordinates to machine parts. (More axes available depending on mill) Programmed movement is in primarily 3 axis configuration. From the operator side of the machining center, the X axis is left to right, the Y axis is toward the operator or away from the operator. The third axis is the Z axis, which is up and down, positive, is up away from table (and/or part), negative is down towards the table or work piece.

The operator and programmer must always remember that we are programming the tool, **not the table**. On some machining centers the head (with cutting tool) does move in either X or Y in addition to the Z axis.  On the other hand a large number of machines the head only moves in the Z axis direction and the table moves in X and Y. So when programming and/or operating a CNC machining center the tool direction is programmed not the table movement.

An example of this concept is programming a Y axis movement in the positive direction, based on our coordinate system in the above graphic. The table would move toward the operator, but the cutter is moving away in a positive or Y+ direction.




Here is an example of the X and Y quadrants outlined in a 2D plane.

# Letter Address Descriptions for CNC Mill

**O** Signifies the beginning of a program followed by 4 to 5 digit program number,0-99999. The only place the letter O is permitted in a part program.

**G** Preparatory Functions (G Codes)

The G followed by a 2 or 3 digit number. The number indicates motion, cutting conditions or canned cycles. Depending on the group, the code may or may not be modal. Modal is defined as active until cancelled by another G Code of the same group. More than one G Code can be on the same line.

**F** Feed rate. The value can be in inches per minute or mm per minute (metric)

**M** Miscellaneous Functions (M Codes)

The M followed by a 2 or 3 digit number. M codes are switches, turn on, or turn off.

Multiple M Codes are not allowed on a single line of code.

**N** Line or block number, entirely optional. Only function is to identify and/or locate a line or block within a part program. Most programmers use these to separate and identify processes.

**I** Address used to identify X axis for circular data or to specify values for canned cycles.

**J** Address used to identify Y axis for circular data or to specify values for canned cycles.

**K** Address used to identify Z axis for circular data or to be specify values for canned cycles.

**L** Loop address for specifying repetitive count for sub-programs and/or canned cycles

**P** P is value for time delay in seconds of a dwell command. Also used with M98 sub program call.

**Q** Q is value of peck depth for drilling cycles (positive value).

**R** R is used in canned cycles as a return or reference plane. Also used for circular interpolation.

**S** Spindle speed address in revolutions per minute (RPM)

**T** Tool Selection Code. The T address followed by 2 digits. Then the Tool Change command M6 (or M06)

**H** Tool Length Offset Selection. H address and Tool Number used in conjunction with G43 to activate. Tool number and H number must be the same.

IE: T1M6 (tool change to number 1) G43 H1 Z0.1 (length offset 1, Z0.1 clearance plane)

**X** X used to specify location in the X axis direction

**Y** Y used to specify location in the Y axis direction

**Z** Z used to specify location in the Z axis direction

Some examples of G codes, M codes and Letter addresses in a block of code:

G00 G90 X1.00 Y0.100 S2500 M3 Rapid Positioning in Absolute X and Z, Spindle Speed 2500 RPM, Spindle on CW

G01 G91 X1.00 Y-1.00 F10.0 Linear Interpolation (straight line feed) Incremental Positioning, 10.0 Inches per Min

G02 G90 X1.00 Y-1.00 I0 J-0.250 Circular Interpolation Clockwise X and Z Absolute Positioning of End Points of Arc. I and J, arc center points from start of arc to arc center.

We will extrapolate on G and M codes next week.

Video:

CNC Coordinate Systems - 5 Minutes - This is a good visual presentation for the coordinate systems we are talking about.

## 5.3 Module Assessment/Assignment

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

This week's assignment:

Absolute and Incremental Positioning Exercise - 1 Page **(instructor note: answer key located in course resources module)**

Download the exercise sheet and upload it in the assignments tab. There is a space to do that under quiz.

## 5.4 Module Reflection

**Concept Content:**

This is a completely optional section. The purpose of this section is to ask your students to reflect on the material they have learned in this course. Or, if there is a specific area of the content you wanted to make sure students understood, you could guide them to discuss that in their response to your reflection question(s). You could also use this section to discuss case studies related to the content this section went over. However, if you feel that this would not be an appropriate assignment/task for your specific subject, please feel free to delete this section from your class.

## 5.5 Module Discussion Board

**Concept Content:**

This is a completely optional section. The prupose of this section is to invite your students to discuss the week's content and what they learned from it with each other. If you feel this would not be approriate for your class or at least this week's content, feel free to delete it. If you are interested in doing a discussion board, a good idea would be to come up with a question related to the week's content for the students to answer. From there, require them to answer the quesion and respond to a least one other student's answer to foster discussion.

## 5.6 Module Wrap-Up

**Concept Goals:**

Module Learning Objectives:

- Understand how the X, Y, and Z axes work in a CNC coordinate system (SLO 4)

- Define the various types of coordinate systems used in CNC milling (SLO 4)

**Concept Content:**

This week we started our discussion on CNC Milling Coordinates. Next week we will finish our discussion before our mid-term exam.

This week in review:

Lectures:

CNC Mill Coordinates Overview - 9 Slides

Reading:

Embedded in module 5.2

Video:

CNC Coordinate Systems - 5 Minutes - This is a good visual presentation for the coordinate systems we are talking about.

Assignment:

Absolute and Incremental Positioning Exercise - 1 Page

# Module 6 - CNC Coordinates and Codes Week 2

## 6.1 Module Overview

**Concept Goals:**

By the end of this module, you should:

- Understand how G and M codes work (SLO 4)
- Be able to create simple lines of programing using G and M codes (SLO 4)

**Concept Content:**

This week we will continue our coverage of CNC Coordinates and Codes. See module 6.2 for more

detail.

This week at a glance:

Lectures:

G and M Codes - 10 Slides

Reading:

Embedded in module 6.2

Videos:

CNC Machinist Made Easy: Intro to G codes: - 12 Minutes

Basic Movements with G-Code - 8.5 Minutes

Absoulte vs Incremental Positioning - 19.5 Minutes

Assignment:

Module 6 Quiz - 5 Questions

## 6.2 Module Content Resources

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

This week we will continue our discussion of coordinates and program codes. We will delve into G and M codes and how they function in CNC programing. Near the bottom of this module, there are videos to help provide visual examples of the concepts the lecture and embedded reading material cover.

Lectures:

G and M Codes - 10 Slides

Reading:

# Often Used Miscellaneous (M) Codes

**M00** The M00 code is used to a Program Stop command on the machine. It stops the spindle, turns off coolant and stops look-a-head processing. Pressing CYCLE START again will continue the program on the next block of the program.

**M01** The M01 code is used for an Optional Program Stop command. Pressing the OPT STOP key on the control panel signals the machine to perform a stop command when the control reads any M01 command. It will then perform like an M00.

**M03** Starts the spindle CLOCKWISE. Must have a spindle speed defined.

**M04** Starts the spindle COUNTERCLOCKWISE. Must have a spindle speed defined.

**M05** Stops the spindle.

**M06** Tool change command along with a tool number will execute a tool change for that tool. This command will automatically stop the spindle, Z-axis will move up to the machine zero position and the selected tool will be put in the spindle. The coolant pump will turn off right before executing the tool change.

**M08** Coolant ON command.

**M09** Coolant OFF command.

**M30** Program End and Reset to the beginning of program.

**M97** Local Subroutine call.

**M98** Subprogram call.

**M99** Subprogram return (M98) or Subroutine return (M97), or a Program loop.

*NOTE: Only one "M" code can be used per line, and they will be the last commando to be performed in a line, regardless of where it's located in that line.*

# OFTEN USED PREPARTORY "G" CODES – CNC Mill

**G00** Rapid traverse motion: Used for non-cutting moves to quickly position tool to a location to be machined, or rapid away after cuts have been performed.

**G01** Linear interpolation motion: Used for actual machining and metal removal, governed by a programmed feed rate in inches (or mm) per minute.

**G02** Circular interpolation-Clockwise (CW)

**G03** Circular interpolation-Counter clockwise (CCW)

**G28** Machine Home (in rapid traverse)

**G40** Cutter Compensation CANCEL

**G41** Cutter Compensation ON LEFT of programmed tool path

**G42** Cutter Compensation ON RIGHT of programmed tool path

**G43** Tool Length Compensation ON

**G53** Machine Coordinate Positioning, NON_MODAL

**G54** Work Coordinate #1 (Part zero offset location)

**G80** Canned cycle CANCEL

**G81** Drill - canned cycle

**G82** Spot Drill - canned cycle

**G83** Peck Drill - canned cycle

**G90** Absolute Programming Positioning

**G91** Incremental Programming Positioning

**G98** Canned cycle - Initial Point Return

**G99** Canned cycle-Rapid (R) Plane Return

# Multiple Coordinate Systems

The standard coordinates are G54 through G59, so the programming can have multiple work pieces at different locations on the table. Possibly the same part at 6 different locations for a production run. Or, 6 different parts at each of those locations. If not specified for machining just one part, G54 is the default coordinate system used by most CNC machine tools.

There are additional coordinate systems available on a variety of machining centers and those are described as extended coordinates. These are called out in a number of different ways. Some examples: G54.1 P1 (1-99) G154 P1(1-99)

If needed the programmer can have an additional 99 work coordinates to machine multiple parts and/or assign work coordinates to features that have critical tolerances to allow operators to adjust during the production run to maintain dimensional conformity.

Videos:

CNC Machinist Made Easy: Intro to G codes: - 12 Minutes

Basic Movements with G-Code - 8.5 Minutes

Absoulte vs Incremental Positioning - 19.5 Minutes

## 6.3 Module Assessment/Assignment

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

This Week's Assignment:

Module 6 Quiz - 5 Questions

## 6.4 Module Reflection

**Concept Content:**

This is a completely optional section. The purpose of this section is to ask your students to reflect on the material they have learned in this course. Or, if there is a specific area of the content you wanted to make sure students understood, you could guide them to discuss that in their response to your reflection question(s). You could also use this section to discuss case studies related to the content this section went over. However, if you feel that this would not be an appropriate assignment/task for your specific subject, please feel free to delete this section from your class.

## 6.5 Module Discussion Board

**Concept Content:**

This is a completely optional section. The prupose of this section is to invite your students to discuss the week's content and what they learned from it with each other. If you feel this would not be approriate for your class or at least this week's content, feel free to delete it. If you are interested in doing a discussion board, a good idea would be to come up with a question related to the week's content for the students to answer. From there, require them to answer the quesion and respond to a least one other student's answer to foster discussion.

## 6.6 Module Wrap-Up

**Concept Goals:**

Module Learning Objectives:

- Understand how G and M codes work (SLO 4)
- Be able to create simple lines of programing using G and M codes (SLO 4)

**Concept Content:**

This week we finished our coverage of programing codes and coordinates. Next week we will take our mid-term exam.

This week in review:

Lectures:

G and M Codes - 10 Slides

Reading:

Embedded in module 6.2

Videos:

CNC Machinist Made Easy: Intro to G codes: - 12 Minutes

Basic Movements with G-Code - 8.5 Minutes

Absoulte vs Incremental Positioning - 19.5 Minutes

Assignment:

Module 6 Quiz - 5 Questions **- Due by (insert due date here)**

# Module 7 - Mid-Term Exam

## 7.1 Mid-Term Exam

**Concept Goals:**

Module Learning Objective:

- Demonstrate understand of course material thus far

**Concept Content:**

This week we have our mid-term exam. Click on the assignments tab and look under test to find it.

Mid-Term Exam:

25 Questions **(Instructor Note: This can be adjusted by you, see the exam itself for more detail)**

### 7.2 Module Wrap-Up

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

Thank you for taking the mid-term exam! We will continue our work in the course next week. Now, take a breather from MAC 124, you've earned it!

# Module 8 - Speeds and Feeds

### 8.1 Module Overview

**Concept Goals:**

By the end of this module, you should:

- Understand how to calculate feeds and speeds for basic shop materials (SLO 4)

**Concept Content:**

With the mid-term exam over, we are now entering the second half of the semester. Our first topic will be feeds and speeds. See module 8.2 for more detail.

This week at a glance:

Lecture:

CNC Milling Speeds and Feeds - 7 Slides

Reading:

Speeds and Feeds - 4 Pages

Video:

Speeds & Feeds Tutorial - 20 Minutes

Assignment:

Feeds and Speeds Practice Worksheet - 6 Questions

## 8.2 Module Content Resources

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

This week we will cover feeds and speeds. In order to make sure your machine parts come out efficiently, you will need to know how to calculate speeds and feeds. Below is the material we will cover this week to get you prepared to start programing functions that account for feeds and speeds.

Lecture:

CNC Milling Speeds and Feeds - 7 Slides

Reading:

Speeds and Feeds - 4 Pages



Video:

Speeds & Feeds Tutorial - 20 Minutes

## 8.3 Module Assessment/Assignment

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

This week's assignment:

Feeds and Speeds Practice Worksheet - Download the worksheet and upload the completed version to the assignments tab under quiz.

## 8.4 Module Reflection

**Concept Content:**

This is a completely optional section. The purpose of this section is to ask your students to reflect on the material they have learned in this course. Or, if there is a specific area of the content you wanted to make sure students understood, you could guide them to discuss that in their response to your reflection question(s). You could also use this section to discuss case studies related to the content this section went over. However, if you feel that this would not be an appropriate assignment/task for your specific subject, please feel free to delete this section from your class.

## 8.5 Module Discussion Board

**Concept Content:**

This is a completely optional section. The prupose of this section is to invite your students to discuss the week's content and what they learned from it with each other. If you feel this would not be approriate for your class or at least this week's content, feel free to delete it. If you are interested in doing a discussion board, a good idea would be to come up with a question related to the week's content for the students to answer. From there, require them to answer the quesion and respond to a least one other student's answer to foster discussion.

## 8.6 Module Wrap-Up

**Concept Goals:**

Module Learning Objective:

- Understand how to calculate feeds and speeds for basic shop materials (SLO 4)

**Concept Content:**

This week we discussed feeds and speeds. Next week we will start with going over CNC programing and our first project of the semester.

This week in review:

Lecture:

CNC Milling Speeds and Feeds - 7 Slides

Reading:

Speeds and Feeds - 4 Pages

Video:

Speeds & Feeds Tutorial - 20 Minutes

Assignment:

Feeds and Speeds Practice Worksheet - 6 Questions - Due by (insert due date here)

# Module 9 - CNC Milling Programing Week 1

## 9.1 Module Overview

**Concept Goals:**

By the end of the module, you should be able to:

- Draft a basic CNC program (SLO 4)
- Understand the use of safety lines in CNC coding (SLO 4)
- Define what a canned cycle is (SLO 4)

**Concept Content:**

This week we will begin our two part section on CNC Programming. See module 9.2 for more detail.

This week at a glance:

Lectures:

CNC Program Format and Structure - 7 Slides

CNC Canned Cycles - 10 Slides

Reading:

CNC Program Formatting and Formulas - 14 Pages

Video:

CNC Safety Lines Explained - 6.5 Minutes

Intro to Canned Cycles - 7.5 Minutes

Assignment:

CNC Circular Interpolation Assignment

## 9.2 Module Content Resources

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

This week we will start our section on CNC Programming. We will cover the basic format and structure of a block of programming, canned cycles, and safety lines. Our assignment this week will be our first project of the semester to help you learn how to program and execute a milling project.

Lectures:

CNC Program Format and Structure - 7 Slides

CNC Canned Cycles - 10 Slides

Reading:

CNC Program Formatting and Formulas - 14 Pages



Video:

CNC Safety Lines Explained - 6.5 Minutes

Intro to Canned Cycles - 7.5 Minutes

## 9.3 Module Assessment/Assignment

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

This Week's Assignment:

CNC Circular Interpolation Assignment - 10 Slides - We will do this small project in class. Download the presentation so you have the program code needed to execute the project.

## 9.4 Module Reflection

**Concept Content:**

This is a completely optional section. The purpose of this section is to ask your students to reflect on the material they have learned in this course. Or, if there is a specific area of the content you wanted to make sure students understood, you could guide them to discuss that in their response to your reflection question(s). You could also use this section to discuss case studies related to the content this section went over. However, if you feel that this would not be an appropriate assignment/task

for your specific subject, please feel free to delete this section from your class.

## 9.5 Module Discussion Board

**Concept Content:**

This is a completely optional section. The prupose of this section is to invite your students to discuss the week's content and what they learned from it with each other. If you feel this would not be approriate for your class or at least this week's content, feel free to delete it. If you are interested in doing a discussion board, a good idea would be to come up with a question related to the week's content for the students to answer. From there, require them to answer the quesion and respond to a least one other student's answer to foster discussion.

## 9.6 Module Wrap-Up

**Concept Goals:**

Module Learning Objectives:

- Draft a basic CNC program (SLO 4)
- Understand the use of safety lines in CNC coding (SLO 4)
- Define what a canned cycle is (SLO 4)

**Concept Content:**

This week we started our section on CNC Programming. Next week we will continue our section on CNC programming.

This week in review:

Lectures:

CNC Program Format and Structure - 7 Slides

CNC Canned Cycles - 10 Slides

Reading:

CNC Program Formatting and Formulas - 14 Pages

Video:

CNC Safety Lines Explained - 6.5 Minutes

Intro to Canned Cycles - 7.5 Minutes

Assignment:

CNC Circular Interpolation Assignment

# Module 10 - CNC Milling Programing Week 2

## 10.1 Module Overview

**Concept Goals:**

By the end of this module, you should:

- Demonstrate the ability to properly program simple CNC jobs (SLO 4)
- Define what linear and circular interpolation are (SLO 4)
- Explain the difference between linear and circular interpolation (SLO 4)

**Concept Content:**

This week we will finish our section on CNC Programming. See module 10.2 for more details.

This week at a glance:

Videos:

Titan Teaches Manual Programming on a CNC Machine - 26.5 Minutes

Linear Programing Part 1 - 5.5 Minutes

Linear Programing Part 2 - 4.5 Minutes

Reading:

Linear and Circular Interpolation on CNC Machines

Lectures/In-Class Projects:

CNC Mill Operator Bolt Part Program - 15 Slides

CNC Mill Circular Pocket Mill Cycles - 7 Slides

CNC Mill General Pocket Mill Cycle - 8 Slides

Assignments:

Complete the projects from this week's lectures.

## 10.2 Module Content Resources

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

This week we will continue studying CNC programing. We will cover more of the basics of CNC programing, linear programing, and we will work on a few simple projects in class this week.

This week's material:

Videos:

Titan Teaches Manual Programming on a CNC Machine - 26.5 Minutes

Linear Programing Part 1 - 5.5 Minutes

Linear Programing Part 2 - 4.5 Minutes

Reading:

Linear and Circular Interpolation on CNC Machines

Hub, O. (2023, April 26). *Linear and circular interpolation on CNC machines: Ino*. INO Machinery. https://inomachinery.com/linear-and-circular-interpolation-on-cnc-machines/

Lectures/In-Class Projects:

CNC Mill Operator Bolt Part Program - 15 Slides

CNC Mill Circular Pocket Mill Cycles - 7 Slides

CNC Mill General Pocket Mill Cycle - 8 Slides

## 10.3 Module Assessment/Assignment

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

This Week's Assignment:

Work on the projects from this week's lectures

## 10.4 Module Reflection

**Concept Content:**

This is a completely optional section. The purpose of this section is to ask your students to reflect on the material they have learned in this course. Or, if there is a specific area of the content you wanted to make sure students understood, you could guide them to discuss that in their response to your reflection question(s). You could also use this section to discuss case studies related to the content this section went over. However, if you feel that this would not be an appropriate assignment/task for your specific subject, please feel free to delete this section from your class.

## 10.5 Module Discussion Board

**Concept Content:**

This is a completely optional section. The prupose of this section is to invite your students to discuss the week's content and what they learned from it with each other. If you feel this would not be approriate for your class or at least this week's content, feel free to delete it. If you are interested in doing a discussion board, a good idea would be to come up with a question related to the week's content for the students to answer. From there, require them to answer the quesion and respond to a least one other student's answer to foster discussion.

## 10.6 Module Wrap-Up

**Concept Goals:**

Module Learning Objectives:

- Demonstrate the ability to properly program simple CNC jobs (SLO 4)
- Define what linear and circular interpolation are (SLO 4)
- Explain the difference between linear and circular interpolation (SLO 4)

**Concept Content:**

This week we completed our section on CNC Milling Programming. Next week, we will start our two week dive into proper set up and operation of a CNC Mill.

This week in review:

Videos:

Titan Teaches Manual Programming on a CNC Machine - 26.5 Minutes

Linear Programing Part 1 - 5.5 Minutes

Linear Programing Part 2 - 4.5 Minutes

Reading:

Linear and Circular Interpolation on CNC Machines

Lectures/In-Class Projects:

CNC Mill Operator Bolt Part Program - 15 Slides

CNC Mill Circular Pocket Mill Cycles - 7 Slides

CNC Mill General Pocket Mill Cycle - 8 Slides

Assignments:

Complete the projects from this week's lectures.

# Module 11 - CNC Milling Set Up and Operation Week 1

## 11.1 Module Overview

**Concept Goals:**

By the end of this module, you should:

- Be able to list the parts of a CNC milling machine (SLO 3)
- Understand that cutting tools are used for milling operations (SLO 3)
- Create a small CNC part utilizing a blueprint (SLO 2)

**Concept Content:**

This week we will begin our two week overview of CNC mill set up and operations. See module 10.2 for more detail

This week at a glance:

Lectures:

CNC Mill Componets - 8 Slides

CNC Milling Cutting Toool Holders - 5 Slides

Handouts:

CNC Set Up and Operations - 26 Pages

Setting Tool Length Offsets - 1 Page

Videos:

Cutting Tools and Milling Machines - 12.5 Minutes

Reading:

CNC Milling Machine Parts

N, A. (2021, December 23). ▷ *CNC milling machine parts and working*. Inoxform. https://inoxform.eu/milling-machine-parts/

Assignment:

Module 11 Project

## 11.2 Module Content Resources

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

This week we will look into CNC Set Up and Operation. We will look over the components of a milling machine, the basic set up and operation procedures, and look at the various cutting tools used in milling. This week's assignment we will create a part in our milling machines following a specific blueprint embedded in module 10.3

This Week's Material:

Lectures:

CNC Mill Componets - 8 Slides

CNC Milling Cutting Toool Holders - 5 Slides

Handouts:

CNC Set Up and Operations - 26 Pages

Setting Tool Length Offsets - 1 Page

Videos:

Cutting Tools and Milling Machines - 12.5 Minutes

Reading:

CNC Milling Machine Parts

N, A. (2021, December 23). ▷ *CNC milling machine parts and working*. Inoxform. https://inoxform.eu/milling-machine-parts/

## 11.3 Module Assessment/Assignment

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

Module 11 Project - We will follow this blueprint in class to create our part for the week.

## 11.4 Module Reflection

**Concept Content:**

This is a completely optional section. The purpose of this section is to ask your students to reflect on the material they have learned in this course. Or, if there is a specific area of the content you wanted to make sure students understood, you could guide them to discuss that in their response to your reflection question(s). You could also use this section to discuss case studies related to the content this section went over. However, if you feel that this would not be an appropriate assignment/task for your specific subject, please feel free to delete this section from your class.This is a completely optional section. The purpose of this section is to ask your students to reflect on the material they have learned in this course. Or, if there is a specific area of the content you wanted to make sure students understood, you could guide them to discuss that in their response to your reflection question(s). You could also use this section to discuss case studies related to the content this section went over. However, if you feel that this would not be an appropriate assignment/task for your specific subject, please feel free to delete this section from your class.

## 11.5 Module Discussion Board

**Concept Content:**

This is a completely optional section. The prupose of this section is to invite your students to discuss the week's content and what they learned from it with each other. If you feel this would not be approriate for your class or at least this week's content, feel free to delete it. If you are interested in doing a discussion board, a good idea would be to come up with a question related to the week's content for the students to answer. From there, require them to answer the quesion and respond to a least one other student's answer to foster discussion.

## 11.6 Module Wrap-Up

**Concept Goals:**

Module Learning Objectives:

- Be able to list the parts of a CNC milling machine (SLO 3)
- Understand that cutting tools are used for milling operations (SLO 3)
- Create a small CNC part utilizing a blueprint (SLO 2)

**Concept Content:**

This week we began our two week overview of CNC mill set up and operations. Next week we will continue discussing proper set up and operations.

This week in review:

Lectures:

CNC Mill Componets - 8 Slides

CNC Milling Cutting Toool Holders - 5 Slides

Handouts:

CNC Set Up and Operations - 26 Pages

Setting Tool Length Offsets - 1 Page

Videos:

Cutting Tools and Milling Machines - 12.5 Minutes

Reading:

CNC Milling Machine Parts

N, A. (2021, December 23). ▷ *CNC milling machine parts and working*. Inoxform. https://inoxform.eu/milling-machine-parts/

Assignment:

Module 11 Project

# Module 12 - CNC Milling Set Up and Operation Week 2

## 12.1 Module Overview

**Concept Goals:**

By the end of this module, you should:

- Be able to complete circular pocket milling using a blueprint (SLO 2)
- Understand how conditional switches work (SLO 3 and SLO 4)

**Concept Content:**

This week we will continue with looking over CNC milling set up and operations. See module 12.2 for more detail.

This week at a glance:

Lectures:

Tools for Milling - 16 Slides

Machining Holes - 10 Slides

Conditional Switches - 5 Slides

CNC Milling Circular Pocket Exercises - 7 Slides

Videos:

CNC Macro Programing: Conditional Statements - 8 Minutes

In Class Activity:

Tool Length Offset Exercises - 5 Pages

Assignment:

Circular Milling Pocket Exercise

Circular Milling Pocket Exercise Blueprint

## 12.2 Module Content Resources

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

This week we will continue our study of CNC milling and set up and operation. We will look over tool length offsets, conditional switches and conditional statements, and reviewing tools for milling. We will also complete some in-class exercises and one more project.

Lectures:

Tools for Milling - 16 Slides

Machining Holes - 10 Slides

Conditional Switches - 5 Slides

CNC Milling Circular Pocket Exercises - 7 Slides - We will go over these exercises in class

Videos:

CNC Macro Programing: Conditional Statements - 8 Minutes

In Class Activity:

Tool Length Offset Exercises - 5 Pages - If we have time, we will also go over these in class

## 12.3 Module Assessment/Assignment

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

This week's assignment:

Circular Milling Pocket Exercise - 1 Page

Circular Milling Pocket Exercise Blueprint

## 12.4 Module Reflection

**Concept Content:**

This is a completely optional section. The purpose of this section is to ask your students to reflect on the material they have learned in this course. Or, if there is a specific area of the content you wanted to make sure students understood, you could guide them to discuss that in their response to your reflection question(s). You could also use this section to discuss case studies related to the content this section went over. However, if you feel that this would not be an appropriate assignment/task for your specific subject, please feel free to delete this section from your class.

## 12.5 Module Discussion Board

**Concept Content:**

This is a completely optional section. The prupose of this section is to invite your students to discuss the week's content and what they learned from it with each other. If you feel this would not be approriate for your class or at least this week's content, feel free to delete it. If you are interested in doing a discussion board, a good idea would be to come up with a question related to the week's content for the students to answer. From there, require them to answer the quesion and respond to a least one other student's answer to foster discussion.

## 12.6 Module Wrap-Up

**Concept Goals:**

Module Learning Objectives:

- Be able to complete circular pocket milling using a blueprint (SLO 2)

- Understand how conditional switches work (SLO 3 and SLO 4)

**Concept Content:**

This week we finished our section on CNC milling set up and operations. Next week we will have some time to dedicate on projects.

This week in review:

Lectures:

Tools for Milling - 16 Slides

Machining Holes - 10 Slides

Conditional Switches - 5 Slides

CNC Milling Circular Pocket Exercises - 7 Slides

Videos:

CNC Macro Programing: Conditional Statements - 8 Minutes

In Class Activity:

Tool Length Offset Exercises - 5 Pages

Assignment:

Circular Milling Pocket Exercise

Circular Milling Pocket Exercise Blueprint

## Module 13 - Project Work Week

## 13.1 Module Overview

**Concept Goals:**

By the end of this module, you should:

- Utilize blueprints to create simple machine parts (SLO 2)

**Concept Content:**

This week is a project work week. See module 13.2 for more details.

This Week At A Glance:

Project Blueprint:

Module 13 Project Option #1

Module 13 Project Option #2

NIMS Level 1 Milling Certification Project **(Instructor Note: This project will help students get the verticial milling level 1 certification from NIMS. The file includes the grading rubric. Please see instructor resources for more detail on NIMS certifications)**

Assignment:

Work on your project(s) from this semester thus far.

## 13.2 Module Content Resources

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

This week we will take time to work on projects. If there were projects from earlier in the course you have not yet completed, this week is the time to work on those. If you have completed the projects and assignments so far, below is are two projects to work on this week. You can choose between the two of them or do both if you have the time.

Project Blueprint:

Module 13 Project Option #1

Module 13 Project Option #2

## 13.3 Module Assessment/Assignment

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

This week's assignment:

Work on your projects from this semester.

## 13.4 Module Reflection

**Concept Content:**

This is a completely optional section. The purpose of this section is to ask your students to reflect on the material they have learned in this course. Or, if there is a specific area of the content you wanted to make sure students understood, you could guide them to discuss that in their response to your reflection question(s). You could also use this section to discuss case studies related to the content this section went over. However, if you feel that this would not be an appropriate assignment/task for your specific subject, please feel free to delete this section from your class.

## 13.5 Module Discussion Board

**Concept Content:**

This is a completely optional section. The prupose of this section is to invite your students to discuss the week's content and what they learned from it with each other. If you feel this would not be approriate for your class or at least this week's content, feel free to delete it. If you are interested in doing a discussion board, a good idea would be to come up with a question related to the week's content for the students to answer. From there, require them to answer the quesion and respond to a least one other student's answer to foster discussion.

## 13.6 Module Wrap-Up

**Concept Goals:**

Module Learning Objectives:

- Utilize blueprints to create simple machine parts (SLO 2)

**Concept Content:**

This week we took time to work on milling projects. Next week, we will discuss how to inspect machine parts.

This Week In Review:

Project Blueprint:

Module 13 Project Option #1

Module 13 Project Option #2

Assignment:

Work on your project(s) from this semester thus far.

# Module 14 - CNC Part Inspection

## 14.1 Module Overview

**Concept Goals:**

By the end of this module, you should:

- Make use of precision instruments to gauge part quality (SLO 1 and SLO 5)
- Understand the purpose of quality inspection/improvement (SLO 5)
- Carry out a successful part inspection (SLO 5)

**Concept Content:**

This week we will work on inspecting machine parts. See module 14.2 for more detail.

This week at a glance:

Lectures:

Quality Improvement -14 Minutes

Handouts:

ISO Quality Inspection Principles - 14 Pages

Reading:

A Deep Dive Into CNC Machining Quality Control and Inspection

Videos:

How to make Final Inspection for CNC Machined Parts - 1.5 Minutes

How to Properly Debur and Inspect a Part and Record the Findings - 14 Minutes

Inspections: Which Feature to Inspect First - 20 Minutes

Assignment:

Circular Interpolation Training Part - We will complete this project and inspect our projects in class

## 14.2 Module Content Resources

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

This week we will go over how to inspect parts created by a CNC machine. In order to be effective at machining, it is important to know how to inspect the parts you make. This can save you time and hassle from quality control managers at facilities you may work at.

Lectures:

Quality Improvement -14 Minutes

Handouts:

ISO Quality Inspection Principles - 14 Pages

Reading:

A Deep Dive Into CNC Machining Quality Control and Inspection

Corporation, G. (2023, November 1). *A deep dive into CNC machining quality control and inspection*. GN Corporations - The Manufacturing Solution. https://www.gncorporations.com/a-deep-dive-into-cnc-machining-quality-control-and-inspection

Videos:

How to make Final Inspection for CNC Machined Parts - 1.5 Minutes

How to Properly Debur and Inspect a Part and Record the Findings - 14 Minutes

Inspections: Which Feature to Inspect First - 20 Minutes

## 14.3 Module Assessment/Assignment

**Concept Goals:**

Outline the learning goals for this module here.

**Concept Content:**

This week's assignment:

Circular Interpolation Training Part - We will create this part in class and inspect them utilizing the tools and techniques we discussed this week.

## 14.4 Module Reflection

**Concept Content:**

This is a completely optional section. The purpose of this section is to ask your students to reflect on the material they have learned in this course. Or, if there is a specific area of the content you wanted to make sure students understood, you could guide them to discuss that in their response to your reflection question(s). You could also use this section to discuss case studies related to the content this section went over. However, if you feel that this would not be an appropriate assignment/task for your specific subject, please feel free to delete this section from your class.

## 14.5 Module Discussion Board

**Concept Content:**

This is a completely optional section. The prupose of this section is to invite your students to discuss the week's content and what they learned from it with each other. If you feel this would not be approriate for your class or at least this week's content, feel free to delete it. If you are interested in doing a discussion board, a good idea would be to come up with a question related to the week's content for the students to answer. From there, require them to answer the quesion and respond to a least one other student's answer to foster discussion.

## 14.6 Module Wrap-Up

**Concept Goals:**

Module Learning Objectives:

- Make use of precision instruments to gauge part quality (SLO 1 and SLO 5)
- Understand the purpose of quality inspection/improvement (SLO 5)
- Carry out a successful part inspection (SLO 5)

**Concept Content:**

This week we discussed inspecting machine parts and quality improvement. Next week, we will have our final exam.

This week in review:

Lectures:

Quality Improvement -14 Minutes

Handouts:

ISO Quality Inspection Principles - 14 Pages

Reading:

A Deep Dive Into CNC Machining Quality Control and Inspection

Videos:

How to make Final Inspection for CNC Machined Parts - 1.5 Minutes

How to Properly Debur and Inspect a Part and Record the Findings - 14 Minutes

Inspections: Which Feature to Inspect First - 20 Minutes

Assignment:

Circular Interpolation Training Part - We will complete this project and inspect our projects in class

# Module 15 - Final Exam

## 15.1 Final Exam

**Concept Goals:**

Module Learning Objective:

- Demonstrate understanding of course material

**Concept Content:**

This week is our final exam. To access it, click on the assignments tab and look under test. Best of luck!

Final Exam:

31 Questions **(Instructor Note: This can be adjusted by you, see the exam itself for more detail)**

## 15.2 Course Wrap-Up

**Concept Content:**

You have now completed your final exam and this course. It has been great working with you all this semester. Thank you for applying yourselves to the material and making it this far! Best of luck on the rest of your academic journey.

# 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.

## Module 5 Assignment Answer Key

**Concept Content:**

Answer Key for module 5's assignment - 1 Page

## NIMS Milling I Certification Info

**Concept Content:**

Per the third project option in Module 13, students who complete the project are eligible to apply for the Milling I certification provided by NIMS. NIMS is a nationally recognized credentialling body that provides industry-recognized credentials for advanced manufacturing.

Per NIMS' website, here is a description of the credential:

**Classic Credential: Milling I**

Description:

Independently plan, set up and execute jobs. Execution includes inspecting parts while monitoring and adjusting process, machine and tool conditions.

- Industry Standards:
  - Classic standards only available upon request
- Performance Requirements:
  - Completion of Project
- Documentation:
  - Submission of online affidavit certifying all project part characteristics meet drawing requirements
- Theory Requirements:
  - Theory Exam: 56 questions
- Study Material (Textbook/E-Learning):

- Cengage Learning, Precision Machining Technology 3rd Edition
- Goodheart-Willcox, Machining Fundamentals, 11th Edition
- Sample Test Printable

Completing the project and turning it in for review by NIMS is just half of the process. The other half is the theory exam provided by NIMS. The linked sample test is a practice test for students and it can show you what materials the NIMS test will cover.