1 Introduction to CNC Programming

Objective

Students will be able to:

- Discuss the different CNC programming formats
- Construct tool paths using the Cartesian coordinate word system
- Define and explain the three CNC Programming Formats
- Perform axes movement on CNC machinery

Orienting Questions

- ✓ What are the differences between the CNC programing formats?
- ✓ What is the Cartesian Coordinate Word System?
- ✓ How does CNC address control axes movement?

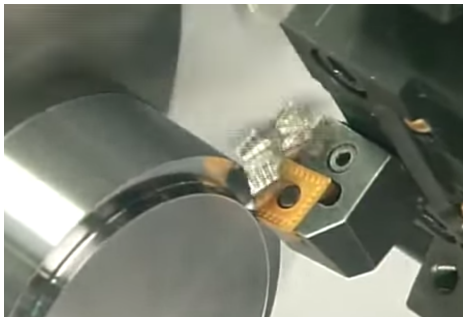
The **bolded/underlined words are key terms…click on the **blue underlined terms** for more information.

Closed Captions and transcripts are available for all videos in this module. Click the CC button at the bottom right of the play menu to turn on closed captioning in the language of your choice. You may also read a full transcript of this video by clicking on the bottom below the play menu.

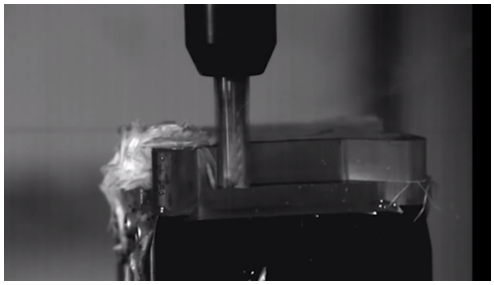
INTRODUCTION

This module is designed to provide a simple review for CNC students. At this time, we will cover a few general topics to refresh the individual for future expansion into more advanced topics needed for CNC machining. **CNC** is the acronym used for **Computer Numerical Control**. Computer Numerical Controls (CNC) govern the movement of machine tools. Machine tools can be generally divided into two basic groups Turning and Milling. There are several other machine tool categories, but for simplicity, we will concentrate on turning and milling. CNC is basically the means to the end; the "means" is the controlling device and the "ends" is the machine movement. CNC control various modes of drive systems that move axis direction and determine cutter movement and speed. This process of removing stock by turning and milling is called **"Machining**". Turning operations generally consist of "**X**" and "**Z**" movement and Milling operations generally consist of "**X**", "**Y**" and "**Z**" movement.

Click on the images to watch 2 videos. Video 1 shows a CNC turning operation. Video 2 demonstrates a CNC milling operation.



Video 1. Daewoo Puma turning operation.



Video 2. CNC Machining Center milling operation.

1.1 CNC PROGRAMMING FORMATS

There are three basic types of **Computer Numerical Controls (CNC)**, **G-Code** or **FANUC**, **Conversational** and **CAD/CAM** systems. All three formats end in machine movement, but the approach to establishing the code varies. There are advantages and disadvantages to each one depending upon various factors that we will discuss later. We will explore all three concepts, but we will emphasize the G-Code / FANUC format throughout the course.

1.1.1 G-CODES / FANUC

G-Code is the common name used for Numerical Control (NC); Numerical Controls have evolved into today's Computer Numerical Controls (CNC). FANUC is the company that features these codes. The merging of G-Code and FANUC terminology has resulted in the most widely recognized CNC controller in the world today. Most industry consultants refer to the G-Code format as a FANUC control. (Figure 1)

G-Codes are generally entered in using a keypad on a CNC controller, establishing a working program. The program in turn will control the movement of the machine, in which machines the part. The advantage of a FANUC control is the universal format or language that adapts to most CNC machine tool builders. The disadvantage of a G-Code program is the required knowledge associated with individual codes and programming formats. FANUC controls come with a variety of options depending upon the needs and functions of the manufacturing company and its product.

Figure 1. FANUC Control (by Mark Cramer, CC-SA- 4.0)

1.1.2 CONVERSATIONAL CONTROLS

Conversational Controls were established to be a user friendly format for creating CNC programs. Conversational Controls are based upon a question and answer format, not requiring the knowledge of individual G-Codes. Conversational Controls are widespread as far as manufacturers are concerned; most machine tool builders have their version of a "Conversational Control". Conversational Controls were developed to produce programs using "Layman Terminology". Layman terminology is basic machine tool language that results in a CNC program without the knowledge of using the G-Code format. The main advantage of a conversational control is the ease of learning the programming process in comparison to a

FANUC control. The disadvantages of Conversational Controllers are the added expense of the controller itself and they are not universal. Every manufacturer who produces a "Conversational Control" will have their brand of controller with slight differences not producing a universal language as a FANUC control produces.

1.1.3 CAD / CAM PROGRAMS

The **CAD/CAM** approach is the third option of creating a CNC program. The CAD/CAM system is the merging of "**Computer Aided Drafting**" and "**Computer Aided Manufacturing**". Computer Aided Drafting was originally developed to produce architectural drawings on PC's. This would eliminate the old drawing board approach to producing a working drawing. This process would evolve from basic 2-D drawings to many advanced processes such as 3-D drawings and solid-models. There are many companies who specialize in CAD and Solid Modeling software today for industry needs. The CNC industry capitalized on the advancement of CAD software by using the "CAD Geometry" to produce a CNC code that results in Computer Aided Manufacturing (CAM). The CAD/CAM method is the best of both worlds when it comes to programming; the generated CAD drawing is formatted into a G-Code based program using a post-possessor designed for that particular machine tool. Not only do you have a working blueprint from the CAD option, but now you have a generated program from the same file. The great advantage to CAD/CAM programming is that multiple machine tools can be supplied with programs off-line to minimize down time in a production environment.

ACTIVITY #1

Match the following terms and definitions listed below.

1. CNC	_____	A. Computer Aided Manufacturing
2. FANUC	_____	B. Computer Aided Drafting
3. Conversational Control	_____	C. Process of removing stock
4. Machining	_____	D. Computer Numerical Control
5. Turning Axis	_____	E. X, Y, Z Movements
6. CAM	_____	F. Question and Answer Format
7. CAD	_____	G. G-Code Based
8. Milling Axis	_____	H. X and Z Movements

ANSWERS TO ACTIVITY #1

Matching
1. D 2. G 3. F 4. C 5. H 6. A 7. B 8. E

1.2 CARTESIAN COORDINATE WORD SYSTEM

Computer Numerical Control (**CNC**) can best be described by the **Cartesian Coordinate Word System**. The Cartesian Coordinate "Word" System is made up with at least one "X", "Y" & "Z" directional movement and at least one value. The **"Word System"** is comprised with an **"Address"** and **"Value"**.

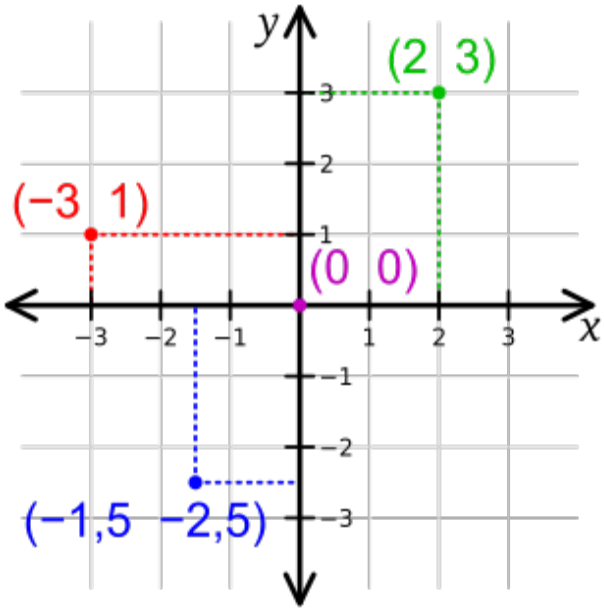


Figure 2. Cartesian Coordinate Word System

1.2.1 WORD (X 5.00)

The "**Word System**" controls the direction and length of movement when controlling a CNC machine tool. The "Word System" must have an "address" and "value**"** in place to function properly. An example of a proper "Word System" would be "X 5.00". This would be a positive movement of 5.00 inches in the "X" direction. Another example would be "Z-.500," this would be a negative movement of .500 inches in the "Z" direction.

1.2.2 ADDRESS ("X")

The **X**, **Y**, & **Z** portion of the system is known as the "Address". The "Address" portion is the direction of movement. CNC programming for **3-Axis** movement is governed by three **G-Codes**: **G17**, **G18**, and **G19**. These G-Codes determine what movements can be the dominate movements**. G17** sets the "**X**" and "**Y**" planes; **G18** sets the "**X**" and "**Z**" and **G19** sets the "**Y**" and "**Z**" movements. The "Address" portion can be best described as if you are looking at a physical mailing or street address. The **X**, **Y** and **Z** would be the name of the street such as Pine or Main Street. The **X**, **Y**, and **Z** movements are coupled with "Positive" and "Negative" values.

1.2.3 VALUE ("5.00")

The numerical "**Value**" establishes the location of the "**Address**". This value is determined with either an inch or metric movement depending upon the machine tool builders' preference. Our exercises will consist of inch coordinates. These values are given in basic decimal formats such as "5.00", this would be 5 inches. Going back to the last description of a street address, a physical mailing address would read 301 Main Street or 555 Pine Avenue. This "Value" coupled with the "Address" make up the "Word System" for CNC movement.

ACTIVITY #2

Record the "X" and "Y" Values for the Figure 3.

1. X _____ Y _____
2. X _____ Y _____
3. X _____ Y _____
4. X _____ Y _____

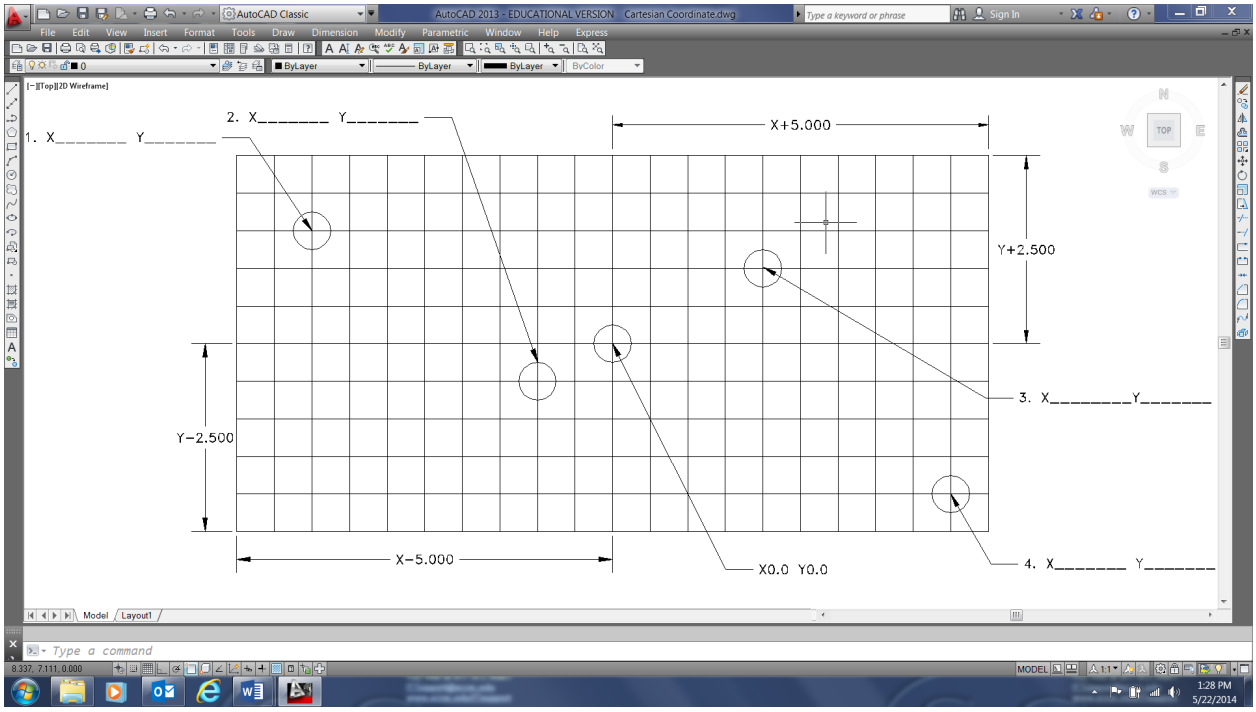


Figure 3. X & Y Grid Exercise

ANSWERS TO ACTIVITY #2

X & Y Coordinates
1. X -4.0 Y 1.5
2. X -1.0 Y -.5
3. X 2.0 Y 1.0
4. X 4.5 Y -2.0

ACTIVITY #3

Record the “X” and “Z” values for Figure 4., beginning with the smallest diameter on the face of part.

1. X _____ Z _____
2. X _____ Z _____
3. X _____ Z _____
4. X _____ Z _____
5. X _____ Z _____
6. X _____ Z _____
7. X _____ Z _____
8. X _____ Z _____

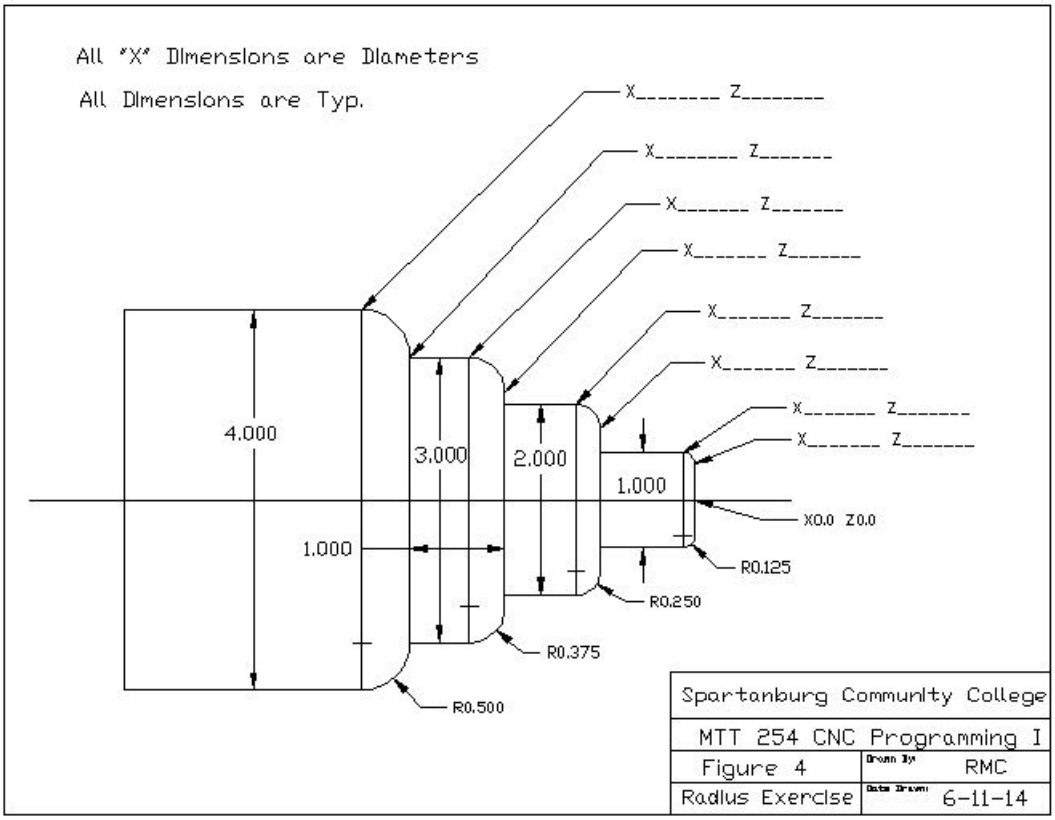


Figure 4. X & Z Coordinate Exercise

ANSWERS TO ACTIVITY #3

X & Z Coordinates		
1.	X .75	Z 0.0
2.	X 1.0	Z -.125
3.	X 1.5	Z -1.0
4.	X 2.0	Z -1.25
5.	X 2.25	Z -2.0
6.	X 3.0	Z -2.375
7.	X 3.0	Z -3.0
8.	X 4.0	Z -4.0

MAJOR CONCEPTS

KEY CONCEPTS

- The **Computer Numerical Control** (CNC) is the means of controlling the machine tool. The universal acronym "CNC" is derived from Computer Numerical Control. The basis of this concept is a computer controlling the machining process.

- The **Computer Numerical Control** (CNC) is the means of controlling the machine tool. The basis of this concept is using G-Codes or FANUC controls, conversational controls, or the CAD/CAM system to tell the computer how you want to control the machining process.

- The "**Cartesian Coordinate System**" is the directional movement of command. These movements consist of X, Y, and Z planes. These directional movements are the basis of CNC programming.
- The "**Fanuc Control**" is the most recognized CNC controller in the world today. FANUC and G-Code are universal terms that are interchangeable in the machining world today.

KEY TERMS

Computer Numerical Control: Governs the movement of Machine Tools to manufacture parts.

CAD/CAM: Computer Aided Drafting / Computer Aided Manufacturing

Fanuc: Company mainly associated with G and M coding.

Cartesian Coordinate System: X, Y and Z directional movements.

Conversational Controls: Software based upon a question and answer format.

CNC Word Address: Comprised with a directional move and value.

ASSESSMENT

MODULE REINFORCEMENT

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

1. CNC is the acronym for Computer Numerical Control. T or F
2. Fanuc is associated with G-code language. T or F
3. Conversational Controls are based upon a question and answer format. T or F
4. Lathe movements are based upon “Y” and “Z” directional movement. T or F
5. Mill movements are based upon “X”, “Y” and “Z” directional movement. T or F
6. The “Word System” for CNC is comprised of an “Address and Code”. T or F
7. The two basic groups for machining are ‘Turning” and “Grinding”. T or F
8. CAM is the acronym for Computer Aided Machining. T or F
9. CAD is the acronym for Computer Aided Drilling. T or F
10. G17, G18 and G19 set planes for dominate coordinate movements. T or F

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

1. Which system requires the knowledge of individual G-Codes?
   A. Fanuc
   B. Conversational
   C. CAD/CAM
   D. None of the above
2. The process of removing stock is called:
   A. Manufacturing
   B. Machining
   C. Controlling
   D. None of the above
3. The Cartesian Coordinate Word system consist of:
   A. A, B, C movements
   B. All letter value movements
   C. X, Y, Z movements
   D. None of the above
4. Which G-Code does not establish a plane of cutting?
   A. G17
   B. G18
   C. G19
   D. G20
5. The “Word System” is comprised of:
   A. An Address and Value
   B. An Address and G-Code
   C. A Value and G-Code
   D. All of the above
6. Fanuc is a:
   A. Company
   B. Tool
   C. Process
   D. None of the above
7. Which two items blend together?
   A. Fanuc/G-Code
   B. Conversational/Question and Answer
   C. CAD/CAM
   D. All of the above
8. The most widely used CNC controller today is:
   A. Fanuc
   B. Conversational
   C. CAD/CAM
   D. None of the above
9. The greatest advantage of a Fanuc control is:
   A. Universal Format
   B. Universal Language
   C. Universal Acceptance

D. All of the above

10. Which CNC Controller uses “Layman Terms”?
    A. Fanuc
    B. Conversational
    C. CAD/CAM
    D. A and B
11. The main advantage of a Conversational control is:
    A. Cost
    B. Ease of Learning
    C. Universal
    D. All of the above

12. CAD/CAM systems combine:
    A. Drafting and Machining
    B. Computers and Machining
    C. Drafting and Computers
    D. None of the above
13. G17 establishes what directional movement?
    A. X and Y
    B. X and Z
    C. Y and Z
    D. X, Y, and Z
14. G18 establishes what directional movement?
    A. X and Y
    B. X and Z
    C. Y and Z
    D. X, Y and Z
15. G19 establishes what directional Movement?
    A. X and Y
    B. X and Z
    C. Y and Z
    D. X, Y and Z

Answer Key

True or False	Multiple Choice
1. T 2. T 3. T 4. F 5. T 6. F 7. F 8. F 9. F 10. T	1. A 2. B 3. C 4. D 5. A 6. A 7. D 8. A 9. D 10. B 11. B 12. A 13. A 14. B 15. C

DISCUSSION PROMPTS

LIST ADVANTAGES AND DISADVANTAGES OF THE FANUC PROGRAMMING.

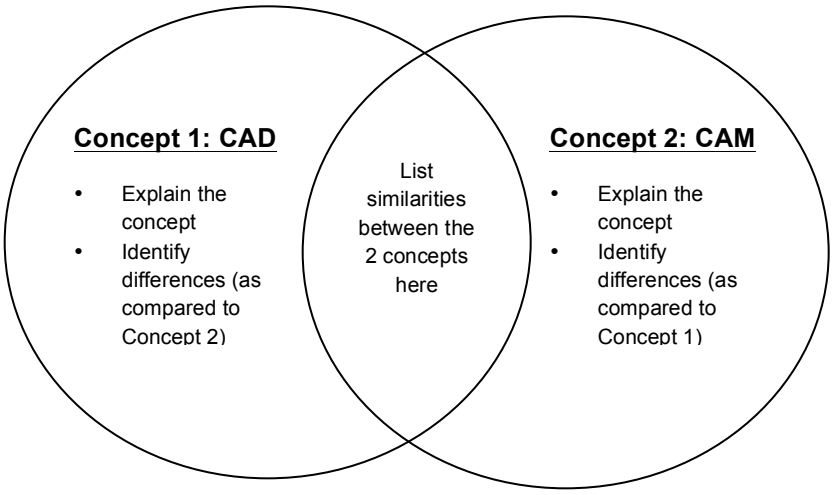
In Module 1, we contrasted the 3 avenues of programming CNC machines. Compare the advantages and disadvantages of all three and trace them back to Fanuc language.

CNC PROGRAMMING AND BASIC MATH

In Module 1, we surveyed the Cartesian Coordinate System, explain the importance of numbers and math in CNC programming.

CRITICAL THINKING

	Concept #1 G-Code Programming	Concept #2 Conversational Programming
Define or explain each concept		
Explain how the concepts are similar		
Explain how each concept is different with respect to specific attributes		



- Explain the outcome of CAD/CAM process in CNC programming and machining.

Attribution Table

Author/s	Title	Source	License
Tim Coggins	Video: Daewoo Puma Turning Operation	https://youtu.be/qp3e2YX0ieQ	CC BY-SA 4.0
Chanmailleman	Video: CNC Machining	https://youtu.be/WuGKnL0q1ps	CC BY-SA 4.0
Mark Cramer	Figure 1. Fanuc Control	Module author	CC BY-SA 4.0
Mark Cramer	Figure 2. Cartesian Coordinate Word System	http://upload.wikimedia.org/wikipedia/commons/4/44/Cartesian_coordinate_system_(comma).svg	CC BY-SA 4.0
Mark Cramer	Figure 3. X & Y Grid Exercise	Module author, developed using AutoCad software.	CC BY-SA 4.0
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