Western Technical College

31420310 CNC Mill Programming - Basic

Course Outcome Summary

Course Information

Description	An introduction to planning and writing programs for computer numerically controlled milling machines using G and M code. Participants will write basic programs for CNC (Computer Numerical Control) milling machines, proof programs, and run programs in CNC machine tools. Learners will set up workpieces in machines, enter programs, set tool offsets, enter cutter compensation, and complete part projects. Programming basics will include multiple tool programs, macros, cutter compensation and canned cycles.
Career Cluster	Manufacturing
Instructional Level	Technical Diploma Courses
Total Credits	1.00
Total Hours	36.00

Types of Instruction

Instruction Type	Credits/Hours
Lecture	1 CR / 36 HR

Course History

Purpose/Goals

This course prepares learners to write basic G&M code (EIA/ISO) programs for CNC mills and machining centers.

Target Population

This course is targeted toward individuals who would like to learn the basics of G&M code programming for computer numerically controlled (CNC) mills and machining centers. This course is designed for incumbent workers, displaced workers, workers who would like to improve employability and skills, high school graduates, and individuals in need of application based employer demanded skills. Additionally, this course is designed to help learners meet the requirements for Western Technical College's machine tool technical diploma program and the requirements to earn a "CNC Programmer" certificate as part of a CNC Skills Institute.

Pre/Corequisites

Pre/Corequisite	31420302 Blueprint Reading

Pre/Corequisite	31420314 Machining: Intro to Machining
Pre/Corequisite	31804334 Manufacturing Math 1

Textbooks

420-310 CNC Programming Manual Machine Tool Technology. Western. Publisher: Western. Required.

Learner Supplies

Safety glasses with side eye protection that meet Z87 OSHA guidelines. **Vendor:** Campus Shop. Required.

Scientific calculator (recommend T1-36x Solar). **Vendor:** Campus Shop. Required.

Program Outcomes

1. MACH 1. Apply basic safety practices in the machine shop
Type *TSA* ***Status*** *Active*

Summative Assessment Strategies
1.1. in a performance demonstration in the machine shop or lab
1.2. in a written examination

Criteria
1.1. Demonstrate safety procedures
1.2. Operate machine with all required guards in place
1.3. Maintain clean and organized work environment
1.4. Wear appropriate clothing and Personal Protective Equipment (PPE)
1.5. Explain proper lock-out tag-out procedures

2. MACH 2. Interpret industrial/engineering drawings
Type *TSA* ***Status*** *Active*

Summative Assessment Strategies
2.1. in a performance demonstration

Criteria
2.1. Interpret orthographic projections
2.2. Interpret lines, symbols, standards, and notations
2.3. Interpret a Bill of Materials
2.4. Interpret a title block
2.5. Determine location of part features according to established specifications
2.6. Calculate tolerances according to established specifications
2.7. Develop drawings that follow view projection standards
2.8. Interpret Geometric Dimensioning and Tolerancing

3. MACH 3. Apply precision measuring methods to part inspection
Type *TSA* ***Status*** *Active*

Summative Assessment Strategies
3.1. in a performance demonstration

Criteria
3.1. Select correct measuring tool for job requirements
3.2. Demonstrate care of precision measuring equipment according to established procedures
3.3. Convert English/metric measurements
3.4. Use standard industry measurement terminology
3.5. Perform precision measurement according to established procedures

3.6. Complete an inspection document to verify print specifications
3.7. Use computer aided metrology

4. MACH 5. Perform programming, set-up and operation of CNC Machine Tools
Type *TSA* ***Status*** *Active*

Summative Assessment Strategies
4.1. in a performance demonstration

Criteria
4.1. Write basic programs for specified CNC machine tools according to EIA-ISO standards
4.2. Load the correct program into the machine
4.3. Verify the accuracy of the CNC program
4.4. Verify work and tool offsets
4.5. Execute program
4.6. Adjust speeds and feeds to optimize CNC machining conditions

Course Competencies

1. Apply safety procedures to lab applications
Domain *Psychomotor* ***Level*** *Practice* ***Status*** *Active*

Assessment Strategies
1.1. In the classroom, lab, or shop setting
1.2. In written and applied assignments
1.3. Individually and in groups
1.4. On tests and quizzes
1.5. Given materials and all available shop equipment and supplies

Criteria

Performance will be satisfactory when:

1.1. wears safety glasses 100% of the time while in the machine tool lab
1.2. learner puts tools and tooling away after use
1.3. learner works with others to keep coolant and fluid levels filled
1.4. learner dresses appropriately for CNC machine shop
1.5. learner corrects safety hazards in and around the machine tool lab
1.6. learner explains when machine tools need a warm-up cycle
1.7. learner uses safe methods to secure workpieces in machine tools
1.8. learner practices safe procedures for operating the machine tools
1.9. learner does not use compressed air inside or on machine tools
1.10. learner describes shut-down procedures for machine tools
1.11. learner cleans machines after use
1.12. safety procedures meet the rubric criteria a minimum of 75% for each criteria
1.13. learner scores 90% or higher on safety test

Learning Objectives
1.a. Wear safety glasses in the lab
1.b. Maintain clean work area
1.c. Adhere to machine maintenance schedule
1.d. Identify CNC shop safety hazards
1.e. Follow procedures for machine warm-up, set-up, operation, and shut down
1.f. Respect machine tools and equipment

2. Describe CNC milling machine systems
Domain *Cognitive* ***Level*** *Comprehension* ***Status*** *Active*

Assessment Strategies
2.1. In the classroom, lab, or shop setting
2.2. In written and applied assignments
2.3. Individually

2.4. On tests and quizzes

Criteria

Performance will be satisfactory when:

2.1. learner participates in classroom discussion on the types of CNC machine tools
2.2. learner participates in classroom discussion on CNC milling machine systems
2.3. learner correctly describes the functions of the four CNC machining center systems
2.4. learner lists advantages and disadvantages of CNC machine tools
2.5. learner correctly describes the value of computers in CNC machining processes
2.6. learner identifies programs and software used for creating CNC programs
2.7. learner states the three methods of transferring programs to CNC machine tools
2.8. learner identifies at least three types of CNC machine tools
2.9. learner identifies at least two variation on CNC machining centers
2.10. learner explains the functions of CNC machining centers in manufacturing
2.11. assignments are turned in by the due date and have accuracy of 70% or higher
2.12. learner scores a minimum of 70% on tests, and quizzes

Learning Objectives

2.a. Describe types of CNC machine tools
2.b. Describe CNC machining centers
2.c. Describe CNC machining center systems
2.d. Explain the function of the machine control unit
2.e. Explain the function of CNC machining centers in CNC systems
2.f. Describe the function of computers in CNC systems
2.g. Describe storage medium for CNC systems
2.h. List methods of loading programs into a CNC machining center machine control

3. Associate the Cartesian coordinate system with CNC machining center axes

Domain *Cognitive* ***Level*** *Application* ***Status*** *Active*

Assessment Strategies

3.1. In the classroom, lab, or shop setting
3.2. Using computers and actual CNC machine tools
3.3. In written and applied assignments
3.4. Individually
3.5. On tests and quizzes
3.6. Given prints, diagrams, and all available shop equipment and supplies

Criteria

Performance will be satisfactory when:

3.1. learner participates in classroom discussion on Cartesian coordinates system as it relates to CNC milling applications
3.2. learner selects correct CNC milling machine axis when plotting coordinates
3.3. learner completes assignments by due date and with accuracy of 70% or higher
3.4. learner uses prints to plot coordinate points for CNC machining centers
3.5. learner incorporates the three Z positions appropriately into programs
3.6. learner selects the correct relationship to part zero reference for X and Y coordinates in programs
3.7. learner scores a minimum of 70% on tests and quizzes

Learning Objectives

3.a. Discuss the purpose of the Cartesian coordinate system in CNC machining center machining
3.b. Identify coordinate axes of CNC mills and machining centers
3.c. Describe the three Z position relationships between the workpiece and tool
3.d. Explain the X and Y coordinate relationships to the part zero reference location
3.e. Locate coordinate points graphically for CNC machining center axes

4. Identify standard and auxiliary machine tool axes

Domain *Cognitive* ***Level*** *Comprehension* ***Status*** *Active*

Assessment Strategies

4.1. In the classroom, lab, or shop setting
4.2. Using computers and actual CNC machine tools
4.3. In written and applied assignments
4.4. Individually
4.5. On tests and quizzes
4.6. Given prints, diagrams, and all available shop equipment and supplies

Criteria

Performance will be satisfactory when:

4.1. learner correctly locates X, Y and Z axes of part when writing programs
4.2. learner correctly places workpiece in CNC machining center relative to print specifications
4.3. learner tabulates coordinates from prints for CNC machining center assignments
4.4. learner tabulates coordinates using absolute positioning
4.5. learner tabulates coordinates using incremental positioning
4.6. assignments are turned in by due date and have accuracy of 70% or higher
4.7. tests and quizzes have a minimum of 70% correct answers

Learning Objectives

4.a. Differentiate various axis coordinate systems for CNC machining centers
4.b. Identify standard CNC machining center axes
4.c. Identify auxiliary CNC machining center axes
4.d. Illustrate CNC machining center axis motions
4.e. Tabulate X, Y and Z coordinates for machining centers
4.f. Differentiate incremental and absolute axes and movements on CNC machining centers
4.g. Orient workpieces in CNC machining center relative to part print specifications

5. Describe terminology associated with CNC machining center programming

Domain *Cognitive* ***Level*** *Comprehension* ***Status*** *Active*

Assessment Strategies

5.1. In the classroom, lab, or shop setting
5.2. Using actual CNC machine tools
5.3. In written and applied assignments
5.4. Individually
5.5. On tests and quizzes
5.6. Given prints, materials, and all available shop equipment and supplies

Criteria

Performance will be satisfactory when:

5.1. learner participates in classroom discussion on terminology related to CNC machining
5.2. learner scores 70% or greater on terminology quiz
5.3. learner uses the correct terms for CNC machining center system components
5.4. learner correctly identifies print symbols as they relate to CNC machining
5.5. learner correctly describes the function of CNC general preparatory codes for machining centers
5.6. learner correctly describes the function of miscellaneous CNC codes for machining centers
5.7. learner interprets prints to write CNC machining center programs
5.8. learner selects appropriate tools for CNC milling machine processes
5.9. assignments have accuracy of 70% or higher
5.10. learner describes CNC machining center codes other than G and M codes

Learning Objectives

5.a. Identify terms related to CNC milling machines
5.b. Describe CNC machining center word address terms
5.c. Explain G and M code terms related to CNC machining center programming
5.d. Identify print terms related to CNC machining
5.e. Differentiate tooling terms as they relate to CNC machining centers

6. Classify tooling for CNC machining centers

Domain *Cognitive* ***Level*** *Application* ***Status*** *Active*

Assessment Strategies

6.1. In the classroom, lab, or shop setting
6.2. Using actual CNC machine tools
6.3. In written and applied assignments
6.4. Individually
6.5. On tests and quizzes
6.6. Given prints, process sheets, specification sheets, and all available shop equipment and supplies

Criteria

Performance will be satisfactory when:

6.1. learner correctly identifies the types of face and end mills used in CNC milling machines
6.2. learner correctly identifies the types of hole cutting tools used in milling operations
6.3. learner correctly identifies tools used inside holes in milling operations
6.4. learner accurately recognizes tool wear
6.5. learner differentiates types of materials used for cutting tools
6.6. learner correctly describes the purpose of various materials used for cutting tools
6.7. learner calculates correct speeds and feeds for various tool materials and workpiece material
6.8. learner explains the benefits and disadvantages of climb and conventional machining as they relate to CNC milling machines
6.9. learner correctly describes the types of cutting fluids used in CNC operations
6.10. learner explains how cutting fluids are selected for CNC milling operations
6.11. learner determines correct spindle rotation based on tooling
6.12. assignments are competed on time and have accuracy of 70% or better
6.13. Quizzes and tests have accuracy of 70% or better

Learning Objectives

6.a. Identify CNC milling machine tooling
6.b. Select appropriate tools for hole operations
6.c. Select appropriate tools for milling operations
6.d. Describe types of materials used for cutting tools
6.e. Calculate speeds and feeds for CNC milling applications
6.f. Explain the purpose of cutting fluids in CNC milling applications

7. Interpret G, M, and other programming code functions

Domain *Cognitive* ***Level*** *Analysis* ***Status*** *Active*

Assessment Strategies

7.1. In the classroom, lab, or shop setting
7.2. Using computers and actual CNC machine tools
7.3. In written and applied assignments
7.4. Individually
7.5. On tests and quizzes
7.6. Given prints, directions, templates, and all available shop equipment and supplies

Criteria

Performance will be satisfactory when:

7.1. learner correctly describes the function of M coolant codes
7.2. learner correctly describes the function of M subprogram codes
7.3. learner uses correct format for codes in program blocks
7.4. learner uses correct format for block placement within programs
7.5. learner selects appropriate codes when writing CNC machining center programs
7.6. learner correctly describes the function of G positioning codes
7.7. learner correctly describes the function of G linear and circular interpolation codes
7.8. learner correctly describes the function of G machine reference codes
7.9. learner correctly describes the function of G cutter compensation codes
7.10. learner correctly describes the function of G tool length compensation codes
7.11. learner correctly describes the function of G workpiece coordinates codes
7.12. learner correctly describes the function of G drilling cycle codes
7.13. learner correctly describes the function of M spindle control codes

7.14. learner correctly describes the function of M stop and program end codes
7.15. learner correctly describes the functions of codes other than G and M codes
7.16. learner differentiates codes used for CNC machining centers versus CNC machining centers
7.17. learner correctly describes "modal"
7.18. learner differentiates modal codes from nonmodal codes
7.19. learner applies correct codes to required machine movements when writing programs
7.20. assignments are completed by the due date with 80% accuracy
7.21. quizzes and tests have accuracy of 80% or higher

Learning Objectives

7.a. Interpret CNC machining center programming codes
7.b. Interpret CNC machining center word address codes
7.c. Describe program and sequence formats for CNC machining center programming
7.d. Determine word address arrangements in blocks
7.e. Apply proper programming language format for CNC machining center programs
7.f. Select appropriate G, M, and other codes for CNC machining center program blocks
7.g. Describe the effect of CNC codes on CNC machining center tool movements

8. Write basic programs for CNC mills or machining centers

Domain *Cognitive* ***Level*** *Application* ***Status*** *Active*

Assessment Strategies

8.1. In the classroom, lab, or shop setting
8.2. Using computers and actual CNC machine tools
8.3. In written and applied assignments
8.4. Individually
8.5. On tests and quizzes
8.6. Given prints, diagrams, inspection sheets, stock, and all available shop equipment and supplies

Criteria

Performance will be satisfactory when:

8.1. learner correctly describes the three basic sections of a CNC machining center program
8.2. learner develops a start sequence format based on class lessons
8.3. learner uses start sequence correctly in all programs written
8.4. learner develops an ending sequence format based on class lessons
8.5. learner uses ending sequence in all programs written
8.6. learner writes absolute positioning linear interpolation program from part print
8.7. learner writes linear interpolation name program using absolute positioning
8.8. learner writes incremental positioning linear interpolation program from part print
8.9. learner writes absolute positioning circular interpolation program from part print
8.10. learner writes incremental positioning circular interpolation program from part print
8.11. learner writes circular interpolation name program using absolute positioning
8.12. learner incorporates Z position moves in programs
8.13. learner uses rapid moves for Zc movements in programs
8.14. learner finds and corrects errors in programs
8.15. assignments have accuracy of 80% or higher
8.16. name programs have accuracy of 90% or higher
8.17. name programs are proofed to run in CNC machining centers without errors
8.18. name programs are accurate enough o run in CNC machining centers
8.19. name programs programs are ran in CNC machining centers
8.20. learner scores a minimum of 70% on tests and quizzes

Learning Objectives

8.a. Write program start sequences for CNC machining centers
8.b. Write linear interpolation programs for CNC machining centers
8.c. Write circular interpolation programs for CNC machining centers
8.d. Write program ending sequence for CNC machining centers
8.e. Write absolute positioning programs for CNC machining centers
8.f. Write incremental positioning programs for CNC machining centers
8.g. Explain the parts of a CNC machining center program
8.h. Write simple programs for CNC machining centers

9. Apply mathematical concepts to write programs for CNC machine tools

Domain *Cognitive* ***Level*** *Application* ***Status*** *Active*

Assessment Strategies

9.1. In the classroom, lab, or shop setting
9.2. Using computers and actual machine tools
9.3. In written and applied assignments
9.4. Individually
9.5. On tests and quizzes
9.6. Given prints, process sheets, specification sheets, and all available shop equipment and supplies

Criteria

Performance will be satisfactory when:

9.1. learner accurately calculates absolute distances from part zero coordinates
9.2. learner accurately calculates incremental distances from previous point
9.3. learner accurately calculates circular interpolation distances from reference point
9.4. learner correctly solves side distances of right triangles
9.5. learner correctly solves angle degrees of right triangles
9.6. learner seeks assistance for math calculations when needed from instructors
9.7. learner correctly calculates cutter compensation for tool radii
9.8. learner correctly calculates programming coordinates from part print dimensions
9.9. assignments are turned in by due dates with 90% mathematical accuracy
9.10. quizzes and tests and tests have 80% mathematical accuracy

Learning Objectives

9.a. Perform addition and subtraction as they relate to CNC machining center coordinates
9.b. Compute triangles using trigonometry
9.c. Calculate machine moves using absolute values
9.d. Calculate machine moves using incremental values
9.e. Determine diametrical coordinates based on radial dimensions

10. Write multiple function programs for CNC machining centers

Domain *Cognitive* ***Level*** *Application* ***Status*** *Active*

Assessment Strategies

10.1. In the classroom, lab, or shop setting
10.2. Using computers and actual CNC machine tools
10.3. In written and applied assignments
10.4. Individually
10.5. On tests and quizzes
10.6. Given prints, process sheets, specification sheets, and all available shop equipment and supplies

Criteria

Performance will be satisfactory when:

10.1. learner writes programs using manual cutter compensation
10.2. learner writes programs using G code cutter compensation
10.3. learner enters cutter compensation offsets in machine tool per program specifications
10.4. learner incorporates at least three tool changes in programs for CNC machining centers
10.5. learner incorporates at least three canned cycles in programs for CNC machining centers
10.6. learner writes a program that uses at least two subprogram calls
10.7. learner writes a program the incorporates cutter compensation, multiple tool changes, and subprograms
10.8. learner identifies and corrects program errors
10.9. learner proofs multiple function programs in simulator
10.10. multiple function programs are ran in CNC machining centers
10.11. multiple function programs are accurate enough to run in CNC machining centers
10.12. multiple function programs have accuracy of 90% or higher
10.13. assignments have accuracy of 90% or higher

Learning Objectives

10.a. Write CNC machining center programs using cutter compensation

10.b. Write CNC machining center programs with multiple tool changes
10.c. Write CNC machining center programs that use canned cycle programs
10.d. Write CNC machining center programs that incorporate subprograms

11. Prepare CNC machining center to run programs

Domain *Psychomotor* ***Level*** *Practice* ***Status*** *Active*

Assessment Strategies

11.1. In the classroom, lab, or shop setting
11.2. Using actual CNC machine tools
11.3. In written and applied assignments
11.4. Individually
11.5. On tests and quizzes
11.6. Given prints, diagrams, materials, and all available shop equipment and supplies

Criteria

Performance will be satisfactory when:

11.1. learner participates in class discussion regarding job planning
11.2. learner completes a job process plan
11.3. learner writes CNC machining center programs using approved programming sequences
11.4. learner runs warm up program for CNC machining center
11.5. learner runs warm up program with a tool in the spindle
11.6. learner runs warm up program with coolant flowing
11.7. learner correctly secures work in CNC machining center
11.8. learner correctly uses edgefinder to locate workpiece edges
11.9. learner correctly enters workpiece offsets in machine tool control
11.10. learner correctly loads tools in carousel or magazine
11.11. learner correctly sets tool length offsets
11.12. learner enters offsets correctly in machine tool control
11.13. learner recognizes hazards of sharp tools in the carousel when setting up work or tools
11.14. learner loads programs in the machine tool control using at least two different methods
11.15. learner does not damage tools or work when setting tool and work offsets
11.16. learner does not damage tool presetter when setting tools
11.17. learner does not damage edgefinder when locating work edges
11.18. learner seeks assistance from instructor when unsure of procedures or program
11.19. procedures meet each rubric criterion with 85% proficiency

Learning Objectives

11.a. Discuss CNC machining center job planning and programming sequence
11.b. Explain the importance of warm-up cycles for CNC machining centers
11.c. Demonstrate proper work set up procedures for CNC machining centers
11.d. Demonstrate proper tool set up procedures for CNC machining centers
11.e. Locate work coordinates and set offsets
11.f. Set tool length offsets
11.g. Load programs in CNC machine tools

12. Prove CNC machining center program validity

Domain *Cognitive* ***Level*** *Evaluation* ***Status*** *Active*

Assessment Strategies

12.1. In the lab or shop setting
12.2. In written and applied assignments
12.3. Using actual CNC turning centers
12.4. Individually
12.5. On tests and quizzes
12.6. Given prints, diagrams, materials, and all available shop equipment and supplies

Criteria

Performance will be satisfactory when:

12.1. learner locates the correct CNC milling program

12.2. learner correctly activates program to run
12.3. learner runs program in graphical interface or simulator
12.4. learner verifies accuracy of CNC machining center program
12.5. learner correctly identifies problems with program
12.6. learner corrects program errors
12.7. learner re-proofs program in simulator to verify errors have been corrected
12.8. learner saves program as text file in specified location
12.9. learner uses at least two of the specified storage mediums to save programs
12.10. learner sends programs to instructor as e-mail attachments
12.11. learner runs programs to cut part or design that was specified
12.12. learner inspects part before removing from the machine
12.13. programs have 90% accuracy prior to running in CNC machining center
12.14. projects or parts are produced per print specification projects or parts meet 70% of specified criteria
12.15. lab exams meet a minimum of 70% of specified criteria

Learning Objectives

12.a. Call up and activate programs
12.b. Verify programs in graphical interface
12.c. Correct program errors
12.d. Inspect part accuracy