**MTT 232 Computer Numerical Control II**

**Credits: 4**

**Contact hours: 60**

**Grading: Traditional**

**Course Description:**

Covers computer numerical control (CNC) milling operations, program format, and machine setup. G & M codes, control functions, the letter address system, and math issues related to CNC are included. Students will program, set-up and produce a variety of CNC milling projects.

This course satisfies 7.5 hours of instruction toward completing the embedded human relations curriculum requirements, in accordance with Embedded Curriculum Guidelines Option A.

This course satisfies 8 hours of instruction toward completing the embedded mathematics curriculum requirements, in accordance with Embedded Curriculum Guidelines Option A.

This course may not transfer to a baccalaureate degree of art or science within the universities in the Nevada System of Higher Education (NSHE).

**The Objectives of this course are to:**

Introduce CNC milling machine safety.

Demonstrate CNC milling principles and operations.

**Learning Outcome:**

Students will program, set-up and produce a variety of precision CNC mill projects.

Learning Measure:

Ability will be measured by quizzes, tests, exams, and/or reports that use predetermined rubrics and/or industry standards.

**Learning Outcome:**

Students will discuss and employ machine management principals governing CNC mill operations.

**Learning Measure:**

Ability will be measured by quizzes, tests, exams, documented instructor observations, and/or reports that use predetermined rubrics and/or industry standards.

**Learning Outcome:**

Students will operate a CNC milling machine to facilitate completion of student projects.

**Learning Measure:**

Ability will be measured by quizzes, tests, exams, documented instructor observations, and/or reports that use predetermined rubrics and/or industry standards.

**Learning Outcome:**

Students will work as a team to design, program, produce and assemble a group CNC project.

**Learning Measure:**

Ability will be measured using summative assessment through hands-on lab activities.

**Learning Outcome:**

Students will calculate data point locations within a three axis Cartesian coordinate system.

**Learning Measure:**

Ability will be measured by a pretest and a post test.

**Learning Outcome:**

Students will use right angle trigonometry to calculate CNC program data points.

**Learning Measure:**

Ability will be measured by a pretest and a post test.

**Learning Outcome:**

Students will calculate cutter speeds and feed rates.

**Learning Measure:**

Ability will be measured by a pretest and a post test.

**Textbook:**

HAAS Mill Programming Workbook - Complete

**Supplemental Text:**

Precision Machining Technology 2nd Edition, Cengage Learning, Author: Hoffman, Hopewell, Janes. ISBN: 978-1-285-44454-3

Section 8: Computer Numerical Control

Unit 1: CNC Basics

Unit 5: Introduction to CNC Milling

Unit 6: CNC Milling: Programming

Unit 7: CNC Milling: Set-up and Operation

**Competencies - Direct Instruction.**

Direct instruction via traditional lecture format.

A.1. Explain the history and development of CNC machine tools.

A.2. Identify the major types of CNC machine tools and the part types they are most suited for.

A.3. Discuss the major advantages and disadvantages of CNC machine tools as compared to manual machine tools.

A.4. Locate, identify, and explain the purpose of the major components of a CNC milling machine.

A.5. Identify and explain the purpose of major accessories used with CNC milling machines.

A.6. Explain the Cartesian coordinate grid system as it relates to CNC programming.

A.7. Explain the polar coordinate system as it relates to CNC programming.

A.8. Explain the components of a CNC process plan and the methodology used in their development.

A.9. Explain what is meant by the machine work envelope.

A.10. List and differentiate between the parts of a CNC program.

A.11. Discuss the makeup of a typical program block.

A.12. Explain and differentiate between the function a modal code and a non-modal code.

A.13. Explain the function of the block numbering codes (N).

A.14. Explain the purpose and function of program numbers (O).

A.15. Discuss the purpose of a programmed safety block.

A.16. List and define codes associated with a programmed safety block.

A.17. Explain the function of the tool change codes (T1M6) and the actions of the automatic tool change process.

A.18. Describe and differentiate between the purposes of the optional stop code (M1) and the program stop code (M0).

A.19. Explain and differentiate between the application of the spindle codes (M3, M4, M5 & S).

A.20. Explain the purpose and use of work coordinate systems on a CNC milling machine (G54-G59).

A.21. Differentiate between the machine coordinate system and the part or work coordinate systems.

A.22. Explain the function of the tool height compensation codes (G43, G44, & G49) in conjunction with the tool height offset code (H).

A.23. Explain the application of the coolant codes (M8 & M9)

A.24. Explain the use of the X, Y, & Z letter address system to define locations within the CNC work envelope.

A.25. Explain and differentiate between the functions of the absolute programming mode (G90) and the incremental programming mode (G91).

A.26. Explain the use and purpose of the machine rapid motion command (G0).

A.27. Explain the use and purpose of the machine linear interpolation command (G1).

A.28. Explain the use and purpose of the machine circular interpolation clockwise command (G2).

A.29. Explain the use and purpose of the machine circular interpolation counter-clockwise command (G3).

A.30. Explain the use and purpose of the machine feed rate code (F).

A.31. Explain and differentiate between the use of the R code and the I, J, & K codes to program arc size when using circular interpolation codes.

A.32. Discuss and differentiate between cutter compensation automatic, manual, and non-compensated programs and the requirements of each.

A.33. Explain and differentiate between the application of the cutter compensation left code (G41), the cutter compensation right code (G42), and the cutter compensation cancel code (G40).

A.34. Explain the function of the diameter code (D) in a cutter compensated program.

A.35. Describe the function of the dwell codes (G4 P) as it relates to axis motion.

A.36. Explain the function and application of canned cycles.

A.37. Explain the purpose and application of the simple drill canned cycle (G81).

A.38. Explain the purpose and application of the spot drill/counter-bore canned cycle (G82).

A.39. Explain the purpose and application of deep hole peck canned cycle (G83).

A.40. Explain the purpose and application of the chip breaking canned cycle (G73).

A.41. Explain the purpose and application of the tapping canned cycles for right and left hand threaded holes (G84, G74, G184, & G174).

A.42. Calculate appropriate RPM and federate values for tapping cycles (G84, G74, G184, & G174).

A.43. Explain the function of the rapid/retract plane code (R) as it relates to canned drill, tap, and boring cycles.

A.44. Explain and differentiate between the application of the initial point return code (G98) and the R-plane return code (G99) as they relate to drill, tap, and boring canned cycles.

A.45. Explain and differentiate between the use of the peck amount code (U) and the peck amount calculation codes (I, J, & K) as they apply to G83 & G73.

A.46. Explain the purpose and application of the circular clockwise pocketing canned cycle (G12).

A.47. Explain the purpose and application of the circular counter-clockwise pocketing canned cycle (G13).

A.48. Explain the purpose and application of the irregular shaped pocketing canned cycle (G150).

A.49. Explain and differentiate between the application of sub-routines and sub-programs (M97, M98, & M99).

A.50. Explain the purpose and application of the machine zero return code (G28).

A.51. Explain and differentiate between the applications of the program end codes (M30 & M2).

**Competencies - Directed Instruction.**

Directed instruction via guided hands-on training on CNC control simulation equipment and CNC milling equipment.

B.1. Prepare a standard CNC milling machine for operation.

B.2. Perform appropriate safety checks prior to machine start up.

B.3. Locate machine coolant tank/sump and check for proper operating level.

B.4. Utilize coolant refractometer to measure coolant tank/sump concentration.

B.5. Calculate coolant add concentration to raise or lower existing coolant tank/sump concentration.

B.6. Mix appropriately concentrated coolant for addition to coolant tank/sump.

B.7. Add coolant to CNC milling machine as necessary to maintain coolant levels at normal operating level.

B.8. Locate CNC milling machine hydraulic tank/sump and check for proper operating level.

B.9. Identify make-up hydraulic fluid and add as required to maintain normal operating level.

B.10. Locate system hydraulic pressure gage and check for normal operating pressure.

B.11. Adjust hydraulic pressure as required to raise and lower hydraulic system pressure.

B.12. Locate spindle lubrication system and check for proper operating level.

B.13. Identify make-up spindle oil and add as necessary to maintain normal operating levels.

B.14. Locate way lubrication/grease system and check for proper operating levels.

B.15. Identify make-up way oil/grease and add as required to maintain normal operating level.

B.16. Locate pneumatic system pressure gage and check for normal operating pressure.

B.17. Adjust pneumatic pressure as required to maintain proper operating pressure.

B.18. Locate pneumatic system air dryer and drain as required.

B.19. Utilize CNC operating manual to identify and perform routine machine preventative maintenance requirements.

B.20. Prepare a comprehensive CNC milling process plan for given part blueprint.

B.21. Perform pre-startup clearance checks to ensure machine is clear to execute automatic motion.

B.22. Perform system power up operations to establish power and locate machine home position.

B.23. Switch machine between run and set-up modes.

B.24. Locate and turn on and off machine work lights.

B.25. Locate and load existing CNC program from machine memory.

B.26. Load existing CNC program from USB device.

B.27. Load existing program from wired/wireless network connection.

B.28. Manually input CNC program via machinery control panel.

B.29. Locate and enter program edit mode.

B.30. Manually edit existing program utilizing insert, alter, and delete options.

B.31. Determine cause for machine alarm.

B.32. Correct alarming machine condition.

B.33. Reset machine alarms.

B.34. Locate and enter manual data input (MDI) mode.

B.35. Input and execute machine codes in MDI mode.

B.36. Locate manual coolant controls and manually turn on and off coolant system.

B.37. Locate manual tool changer controls and index tool changer forward, reverse, and to specific tool locations.

B.38. Employ tool selection techniques to develop CNC job tool list.

B.39. Locate, identify, and measure tooling for CNC milling operations.

B.40. Locate and assemble CNC milling tool holders.

B.41. Mount appropriate CNC milling cutters in their respective tool holders.

B.42. Load CNC milling tool holders and tooling in a CNC milling machine.

B.43. Dismount CNC milling tool holders and tooling from a CNC milling machine.

B.44. Assemble and mount CNC milling work holding device/fixture on a CNC milling machine.

B.45. Locate and enter machine hand jog mode.

B.46. Manually switch between active axis while in hand jog mode.

B.47. Manually switch between active axis jog increments.

B.48. Perform manual machine axis movements while in hand jog mode.

B.49. True and align work holding devices/fixtures to corresponding machine axis.

B.50. Load and unload a part from a CNC milling work holding device/fixture.

B.51. Utilize machine controls to manually start and stop the machine spindle.

B.52. Utilize MDI mode to enter and execute machine spindle speed control commands.

B.53. Utilize an edge finder to locate part boundaries.

B.54. Utilize a test indicator to locate the center of a circular work piece.

B.55. Enter appropriate machine coordinates in the work coordinate system offset library to establish part zero locations.

B.56.Adjust work coordinate system offsets to manipulate part dimensions in both the plus and minus directions.

B.57. Jog machine appropriately to establish Z zero (part) H value offset.

B.58. Perform a Z zero H value touch off using soft shim stock (paper).

B.59. Perform a Z zero H value touch off using hard shim stock (metallic feeler gages).

B.60. Perform a Z zero H value touch off without using shim stock (rotating tool).

B.61. Locate and set appropriate programmable coolant offsets.

B.62. Assemble and set coolant spray utilizing adjustable coolant hose connections.

B.63. Locate and initiate program graphics mode on a CNC milling machine.

B.64. Operate CNC milling machine in graphics mode and observe program simulation.

B.65. Locate and initiate single block mode on a CNC milling machine.

B.66. Operate CNC milling machine in single block mode.

B.67. Locate and initiate optional stop mode on a CNC milling machine.

B.68. Operate CNC milling machine in optional stop mode.

B.69. Locate and initiate automatic mode on a CNC milling machine.

B.70. Operate CNC milling machine in automatic mode.

B.71. Monitor CNC milling machine during automatic operation.

B.72. Perform required part inspections to assure compliance with print specifications.

B.73. Perform required offset adjustments to comply with print specifications.

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