PLTW—Computer Integrated Manufacturing

Levels: 11-12
Units of Credit: 1.0
CIP Code: 21.0123
Core Code: 38-01-00-00-003
Prerequisite: Principles of Engineering, Introduction to Engineering Design
Test: #965

COURSE DESCRIPTION
This course teaches the fundamentals of computerized manufacturing technology. It builds on the solid-modeling skills developed in the Introduction to Engineering Design course. Students use 3-D computer software to solve design problems. They assess their solutions through mass propriety analysis (the relationship of design, junction, and materials), modify their designs, and use prototyping equipment to produce 3-D models. The course includes these integrated concepts:

- Computer Modeling: Students use 3-D software for mass property analysis.
- Computer Numerical Control (CNC) Equipment: Students develop an understanding of the operating procedures and programming capabilities of machine tools.
- Computer-aided Manufacturing (CAM): Students convert computer-generated geometry into a program to direct the operation of CNC machine tools.
- Robotics: Student program robots to handle materials in assembly-line operations.
- Flexible Manufacturing Systems: Teams of students design manufacturing work cells and tabletop factories to solve complex problems that arise in integrating multiple pieces of computer-controlled equipment.

CORE STANDARDS, OBJECTIVES, AND INDICATORS

STANDARD 1
Students will use 3-D software for mass property analysis.

Objective 1: Demonstrate the ability to store, retrieve copy, and output drawing files depending upon system setup.

Objective 2: Utilize instructor identified 2-D computer sketching functions.

Objective 3: Incorporate various coordinate systems in the construction of 2-D geometrical shapes.

Objective 4: Calculate the x and y coordinates given a radius and angle.

Objective 5: Produce 2-D sketches using available sketching features.

Objective 6: Apply editing techniques to produce accurate sketches.

Objective 7: Understand and apply sketch constraints.

Objective 8: Analyze drawings with appropriate inquiry functions.

Objective 9: Define sketched objects with dimensions and geometric constraints.

Objective 10: Apply necessary sketched features to generate a solid model.

Objective 11: Demonstrate the application and modifying of placed features.

Objective 12: Develop multi-view drawings such as top, front, right side, isometric, section, and auxiliary views from the solid model.

Objective 13: Demonstrate the proper application of annotations and reference dimensions while conforming to established drafting standards.

Objective 14: Update model and drawing views using revision specification sheets provided by the instructor.

Objective 15: Create assembly models through the integration of individual parts and sub-assemblies.

Objective 16: Generate an assembly drawing, which include Views, Balloons, and Bill of Materials (BOM).

Objective 17: Recognize the wide array of industry-wide prototyping methods in use.

Objective 18: Identify the need for rapid-prototyping.

Objective 19: Prepare a prototype model from a drawing database.

STANDARD 2
Students will develop an understanding of the operating procedures and programming capabilities of machine tools.

Objective 1: Explain the history of Computer Controlled Machines charting the growth of NC and how it has been implemented into Private Industry.

Objective 2: Explain how the application of CNC machines has impacted manufacturing.

Objective 3: Explain the advantages and disadvantages of CNC Machining.

Objective 4: Chart the evolution of machine tools, controllers, and software used in programmable machines.

Objective 5: Explore career opportunities and educational requirements within the field of programmable machines.

Objective 6: Identify the axis relative to various CNC machines.

Objective 7: Contrast open and closed loop control systems.

Objective 8: Identify the types of drive systems used in CNC machines.

Objective 9: Use the CNC control program to indicate the machine position and then contrast that position to the relative position of the part origin (PRZ).

Objective 10: Identify and explain the function of the major components of a CNC machine tool.

Objective 11: Apply various work holding devices commonly used for CNC machining.

Objective 12: Identify various types of tool changes used in CNC machine tools.

Objective 13: Define the three primary axes used in CNC machining and explore the remaining axes used in advanced machining.

Objective 14: Explain the importance of cutting tool materials and how they affect the speed and feed rates used by machine tools.

Objective 15: Examine different types of tool holding devices used in CNC machine tools.

Objective 16: Select appropriate cutting tools to efficiently, safely and accurately cut parts using a CNC machine.

Objective 17: Understand the difference between reference and position points.

Objective 18: Understand that CNC machine movements are identified by axes.

Objective 19: Understand that the axis system is a worldwide standard for machine movement.

Objective 20: Be able to plot points using absolute, relative (incremental) and polar coordinates.

Objective 21: Identify Significant Points on geometric shapes (ex. Center point, end point).

Objective 22: Identify the optimum location for the Program Reference Zero (PRZ) point.

Objective 23: Identify the three categories of machine movement: straight line, curved line, and non-regular shape.

Objective 24: Complete a preliminary planning sheet to identify necessary work holding devices, cutting tools, reference points, machining sequences and safe operation.

Objective 25: Define the term “Alphanumeric Coding.”

Objective 26: Define the term “G codes.”

Objective 27: Define the term “M code.”

Objective 28: Identify the three sections of a program; Initial Commands, Program Body, and Program End.

Objective 29: Write a basic NC part program using necessary G and M codes including remarks that describe the function of each code.

Objective 30: Explore the advantages and disadvantages of shop floor programming as well as off line programming.

Objective 31: Create a simple NC part program using a text editor and a CAM package.

Objective 32: Employ a CAD/CAM/CNC software solution to create a part.

Objective 33: Analyze, identify and correct errors found in NC part program files.

Objective 34: Use simulation software to graphically verify NC program operation.

Objective 35: Perform a “Dry Run” to verify the machine setup and program operation.

Objective 36: Demonstrate the ability to safely setup, maintain and operate a CNC machine center using appropriate documentation and procedures.

Objective 37: Analyze part geometry to select appropriate cutting tools and fixturing devices needed to create the part using a CNC machine.

Objective 38: Setup and edit the tool library of a CNC control program providing offset values and tool geometry.

Objective 39: Calculate and verify appropriate spindle speeds and feed rates specific to each cutting tool utilized in an NC part program.

Objective 40: Safely and accurately fixture a part in a CNC machine and set the program reference zero (PRZ).

Objective 41: Verify NC part programs using a simulation software before machining the part on a CNC device.

Objective 42: List and demonstrate all possible methods of disabling a CNC machine in the event of an emergency.

Objective 43: Follow a safety checklist prior to running an NC part program on a CNC machine.

Objective 44: Operate a CNC machine to cut a part to specifications.

STANDARD 3
Students will convert computer-generated geometry into a program to direct the operation of CNC machine tools.

Objective 1: Measure using standards and metric systems.

Objective 2: Convert measurements between metric and standard inch systems.

Objective 3: Read technical drawings identifying and understand the dimensional tolerances and limits.

Objective 4: Make precision measurements to the degree of accuracy required by plan specification using appropriate instruments.

Objective 5: Understand how comparison instruments can be used to check dimensions, compare shapes, indicate centers and check parallel surfaces.

Objective 6: Be aware of advanced and automated measurement systems that are applied in industry. (ex. Coordinate Measuring Systems, Digital Probes and Optical Scanners).

Objective 7: Be aware of the importance of precision measurement in SPC and quality control.

Objective 8: Define the acronym CAM and explain what the purpose of a CAM package is.

Objective 9: Demonstrate their ability to operate the user interface of a CAM package and access help using appropriate documentation and help screens.

Objective 10: Perform basic file operations using a CAM package such as saving, opening, printing an editing part program files.

Objective 11: Demonstrate an ability to import and export CAD files using a CAM package.

Objective 12: Setup a CAM package by editing the material and tool libraries, defining stock sizes, selecting the appropriate post processor and defining the units of measure to be used.

Objective 13: Apply the fundamental and advanced milling and turning procedures used in CAM packages.

Objective 14: Use a CAM package to generate and edit tool paths by applying appropriate machining processes to geometry from a CAD program.

STANDARD 4
Students will program robots to handle materials in assembly-line operations.

Objective 1: Explore the chronological development of automation leading to robotics.

Objective 2: Investigate career opportunities in the robotics career fields.

Objective 3: Demonstrate the development of robotics from Science Fiction.

Objective 4: Identify a minimum of four dangerous and repetitive jobs that robots are used for.

Objective 5: Formulate a definition of a robot.

Objective 6: Classify different types of Robots.

Objective 7: Evaluate the positive impact robots have on manufacturing.

Objective 8: Discuss the social implications of robots.

Objective 9: Identify and compare the four classifications of robots.

Objective 10: Investigate a classification of robot.

Objective 11: Design and build a working model of a robot.

Objective 12: Identify and report specifications and work envelopes of robots.

Objective 13: Identify and sketch the mechanical components to a robot.

Objective 14: Design and develop an end effector.

Objective 15: Demonstrate their understanding of the way end effectors are specific to a process.

Objective 16: Understand the various drive systems used in robotics and analyze the advantages and disadvantages of each.

Objective 17: Understand the basic components of robot controllers.

Objective 18: Demonstrate an understanding of control techniques and computer situations.

Objective 19: Design and build a feed system with sensors.

Objective 20: Program a robot to perform several tasks.

Objective 21: Program a robot to solve a materials handling problem.

Objective 22: Recognize the need for end of arm tooling and how this tooling affects the robots operation.

Objective 23: Understand the necessity for specialty tooling applications in robotics.

Objective 24: Prepare and document a presentation on end of arm tooling.

Objective 25: Analyze and generate the solution to a robotic manufacturing problem.

STANDARD 5
Teams of students will design manufacturing work cells and tabletop factories to solve complex problems that arise in integrating multiple pieces of computer-controlled equipment.

Objective 1: Understand how the individual components of a flexible manufacturing system are interrelated.

Objective 2: Recognize the benefits and problems associated with CIM technology and how they affect the manufacturing process.

Objective 3: Identify some basic characteristics of a manufacturing operation that lend themselves to computer integrated manufacturing.

Objective 4: Identify some of the typical components and sub systems that make up an automated machining, assembly and process-type manufacturing operation.

Objective 5: Identify the three categories of CIM manufacturing systems.

Objective 6: Compare and contrast the benefits and drawbacks of the three categories of CIM manufacturing systems.

Objective 7: Recognize the working relationship between the CNC mill and the robot.

Objective 8: Identify the components of a FMS.

Objective 9: Identify and study the relationship between a CNC milling machine interface and a jointed arm robot interface through a communication handshaking process.

Objective 10: Explore the individual components used in selected CIM systems.

Objective 11: Analyze and select components for a CIM system for a specific industrial application.

Objective 12: Understand the various applications of a Programmable Logic Controller as related to its use in a CIM system.

Objective 13: Understand the difference between a PLC and a computer with interface.

Objective 14: Recognize and understand the necessary safety precautions associated with a fully automated CIM system.

Objective 15: Recognize and explain the significance of teamwork and communication when they combine the designs of the individual groups into a complete miniature FMS.

Objective 16: Demonstrate how their individual components work together to form a complete CIM system.

Objective 17: Assemble and test their individual component designs by integrating them into a complete miniature FMS built from the Fischertechnik models.