COMPUTER INTEGRATED MANUFACTURING
Course Syllabus

Course Number: ST00041
OCAS Code: 8712
Course Length: 120 Hours
Career Cluster: Science, Technology, Engineering and Mathematics
Career Pathway: Engineering and Technology
Career Major(s): PLTW Pre-Engineering (Comprehensive High Schools), PLTW Pre-Engineering

Pre-requisite(s): Introduction to Engineering Design; Principles of Engineering

Course Description:
This course applies principles of robotics and automation and builds on computer solid modeling skills developed in Introduction to Engineering Design. Students use CNC equipment to produce actual models of their three-dimensional designs. Fundamental concepts of robotics used in automated manufacturing and design analysis are included.

Textbooks: Project Lead the Way Materials

Course Objectives:

A. Computer Modeling

1. Fundamentals
   a. Students will be able to demonstrate the ability to store, retrieve copy, and output drawing files depending upon system setup.
   b. Students will be able to utilize instructor identified 2D computer sketching functions.
   c. Students will be able to incorporate various coordinate systems in the construction of 2D geometrical shapes.
   d. Students will be able to calculate the x and y coordinates given a radius and angle.

2. Object Construction
   a. Students will be able to produce 2D sketches using available sketching features.
   b. Students will be able to apply editing techniques to produce accurate sketches.
   c. Student will be able to understand and apply sketch constraints.
   d. Students will analyze drawings with appropriate inquiry functions.

3. Parts Modeling
   a. Students will be able to define sketched objects with dimensions and geometric constraints.
   b. Students will be able to apply necessary sketched features to generate a solid model.
   c. Students will be able to demonstrate the application and modifying of placed features.

4. Creation of Working Drawings
   a. Students will be able to develop multi-view drawings such as top, front,
right side, isometric, section and auxiliary views from the solid model.

b. Students will be able to demonstrate the proper application of annotations and reference dimensions while conforming to established drafting standards.

c. Students will be able to update model and drawing views using revision specification sheets provided by the instructor.

5. Surface Modeling
   a. Students will be able to create assembly models through the integration of individual parts and sub-assemblies.
   b. Students will be able to generate an assembly drawing, which include Views, Balloons, and Bill Of Materials (BOM).

6. Rapid Prototyping
   a. Students will be able to recognize the wide array of industry-wide prototyping methods in use.
   b. Students will identify the need for rapid-prototyping.
   c. Students will prepare a prototype model from a drawing data base.

B. CNC Machining

1. History of Programmable Machining
   a. Students will be able to explain the history of Computer Controlled Machines
   b. Chart the growth of NC and how it has been implemented into private industry.
   c. Students will be able to explain how the application of CNC machines has impacted manufacturing.
   d. Students will be able to explain the advantages and disadvantages of CNC Machining.
   e. Students will be able to chart the evolution of machine tools, controllers, and software used in programmable machines.
   f. Students will explore career opportunities and educational requirements within the field of programmable machines.

2. CNC Characteristics
   a. Students will identify the axis relative to various CNC machines.
   b. Students will contrast open and closed loop control systems.
   c. Students will identify the types of drive systems used in CNC machines.
   d. Students will be able to use the CNC control program to indicate the machine position and then contrast that position to the relative position of the part origin (PRZ).
   e. Students will be able to identify and explain the function of the major components of a CNC machine tool.
   f. Students will examine and apply various work holding devices commonly used for CNC machining.
   g. Students will identify various types of tool changers used in CNC machine tools.
   h. Students will define the three primary axes used in CNC machining and explore the remaining axes used in advanced machining.
   i. Students will explain the importance of cutting tool materials and how they affect the speed and feed rates used by machine tools.
   j. Students will examine different types of tool holding devices used in CNC machine tools.
   k. Students will be able to select appropriate cutting tools to efficiently, safely and accurately cut parts using a CNC machine.
3. **CNC Programming**
   
a. Students will understand the difference between reference and position points.
b. Students will understand that CNC machine movements are identified by axes.
c. Students will understand that the axis system is a worldwide standard for machine movement.
d. Students will be able to plot points using absolute, relative (incremental) and polar coordinates.
e. Students will be able to identify Significant Points on geometric shapes (ex. Center point, end point).
f. Students will be able to identify the optimum location for the Program Reference Zero (PRZ) point.
g. Students will be able to identify the three categories of machine movement: straight line, curved line, and non-regular shape.
h. Students will be able to complete a preliminary planning sheet to identify necessary work holding devices, cutting tools, reference points, machining sequences and safe operation.
i. Students will be able to define the term “Alphanumeric Coding.”
j. Students will be able to define the term “G codes.”
k. Students will be able to define the term “M code.”
l. Students will be able to identify the three sections of a program; Initial Commands, Program Body, and Program End.
m. Students will be able to write a basic NC part program using necessary G and M codes including remarks that describe the function of each code.
n. Students will be able to explore the advantages and disadvantages of shop floor programming as well as off line programming.
o. Students will be able to create a simple NC part program using a text editor and a CAM package.
p. Students will be able to employ a CAD/CAM/CNC software solution to create a part.
q. Students will be able to analyze, identify and correct errors found in NC part program files.
r. Students will be able to use simulation software to graphically verify NC program operation.
s. Students will be able to perform a “Dry Run” to verify the machine setup and program operation.

4. **CNC Operation**
   
a. Student will be able to demonstrate the ability to safely setup, maintain and operate a CNC machine center using appropriate documentation and procedures.
b. Students will be able to analyze part geometry to select appropriate cutting tools and fixturing devices needed to create the part using a CNC machine.
c. Students will be able to setup and edit the tool library of a CNC control program providing offset values and tool geometry.
d. Students will be able to calculate and verify appropriate spindle speeds and feed rates specific to each cutting tool utilized in an NC part program.
e. Students will be able to safely and accurately fixture a part in a CNC machine and set the program reference zero (PRZ).
f. Students will be able to verify NC part programs using a simulation software before machining the part on a CNC device.
Students will be able to list and demonstrate all possible methods of disabling a CNC machine in the event of an emergency.

h. Students will follow a safety checklist prior to running an NC part program on a CNC machine. See Safety Checklist in Unit 2 of the Appendix.

i. Students will be able to Perform a Dry Run to verify the machine setup and program operation.

j. Students will be able to operate a CNC machine to cut a part to specifications.

5. Precision Measurement

a. Students will be able to demonstrate the ability to safely setup, maintain and operate a CNC machine center using appropriate documentation and procedures.

b. Students will be able to analyze part geometry to select appropriate cutting tools and fixturing devices needed to create the part using a CNC machine.

c. Students will be able to setup and edit the tool library of a CNC control program providing offset values and tool geometry.

d. Students will be able to calculate and verify appropriate spindle speeds and feed rates specific to each cutting tool utilized in an NC part program.

e. Students will be able to safely and accurately fixture a part in a CNC machine and set the program reference zero (PRZ).

f. Students will be able to verify NC part programs using a simulation software before machining the part on a CNC device.

g. Students will be able to list and demonstrate all possible methods of disabling a CNC machine in the event of an emergency.

h. Students will follow a safety checklist prior to running an NC part program on a CNC machine. See Safety Checklist in Unit 2 of the Appendix.

i. Students will be able to Perform a Dry Run to verify the machine setup and program operation.

j. Students will be able to operate a CNC machine to cut a part to specifications.

C. Robotics

1. Introduction to Robotics

a. Students will explore the chronological development of automation leading to robotics.

b. Students will investigate career opportunities in the robotics career fields.

c. Students will demonstrate the development of robotics from Science Fiction.

d. Students will identify a minimum of four dangerous and repetitive jobs that robots are used for.

2. Robotics and Automated Systems

a. Students will formulate a definition of a robot.

b. Students will be able to classify different types of Robots.

c. Students will evaluate the positive impact robots have on manufacturing.

d. Students will discuss the social implications of robots.

3. Robot Characteristics

a. Students will identify and compare the four classifications of
robots.
b. Students will investigate a classification of robot.
c. Students will design and build a working model of a robot.
d. Students will identify and report specifications and work envelopes of robots.

4. Mechanical Components
   a. Students will identify and sketch the mechanical components to a robot.
   b. Students will design and develop an end effector.
   c. Students will demonstrate their understanding of the way end effectors are specific to a process.
   d. Students will understand the various drive systems used in robotics and analyze the advantages and disadvantages of each.

5. Control Systems
   a. Students will understand the basic components of robot controllers.
   b. Students will demonstrate an understanding of control techniques and computer simulations.
   c. Students will design and build a feed system with sensors.

6. Programming Methods
   a. Students will program a robot to perform several tasks.
   b. Students will program a robot to solve a materials handling problem.
   c. Students will recognize the need for end of arm tooling and how this tooling affects the robots operation.

7. Robot Applications
   a. Students will understand the necessity for specialty tooling applications in robotics.
   b. Students will prepare and document a presentation on end of arm tooling.
   c. Students will analyze and generate the solution to a robotic manufacturing problem.

D. Computer Integrated Manufacturing
1. Rationale for CIM Manufacturing
   a. Students will understand how the individual components of a flexible manufacturing system are interrelated.
   b. Students will recognize the benefits and problems associated with CIM technology and how they affect the manufacturing process.
   c. Students will identify some basic characteristics of a manufacturing operation that lend themselves to computer integrated manufacturing.
   d. Students will identify some of the typical components and sub systems that make up an automated machining, assembly and process-type manufacturing operation.

2. Types of CIM Systems
   a. Students will identify the three categories of CIM manufacturing systems.
   b. Students will compare and contrast the benefits and drawbacks of the three categories of CIM manufacturing systems.
   c. Students will recognize the working relationship between the
CNC mill and the robot.

d. Students will be able to identify the components of a FMS.

3. Components of CIM Systems
   
a. Students will identify and study the relationship between a CNC milling machine interface and a jointed arm robot interface through a communication handshaking process.
   
b. Students will explore the individual components used in selected CIM systems.
   
c. Students will analyze and select components for a CIM system for a specific industrial application.
   
d. Students will understand the various applications of a Programmable Logic Controller as related to its use in a CIM system.
   
5. Students will understand the difference between a PLC and a computer with interface.

4. CIM System Applications
   
a. Students will identify and study the relationship between a CNC milling machine interface and a jointed arm robot interface through a communication handshaking process.
   
b. Students will explore the individual components used in selected CIM systems.
   
c. Students will analyze and select components for a CIM system for a specific industrial application.
   
d. Students will understand the various applications of a Programmable Logic Controller as related to its use in a CIM system.
   
e. Students will understand the difference between a PLC and a computer with interface.

PLTW objectives

Teaching Methods: The class will primarily be taught by the lecture and demonstration method and supported by various media materials to address various learning styles. There will be question and answer sessions over material covered in lecture and media presentations. Supervised lab time is provided for students to complete required projects.

Grading Procedures: 1. Students are graded on theory and shop practice and performance.
   
2. Each course must be passed with seventy (70%) percent or better.
   
3. Grading scale: A=90-100%, B=80-89%, C=70-79%, D=60-69%, F=50-59%.

Description of Classroom, Laboratories, and Equipment: Tulsa Technology Center campuses are owned and operated by Tulsa Technology Center School District No. 18. All programs provide students the opportunity to work with professionally certified instructors in modern, well-equipped facilities.
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**Available Certifications/College Credit**

The student may be eligible to take state, national or industry exam after completion of the program. College credit may be issued from Oklahoma State University-Okmulgee or Tulsa Community College. See program counselor for additional information.

**College Credit Eligibility:**

The student must maintain a grade point average of 2.0 or better.