Murrieta Valley Unified School District **Board Submission: March 2016**
HIGH SCHOOL COURSE OUTLINE

Course Title: Computer Integrated Manufacturing (CIM) - Project Lead the Way (PLTW)

Department: Industrial Technology

Course #: 7705

Grade Level/s: 10 – 12

Length of Course: Year

Prerequisite/s: Introduction to Design (PLTW)

UC/CSU (A-G) Req: (G) General Elective

Brief Course Description: Computer Integrated Manufacturing (CIM) will be the second course in the Project Lead the Way Engineering sequence. CIM is considered a specialty course and will focus on the high-tech, innovative nature of modern manufacturing. CIM focuses on the fundamentals of computerized manufacturing, automation technologies, product design, and robotics. CIM builds on the solid-modeling skills developed in the Introduction to Design course. Students will use 3-D design software, CAM (Computer-Aided Manufacturing) software, CNC (Computer Numeric Control) machinery, and robotics, to solve multiple design, manufacturing, and automation problems. Through hands-on projects, students will apply engineering standards while documenting their work and designs in an engineer's notebook. Students will design solutions to solve proposed problems and communicate solutions to peers and members of the professional community. The course assumes a solid understanding of topics covered in the Introduction to Design course and will further develop Computer Aided Design skills as tangible projects are produced on CNC machinery.

I. GOALS

The student will:

A. Explore manufacturing through research and projects

B. Explain the different procedures used in manufacturing

C. Create a flowchart that portrays a manufacturing process

D. Identify a control system and explain its application to manufacturing

E. Model and create a program to control an automated system

F. Continue to incorporate the design process

G. Use calculated volume, mass, surface area of parts to determine material cost, waste, and packaging requirements

H. Use solid modeling software to improve a flawed design

I. Make ethical decisions about manufacturing

J. Create a product using solid modeling software

K. Explain the difference between primary and secondary manufacturing processes

L. Analyze a product to propose the manufacturing processes used to create it

M. Explore manufacturing processes via research

N. Explore prototyping processes

O. Determine speeds and feeds for a CNC machine

P. Determine the appropriate speed rate for a given material using a tool with a given diameter

Q. Determine the feed rate for a given material using a tool with a given diameter

R. Read and interpret general and miscellaneous codes known as G & M code on a CNC machine

S. Transfer the drawings made in CAD to a CAM program

T. Create numerical code using a CAM program

U. Verify the creation of part/s using simulation software

V. Create part/s using the CNC machines as demonstrated by the instructor

W. Create a product on the computer using knowledge of manufacturing processes

X. Explore automation careers

Y. Identify the advantages and disadvantages of robotic labor versus human labor

Z. Learn proper technique of handling materials

AA. Create programs using robotic software that will allow the robot to perform a set of tasks

BB. Formulate a list of tasks in which the robot used in class can be used in a large scale CIM cell operation

CC. Identify the three categories of CIM systems.

DD. Understand the significance of teamwork and communication

EE. Design a manufacturing system that contains at least two automated components

FF. Start and maintain an engineering notebook that documents daily work

II. OUTLINE OF CONTENT FOR MAJOR AREAS OF STUDY

Semester I

A. Unit 1: Principles of Manufacturing
   1. Lesson 1.1 History of Manufacturing
   2. Lesson 1.2: Control Systems
   3. Lesson 1.3: Cost of Manufacturing

B. Unit 2: Manufacturing Processes
   1. Lesson 2.1: Designing for Manufacturability
   2. Lesson 2.2: How We Make Things
   3. Lesson 2.3: Product Development

Semester II

A. Unit 3: Elements of Automation
   1. Lesson 3.1: Introduction to Robotic Automation
   2. Lesson 3.2: 2 Introduction to Automation Power
   3. Lesson 3.3: Robotic Programming and Usage

B. Unit 4: Integration of Manufacturing Elements
   1. Lesson 4.1: CIM Systems
   2. Lesson 4.2: Integration of Manufacturing

III. ACCOUNTABILITY DETERMINANTS

A. Key Assignments
   1. Unit 1: Principles of Manufacturing. Manufacturing has a long history of innovation and continuous improvement. While improvement once focused on refining individual manufacturing processes, more recently manufacturing has been considered a system. Sustainable manufacturing organizations focus on safety while improving material, financial, and time efficiency. The integration of hardware and software solutions is transforming worldwide manufacturing into predominantly computer integrated manufacturing.
      In this unit students will explore the history of manufacturing and understand how manufacturing components are interconnected within a system. Students will learn to use input and output devices as a foundation to model manufacturing processes. The design of a model is refined through the introduction of financial consideration.

a. Lesson 1.1 History of Manufacturing
   The goal of this lesson is to provide context for manufacturing as an evolution of processes and systems. Students are given the opportunity to explore a manufacturing topic in greater depth and share this knowledge with their peers while developing presentation skills. Students are introduced to a model for how manufacturing components interact to more efficiently manufacture products.
b. Lesson 1.2: Control Systems
   The goal of this lesson is for students to learn the use of input and output devices. Students will acquire efficient program creation techniques and apply them as they develop manufacturing system models.
c. Lesson 1.3: Cost of Manufacturing
   The goal of this lesson is to integrate financial consideration into manufacturing design. Students collaborate on a project as they financially optimize a manufacturing system.

2. Unit 2: Manufacturing Processes
   The goal of unit 2 is to introduce students to manufacturing processes as discrete steps within a manufacturing system. Students analyze a product to consider design improvements, perform calculations to make manufacturing decisions, and recommend processes. Students explore manufacturing machines while learning to develop machine language called G&M code. Students create G&M code manually to understand how machine code controls a CNC device. Students then practice workflow as they design a part using CAD software, use powerful CAM software to create G&M code, and run that G&M code on a CNC mill to manufacture a part. Ultimately students operate a CNC mill and create a physical part with their G&M code.
   a. Lesson 2.1: Designing for Manufacturability
      The goal of this lesson is consider how an effective product could be efficiently manufactured. In this lesson students analyze bad designs and discuss ways in which these could be improved. Students develop and apply formulas related to manufacturing scenarios while considering safety and ethics.
   b. Lesson 2.2: How We Make Things
      The goal of this lesson is to build a foundation of manufacturing process knowledge. Students are shown processes and the associated machines as these are applied to product manufacturing. Students apply this knowledge as they analyze products and recommend effective manufacturing processes.
   c. Lesson 2.3: Product Development
      The goal of this lesson is for students to execute a workflow from product concept through product creation using a CNC mill. A CNC mill uses a machine language called G&M code to move a cutting tool to remove raw material, resulting in a final product. Students create G&M code manually to understand how machine code controls a CNC device. As students prepare to operate a CNC mill, they learn how to calculate appropriate mill settings to produce products safely and efficiently. Students then practice workflow as they design a part with CAD software and convert the CAD model into G&M code using powerful CAM software. Ultimately students program and operate a CNC mill to create a physical part with their G&M code.

Semester II

1. Unit 3: Elements of Automation
   The goal of this unit is to introduce students to robotic automation within a manufacturing system. Robots as a form of automation have improved manufacturing by performing tasks that may be too mundane, impossible, unsafe, or inefficient for humans to perform. Robot effectiveness is impacted by factors such as robot geometry, controlling program, and robot power sources.
   In this unit students create programs for a robot to move material similarly to pick and place operations typically used in an automated manufacturing setting. Students integrate a robot arm into a more complex environment through integration with other devices.
   a. Lesson 3.1: Introduction to Robotic Automation
      The goal of this lesson is to develop a deeper understanding of the application of robotic automation within manufacturing. In this lesson students are provided a historical frame of reference for robotic automation development. Students create automated sequences that instruct a robot to complete a task in a simulated environment.
   b. Lesson 3.2: 2 Introduction to Automation Power
      The goal of this lesson is for students to apply power concepts related to robotic automation. Students apply power formulas to solve theoretical engineering problems. Students design, build, and develop a program to model the use of fluid power to complete a task.
   c. Lesson 3.3: Robotic Programming and Usage
      The goal of this lesson is to apply concepts learned in the previous lessons to a physical robot. Students create programs to control a robot arm. Ultimately students will integrate the robot into complex systems through communication with other control systems.
2. Unit 4: Integration of Manufacturing
   The goal of this unit is to apply the course concepts to a capstone problem. This opportunity will allow students to develop teamwork and presentation skills. The unit also explores career opportunities available in the manufacturing industry.
   a. Lesson 4.1: CIM Systems
      Students will connect the concepts learned in this course to manufacturing in a real-world setting though a visit to a manufacturing facility. This lesson will also introduce manufacturing career opportunities
   b. Lesson 4.2: Integration of Manufacturing
      The goal of this lesson is to provide students the opportunity to apply the knowledge and skills learned in this and previous engineering courses to a capstone problem. Student teams choose a product to manufacture. Students will break down the processes from simulated raw material to finished product. Students design, build, and program a flexible manufacturing system model with the same prototyping system used earlier in the course.

B. Assessment Methods
   Assessment of student performance will include but not be limited to:
   1. Participation, effort, skill mastery and quality of work
   2. Engineers notebook / portfolio
   3. Tests and quizzes
   4. Individual projects/group projects/final projects

5. Daily student observation of classroom participation, effort and achievement
6. Classwork/homework
7. Performance tasks
8. In-class lecture notes
9. End of unit tests
10. Semester final exam/s

IV. INSTRUCTIONAL MATERIALS AND METHODOLOGIES

A. Required Textbook(s)
   1. PLTW's Learning Management System

B. Supplementary Materials
   1. CNC machine
   2. Robotics hardware
   3. Classroom supplemental materials
   4. VEX Robotics Equipment
   5. CAM Software to accompany the CNC machine
   6. Autodesk Software

C. Instructional Methodologies
   1. Guided Inquiry
   2. Direct Instruction
   3. Cooperative Learning
   4. Discourse
   5. Problem-based Learning
   6. Visual Representations and Concrete Models