PLTW Engineering
Computer Integrated Manufacturing | Course Outline

Manufacturing transforms ideas into products. This course provides an opportunity for students to develop a better understanding of this innovative and exciting industry.

Students learn about manufacturing processes, product design, robotics, and automation. Students develop their knowledge and skills of Computer Aided Design and Manufacturing to produce products using a Computer Numerical Controlled (CNC) mill. Students apply the knowledge and skills gained in this course as they collaborate to design, build, and program factory system models.

Manufacturing provides products we use daily. How can a student become part of it?

Manufactured items are part of everyday life, yet few people understand the excitement and innovation that is used to transform ideas into products. This course provides an opportunity for students to recognize many of the exciting career opportunities in the manufacturing industry.

Computer Integrated Manufacturing is one of the specialization courses in the PLTW Engineering program. The course deepens the skills and knowledge of an engineering student within the context of efficiently creating the products all around us. Students build upon their Computer Aided Design (CAD) experience through the use of Computer Aided Manufacturing (CAM) software. CAM transforms a digital design into a program that a Computer Numerical Controlled (CNC) mill uses to transform a block of raw material into a product designed by a student. Students learn and apply concepts related to integrating robotic systems such as Automated Guided Vehicles (AGV) and robotic arms into manufacturing systems.

Throughout the course students learn about manufacturing processes and systems. This course culminates with a capstone project where students design, build, program, and present a manufacturing system model capable of creating a product.

The following is a summary of the units of study that are included in the course. The course is aligned with Next Generation Science Standards; Common Core State Standards for Mathematical Practice (HS); Common Core State Standards for English Language Arts; and Standards for Technological Literacy. Teachers are provided teacher notes and supplementary materials, including answer keys and instructional videos when appropriate.

The course is planned for a rigorous pace, and it is likely to contain more material than a skilled teacher new to the course will be able to complete in the first iteration. Building enthusiasm while learning real world skills related to manufacturing is a primary goal of the course. Teachers are encouraged to emphasize content that will be fresh and exciting to students, and the course is structured to facilitate local adaptation to a particular group of students' prior knowledge and experience.

CIM Unit Summary

Unit 1	Principles of Manufacturing (18%)
Unit 2	Manufacturing Processes (30%)
Unit 3	Elements of Automation (26%)
Unit 4	Integration of Manufacturing Elements (26%)

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.

Principles of Manufacturing Lesson Summary

Lesson 1.1	History of Manufacturing
Lesson 1.2	Control Systems
Lesson 1.3	Cost of Manufacturing

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.

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.

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.

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.

Manufacturing Processes Lesson Summary

Lesson 2.1 Designing for Manufacturability
Lesson 2.2 How We Make Things
Lesson 2.3 Product Development

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.

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.

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.

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. used in an automated manufacturing setting. Students integrate a robot arm into a more complex environment through integration with other devices.

Elements of Automation Lesson Summary

Lesson 3.1 Introduction to Robotic Automation
Lesson 3.2 Introduction to Automation Power
Lesson 3.3 Robotic Programming and Usage

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.

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.

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.

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.

Integration of Manufacturing Elements Lesson Summary

Lesson 4.1 CIM Systems
Lesson 4.2 Integration of Manufacturing

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.

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.