

PASSAIC COUNTY TECHNICAL INSTITUTE

*WAYNE, NJ*

**PLTW** | Engineering

PROJECT LEAD THE WAY™ 4 CURRICULUM

**Computer Integrated Manufacturing**

Revised February 2015

## Project Lead the Way 4 Curriculum – Overview

### I. COURSE DESCRIPTION

Computer Integrated Manufacturing™ (CIM) is the study of manufacturing planning, integration, and implementation of automation. At the same time, it teaches students about manufacturing processes, product design, robotics, and automation. Students can earn a virtual manufacturing badge recognized by the National Manufacturing Badge system.

The course explores manufacturing history, individual processes, systems, and careers. In addition to technical concepts, the course incorporates finance, ethics, and engineering design. This reflects an integrated approach that leading manufacturers have adopted to improve safety, quality, and efficiency.

Utilizing the activity-project-problem-based (APB) teaching and learning pedagogy, students will analyze, design, and build manufacturing systems. While implementing these designs, students will continually hone their interpersonal skills, creative abilities, and understanding of the design process. Students apply knowledge gained throughout the course in a final open-ended problem to build a factory system.

CIM is one of the specialization courses in the Project Lead The Way high school engineering program. The course applies and concurrently develops secondary-level knowledge and skills in mathematics, science, and technology.

The skills acquired by the students included problem solving, critical thinking, communication, hands-on experience and teamwork which can be applied to many other fields of study.

Through activity, project and problem based activities, students enhance computer modeling skills by applying principles of robotics and automation to the creation of models of three-dimensional designs.

## **Curriculum Design**

### **The PLTW Learning Management System (LMS)**

This Learning Management System course instance is intended to be a complete teaching curriculum, not just a guide or an outline. The curriculum is composed of units and lessons. Each lesson contains Activities, Projects, and Problems (APBs). The teacher resource materials for lesson planning and documentation are located in each lesson module on locked pages.

II. COURSE OBJECTIVE/OUTLINE

PCTI CTE Curriculum Unit Planner

<b>Content Area</b>	<b>Project Lead The Way 4</b>	<b>Grade(s): 12</b>
<b>Unit Plan Title</b>	<b>Unit 1: Principles of Manufacturing</b>	<b>Time Frame: 10 weeks</b>
<b>Standard(s)</b>		
<ul style="list-style-type: none"> <li>• <b>Common Core Reading Standards:</b> <ul style="list-style-type: none"> <li>- (RST.11-12.1) (RST.11-12.2) (RST.11-12.3) (RST.11-12.4) (RST.11-12.5)</li> <li>- (RST.11-12.6) (RST.11-12.7) (RST.11-12.8) (RST.11-12.9) (RST.11-12.10)</li> </ul> </li> <li>• <b>Common Core Writing Standards:</b> <ul style="list-style-type: none"> <li>- (WHST.11-12.1) (WHST.11-12.2) (WHST.11-12.3) (WHST.11-12.4) (WHST.11-12.5)</li> <li>- (WHST.11-12.6) (WHST.11-12.7) (WHST.11-12.8) (WHST.11-12.9) (WHST.11-12.10)</li> </ul> </li> <li>• <b>Common Core Mathematics Standards:</b> <ul style="list-style-type: none"> <li>- <u>Reasoning With Equations And Inequalities</u> (A.REI.3)</li> <li>- <u>Linear, Quadratic, And Exponential Models</u> (F.LE.5)</li> <li>- <u>Linear, Quadratic, And Exponential Models</u> (F.LE.5)</li> </ul> </li> <li>• <b>Career &amp; Technical Education (CTE) Content Area:</b> <ul style="list-style-type: none"> <li>- (9.3.ST.1)(9.3.ST.2)(9.3.ST.3)(9.3.ST.4)(9.3.ST.5)(9.3.ST.6)</li> <li>- (9.3.ST-ET.1)(9.3.ST-ET.2)(9.3.ST-ET.3)(9.3.ST-ET.4)(9.3.ST-ET.5)(9.3.ST-ET.6)</li> <li>- (9.3.ST-SM.1) (9.3.ST-SM.2) (9.3.ST-SM.3) (9.3.ST-SM.4)</li> </ul> </li> <li>• <b>NJCCCS Technology:</b> <ul style="list-style-type: none"> <li>- (8.2.12.A.2) (8.2.12.A.3)</li> <li>- (8.2.12.B.1) (8.2.12.B.2) (8.2.12.B.4) (8.2.12.B.5)</li> <li>- (8.2.12.C.2) (8.2.12.C.3) (8.2.12.C.5) (8.2.12.C.6) (8.2.12.C.7)</li> <li>- (8.2.12.D.1) (8.2.12.D.2) (8.2.12.D.3) (8.2.12.D.4) (8.2.12.D.5) (8.2.12.D.6)</li> <li>- (8.2.12.E.1)</li> </ul> </li> </ul>		
<b>Essential Questions</b>		
<ol style="list-style-type: none"> <li>1. What is manufacturing and why is it important to our economy?</li> <li>2. What are the manufacturing procedures known as JIT, CIM, CAD, and lean manufacturing?</li> <li>3. What is kaizen and how is this technique used in manufacturing?</li> <li>4. What is the enterprise wheel and how does it illustrate a cohesive manufacturing procedure?</li> </ol>		

5. What are the benefits of using flowcharting in manufacturing?
6. During which stage(s) of the design process is flowcharting used?
7. Outside of design, in what other areas can flowcharting methods be applied?
8. How can a control system be designed to make a transfer system function?
9. What is the difference between open and closed loop systems?
10. How is it possible to instruct a machine to interact with its surroundings and call attention if something goes wrong?
11. How can a system's cost be minimized without compromising quality?
12. What safety factors should be considered when developing a control system?

### Anchor Text(s)

- [Project Lead The Way® Curriculum: Computer Integrated Manufacturing](#) © 2014 Charitable Venture Foundation, Indianapolis, IN.

### Suggested Writing Assessments

- Engineering Notebook
- Activity and Project Conclusion Questions
- Research Report on Manufacturing Research

### Resources

Microsoft Office, Internet, Engineering Notebook

### Informational Texts (3-5) *[career-related readings; journal articles, books, etc]*

The PLTW Learning Management System (LMS)

### Expected Proficiencies

- The student will be able to identify the design process.
- Students will be able to document work.
- The student will be able to define and demonstrate time management.
- Students will write concisely using technical writing skills.
- Students will be able to document the project process in an engineering notebook.

## PCTI CTE Curriculum Unit Planner

<b>Content Area</b>	<b>Project Lead The Way 4</b>	<b>Grade(s): 12</b>
<b>Unit Plan Title</b>	<b>Unit 2: Manufacturing Processes</b>	<b>Time Frame: 11 weeks</b>
<b>Standard(s)</b>		
<ul style="list-style-type: none"> <li>• <b>Common Core Reading Standards:</b> <ul style="list-style-type: none"> <li>- (RST.11-12.1) (RST.11-12.2) (RST.11-12.3) (RST.11-12.4) (RST.11-12.5)</li> <li>- (RST.11-12.6) (RST.11-12.7) (RST.11-12.8) (RST.11-12.9) (RST.11-12.10)</li> </ul> </li> <li>• <b>Common Core Writing Standards:</b> <ul style="list-style-type: none"> <li>- (WHST.11-12.1) (WHST.11-12.2) (WHST.11-12.3) (WHST.11-12.4) (WHST.11-12.5)</li> <li>- (WHST.11-12.6) (WHST.11-12.7) (WHST.11-12.8) (WHST.11-12.9) (WHST.11-12.10)</li> </ul> </li> <li>• <b>Common Core Mathematics Standards:</b> <ul style="list-style-type: none"> <li>- <u>Quantities</u>(N.Q .1) (N.Q .2) (N.Q .3)</li> <li>- <u>Seeing Structure In Expressions</u>(A.SSE.1.a)</li> <li>- <u>Creating Equations</u>(A.CED.1) (A.CED.4)</li> <li>- <u>Interpreting Functions</u>(F.IF.2)</li> <li>- <u>Building Functions</u>(F.BF.1.a)</li> <li>- <u>Linear, Quadratic, And Exponential Models</u>(F.LE.5)</li> <li>- <u>Geometric Measurement And Dimension</u>(G.GMD.4)</li> <li>- <u>Modeling With Geometry</u>(G.MG.1) (G.MG.2) (G.MG.3)</li> <li>- <u>Similarity, Right Triangles, And Trigonometry</u>(G.SRT.8)</li> <li>- <u>Circles</u>(G.C.4)</li> <li>- <u>Reasoning With Equations And Inequalities</u>(A.REI.1) (A.REI.3) (A.REI.10)</li> </ul> </li> <li>• <b>Career &amp; Technical Education (CTE) Content Area:</b> <ul style="list-style-type: none"> <li>- (9.3.ST.2)(9.3.ST.3)(9.3.ST.4)(9.3.ST.5)(9.3.ST.6)</li> <li>- (9.3.ST-ET.1)(9.3.ST-ET.2)(9.3.ST-ET.3)(9.3.ST-ET.4)(9.3.ST-ET.5)</li> <li>- (9.3.ST-SM.1) (9.3.ST-SM.2) (9.3.ST-SM.3) (9.3.ST-SM.4)</li> </ul> </li> <li>• <b>NJCCCS Technology:</b> <ul style="list-style-type: none"> <li>- (8.2.12.A.3)</li> <li>- (8.2.12.C.2) (8.2.12.C.3) (8.2.12.C.5) (8.2.12.C.6) (8.2.12.C.7)</li> </ul> </li> </ul>		

- (8.2.12.D.1) (8.2.12.D.2) (8.2.12.D.3) (8.2.12.D.5) (8.2.12.D.6)
- (8.2.12.E.1)

### Essential Questions

1. What are some major causes of defects in products?
2. How do safety and ethics affect product design?
3. When performing a redesign or improving a product, why is it important to follow a design process?
4. What properties are important when creating a new product?
5. What restrictions must you consider when modeling a product?
6. Describe common prototyping techniques.
7. Explain the difference between primary and secondary manufacturing processes.
8. Describe common manufacturing processes.
9. Analyze common prototyping techniques.
10. Identify how manufacturing processes can be used to produce a product.
11. What types of machines exist to perform manufacturing processes?
12. Why is it important for a design engineer to learn about programming codes?
13. What are jigs and fixtures? How are they the same? How are they different?
14. How has the advancement of technology and machines affected the global market?
15. What are some ways that manufacturers can verify how a part will be created without producing it physically?
16. How do machines receive data from a computer?
17. How are manufacturing companies affected by the way a product is created?

### Anchor Text(s)

- [Project Lead The Way® Curriculum: Computer Integrated Manufacturing](#) © 2014 Charitable Venture Foundation, Indianapolis, IN.

### Suggested Writing Assessments

- Engineering Notebook
- Activity and Project Conclusion Questions
- Research Report on Manufacturing Processes Research
- Technical Report on G&M Codes (Absolute and Relative)
- Technical Report on Container Design

**Resources**

Microsoft Office, Autodesk Inventor Professional 2015, EdgeCAM, CNC Base, CNC Motion, Internet, Engineering Notebook

**Informational Texts (3-5)** *[career-related readings; journal articles, books, etc]*

The PLTW Learning Management System (LMS)

**Expected Proficiencies**

- The student will be able to identify the design process.
- Students will be able to document work.
- The student will be able to define and demonstrate time management.
- Students will write concisely using technical writing skills.
- Students will be able to document the project process in an engineering notebook.
- The students will be able to demonstrate computer modeling.
- Students will use Computer Assisted Manufacturing (CAM) software.
- Students will be able to create basic programs for CNC machines.
- Students will be able to safely operate a CNC machine.
- Students will be able to identify Computer Numeric Control (CNC) machine characteristics.

## PCTI CTE Curriculum Unit Planner

<b>Content Area</b>	<b>Project Lead The Way 4</b>	<b>Grade(s): 12</b>
<b>Unit Plan Title</b>	<b>Unit 3: Elements of Automation</b>	<b>Time Frame: 9 weeks</b>
<b>Standard(s)</b>		
<ul style="list-style-type: none"> <li>• <b>Common Core Reading Standards:</b> <ul style="list-style-type: none"> <li>- (RST.11-12.1) (RST.11-12.2) (RST.11-12.3) (RST.11-12.4) (RST.11-12.5)</li> <li>- (RST.11-12.6) (RST.11-12.7) (RST.11-12.8) (RST.11-12.9) (RST.11-12.10)</li> </ul> </li> <li>• <b>Common Core Writing Standards:</b> <ul style="list-style-type: none"> <li>- (WHST.11-12.1) (WHST.11-12.2) (WHST.11-12.3) (WHST.11-12.4) (WHST.11-12.5)</li> <li>- (WHST.11-12.6) (WHST.11-12.7) (WHST.11-12.8) (WHST.11-12.9) (WHST.11-12.10)</li> </ul> </li> <li>• <b>Common Core Mathematics Standards:</b> <ul style="list-style-type: none"> <li>- <u>Quantities</u> (N.Q .1) (N.Q .3)</li> <li>- <u>Creating Equations</u> (A.CED.4)</li> <li>- <u>Reasoning With Equations And Inequalities</u> (A.REI.3)</li> <li>- <u>Functions</u> Linear, Quadratic, And Exponential Models (F.LE.5)</li> <li>- <u>Similarity, Right Triangles, And Trigonometry</u> (G.SRT.8)</li> <li>- <u>Geometric Measurement And Dimension</u> (G.GMD.4)</li> <li>- <u>Modeling With Geometry</u> (G.MG.3)</li> </ul> </li> <li>• <b>Career &amp; Technical Education (CTE) Content Area:</b> <ul style="list-style-type: none"> <li>- (9.3.ST.1)(9.3.ST.2)(9.3.ST.3)(9.3.ST.4)(9.3.ST.5)(9.3.ST.6)</li> <li>- (9.3.ST-ET.1)(9.3.ST-ET.2)(9.3.ST-ET.3)(9.3.ST-ET.4)(9.3.ST-ET.5)(9.3.ST-ET.6)</li> <li>- (9.3.ST-SM.1) (9.3.ST-SM.2) (9.3.ST-SM.3) (9.3.ST-SM.4)</li> </ul> </li> <li>• <b>NJCCCS Technology:</b> <ul style="list-style-type: none"> <li>- (8.2.12.A.2) (8.2.12.A.3)</li> <li>- (8.2.12.B.1) (8.2.12.B.2) (8.2.12.B.4) (8.2.12.B.5)</li> <li>- (8.2.12.C.2) (8.2.12.C.3) (8.2.12.C.5) (8.2.12.C.6) (8.2.12.C.7)</li> <li>- (8.2.12.D.1) (8.2.12.D.2) (8.2.12.D.3) (8.2.12.D.4) (8.2.12.D.5) (8.2.12.D.6)</li> <li>- (8.2.12.E.1)</li> </ul> </li> </ul>		

## Essential Questions

1. What were some early technologies that helped facilitate the development of robots?
2. What are some examples and uses of early robots?
3. Why are robots used in industry?
4. What effect does the robot have on the human worker?
5. What are the benefits of simulation software in industry?
6. What situations require robots to communicate with machines?
7. What is work?
8. What is power?
9. How is torque related to power?
10. Why is Ohm's Law important in finding electrical power?
11. What is a microcontroller?
12. What is the programming language for the robot that you are using?
13. What are the different types of loops and how are they used?
14. What is the purpose of declaring variables and how are they used in programming?
15. How does an engineer determine the size of a robot designed to perform a specific task?
16. What is meant by handshaking and how is this process utilized in industry?
17. What kind of device(s) can be used to safely allow the communication of two or more dissimilar devices?

## Anchor Text(s)

- [Project Lead The Way® Curriculum: Computer Integrated Manufacturing](#) © 2014 Charitable Venture Foundation, Indianapolis, IN.

## Suggested Writing Assessments

- Engineering Notebook
- Activity and Project Conclusion Questions
- Research Report

## Resources

Microsoft Office, Internet, Engineering Notebook

## Informational Texts (3-5) *[career-related readings; journal articles, books, etc]*

## The PLTW Learning Management System (LMS)

### **Expected Proficiencies**

- Students will be able to document work.
- Students will write concisely using technical writing skills.
- Students will be able to document the project process in an engineering notebook.
- Students will develop be able to identify robot characteristics.
- Students will develop be able to understand the basic components of robot controllers.
- Students will develop be able to program a robot.

## PCTI CTE Curriculum Unit Planner

<b>Content Area</b>	<b>Project Lead The Way 4</b>	<b>Grade(s): 12</b>
<b>Unit Plan Title</b>	<b>Unit 4: Integration of Manufacturing</b>	<b>Time Frame: 9 weeks</b>
<b>Standard(s)</b>		
<ul style="list-style-type: none"> <li>• <b>Common Core Reading Standards:</b> <ul style="list-style-type: none"> <li>- (RST.11-12.1) (RST.11-12.2) (RST.11-12.3) (RST.11-12.4) (RST.11-12.5)</li> <li>- (RST.11-12.6) (RST.11-12.7) (RST.11-12.8) (RST.11-12.9) (RST.11-12.10)</li> </ul> </li> <li>• <b>Common Core Writing Standards:</b> <ul style="list-style-type: none"> <li>- (WHST.11-12.1) (WHST.11-12.2) (WHST.11-12.3) (WHST.11-12.4) (WHST.11-12.5)</li> <li>- (WHST.11-12.6) (WHST.11-12.7) (WHST.11-12.8) (WHST.11-12.9) (WHST.11-12.10)</li> </ul> </li> <li>• <b>Common Core Mathematics Standards:</b> <ul style="list-style-type: none"> <li>- <u>Quantities</u>(N.Q .3)</li> <li>- <u>Reasoning With Equations And Inequalities</u>(A.REI.3)</li> <li>- <u>Geometric Measurement And Dimension</u>(G.GMD.4)</li> </ul> </li> <li>• <b>Career &amp; Technical Education (CTE) Content Area:</b> <ul style="list-style-type: none"> <li>- (9.3.ST.2)(9.3.ST.3)(9.3.ST.4)(9.3.ST.5)(9.3.ST.6)</li> <li>- (9.3.ST-ET.1)(9.3.ST-ET.2)(9.3.ST-ET.3)(9.3.ST-ET.4)(9.3.ST-ET.5)</li> <li>- (9.3.ST-SM.1) (9.3.ST-SM.2) (9.3.ST-SM.3) (9.3.ST-SM.4)</li> </ul> </li> <li>• <b>NJCCCS Technology:</b> <ul style="list-style-type: none"> <li>- (8.2.12.A.3)</li> <li>- (8.2.12.C.2) (8.2.12.C.3) (8.2.12.C.5) (8.2.12.C.6) (8.2.12.C.7)</li> <li>- (8.2.12.D.1) (8.2.12.D.2) (8.2.12.D.3) (8.2.12.D.5) (8.2.12.D.6)</li> <li>- (8.2.12.E.1)</li> </ul> </li> </ul>		
<b>Essential Questions</b>		
<ol style="list-style-type: none"> <li>1. What safety issues are common in CIM systems?</li> <li>2. How do engineers choose power systems that will integrate within a CIM system?</li> <li>3. Which machine tools are necessary to fabricate the part or parts?</li> <li>4. What are the appropriate sensors to ensure quality parts and smooth process flow?</li> <li>5. How can a CIM system be automated? What safety issues are common in CIM systems?</li> <li>6. How do engineers choose power systems that will integrate within a CIM system?</li> <li>7. Which machine tools are necessary to fabricate the part or parts?</li> <li>8. What are the appropriate sensors to ensure quality parts and smooth process flow?</li> </ol>		

9. How can a CIM system be automated?

### Anchor Text(s)

- [Project Lead The Way® Curriculum: Computer Integrated Manufacturing](#) © 2014 Charitable Venture Foundation, Indianapolis, IN.

### Suggested Writing Assessments

- Engineering Notebook
- Activity and Project Conclusion Questions
- Research Report

### Resources

Microsoft Office, Internet, Engineering Notebook

### Informational Texts (3-5) *[career-related readings; journal articles, books, etc]*

The PLTW Learning Management System (LMS)

### Expected Proficiencies

- Students will develop be able to understand individual components of a flexible manufacturing system.
- Students will develop be able to recognize the working relationship between the CNC mill and the robot.
- Students will develop be able to explore, analyze and select components for a CIM system for a specific industrial application.

### III. METHODS OF STUDENT EVALUATIONS

Students are evaluated using the following criteria:

1. Projects
2. Class Assignments
3. Technical Reports
4. Presentations
5. Quizzes and Tests
6. Homework
7. Portfolios
8. Attendance

Mastering of the core proficiencies of Project Lead the Way 2 shall be evaluated in accordance with the general grading policies as listed in the student handbook:

- Tests/Projects/Portfolio – 40%
- PLTW/Shop Activities – 20%
- Quizzes – 20%
- Homework – 10%
- Class Participation – 10%

### IV. TEXTBOOKS, INSTRUCTIONAL MATERIALS AND SOFTWARE

Project Lead The Way® Curriculum: Computer Integrated Manufacturing™ © 2014 Charitable Venture Foundation, Indianapolis

Mattson, Mike. (2009) *CNC Programming: Principles and Applications*. Delmar, Cengage Learning. ISBN 0766818888.

Keramas, James G. (1998) *Robot Technology Fundamentals*. Delmar, Cengage Learning. ISBN 0827382367.

Industrial Press. *Machinery's Handbook*, (CD-ROM) 25<sup>th</sup> Edition. Industrial Press, Inc. ISBN: 081126000.

Autodesk Inventor Professional 2015, © 1996-2014 Autodesk, Inc.

CNC Base for Super ProLight 1000, Version 4.3.0.6, Intelitek, Inc.

CNC Motion for ProLight 1000 Machining Center, Version 4.1.0.8

Edgecam Project Lead the Way Version 2013.20.0, Planit Software Limited.

Robocell for Scorbot- Er.4U, Version 5.3.3.5, Intelitek, Inc.

Robot C, Version 3.6.2, Robomatter LLC Inc

Robo Pro, Version 2.1.3.14, Fischertechnik.

Microsoft® Office Professional Plus 2010 © 2010 Microsoft Corporation

Microsoft® Internet Explorer 9 © 2011 Microsoft Corporation

Adobe® Reader® XI © 1984-2012 Adobe Systems Inc.

## V. INSTRUCTIONAL STRATEGIES

Project based learning is used in this course. Projects allow the students to demonstrate understanding of the subject content, engage in meaningful activities, become independent learners, make connections from prior knowledge, use real life technologies and resources, obtain ownership of their learning, and exhibit growth in social skills, self management skills, and ability to learn on one's own.

Instruction will be given using class notes, prepared worksheets, and activities from Computer Integrated Manufacturing Curriculum 2014. Hands on experience in problem solving (in teams and individually) is used along with circuit design software, technical writing, creating spreadsheets and PowerPoint presentations. Research requiring the internet is included.

VI. SOPE AND SEQUENCE CHART

KEY I = Introduced, D = Developed, R = Reinforced

<b>SKILLS TO BE LEARNED</b>	9	10	11	12
Increase knowledge and understanding of computer modeling	IDR		DR	DR
Increase knowledge and understanding of the design process	IDR	DR	DR	DR
Gain knowledge and understanding of engineering notebook documentation	ID	DR	DR	DR
Increase knowledge and understanding of writing a technical report	IDR	DR	DR	DR
Increase knowledge and understanding of making presentations	IDR	DR	DR	R
Increase knowledge and understanding of creating a portfolio	IDR	R	R	R
Increase knowledge and understanding of time management	ID	DR	DR	DR
Gain knowledge and understanding of Computer Numeric Controlled (CNC) Machines				IDR
Gain knowledge and understanding of CNC Programming				IDR
Increase knowledge and understanding of precision measurements	ID	DR	DR	DR
Gain knowledge and understanding of Computer Assisted Manufacturing (CAM) software				IDR
Gain knowledge and understanding of robotics and automated systems				IDR
Gain knowledge and understanding of robotics programming				IDR
Gain knowledge and understanding of robotics control systems				IDR
Gain knowledge and understanding of Flexible Manufacturing Systems				IDR
Gain knowledge and understanding of Computer Integrated Manufacturing (CIM) Systems				IDR
Gain knowledge and understanding of CIM Systems applications				IDR

## VII. PACING CHART

### **Unit 1: Principles of Manufacturing (10 weeks)**

#### **Lesson 1.1: History of Manufacturing (3 weeks)**

##### **Understandings**

1. Manufacturing is a series of interrelated activities and operations that involve product design, planning, producing, materials control, quality assurance, management, and marketing of that product.
2. Manufacturing is essential to a healthy economy.
3. Manufacturing in the United States avoids health risks that are accepted in other countries.
4. There are many jobs associated with manufacturing.
5. A variety of processes are used in the creation of products.

##### **Knowledge and Skills**

*It is expected that students will:*

1. Describe why and how manufacturing evolved.
2. Identify components of a typical manufacturing system.
3. List common manufacturing techniques and processes.
4. Interpret how advances in techniques and technology impact modern manufacturing.
5. Categorize how components of a typical manufacturing system such as customer, knowledge and processes represent manufacturing activities.
6. Research common manufacturing techniques such as Kaizen and Flexible Manufacturing Systems and systems such as Computer Numerical Control and Automated Guided Vehicle.
7. Summarize how manufacturing techniques and processes have evolved.
8. Compare and contrast the advantages and disadvantages common manufacturing techniques and processes.

#### **Lesson 1.2: Control Systems (4 weeks)**

##### **Understandings**

1. Everyday products including cars, microwaves, ovens, hair dryers, coffee pots, and washing machines all use control systems to manage their operation.
2. A flowcharting and pseudocode are powerful tools used by technicians, computer programmers, engineers, and professionals in a variety of roles and responsibilities.

3. During the design and development process, a flowchart or pseudocode are used to plan and depict the process flow for an entire system and all of its subsystems.
4. Computer programmers use a flowchart and pseudocode to organize the flow of program control, including all inputs, outputs, and conditions that may occur.

## **Knowledge and Skills**

*It is expected that students will:*

1. Identify open and closed loop systems.
2. Describe how input and output devices are part of an open and closed loop system.
3. Explain the purpose of a flowchart or pseudocode.
4. Describe functions of a computer program.
5. Identify how functions of a computer program can be applied to perform a task.
6. Operate output devices to perform a function.
7. Relate sensor input to the environment being measured.
8. Create a flowchart or pseudocode to perform a task.
9. Construct a control program to accomplish an objective such as motor reacting to the environment.
10. Modify an open loop system to be a closed loop system using sensors.

## **Lesson 1.3: Cost of Manufacturing (3 weeks)**

### **Understandings**

1. When designing a control system, cost and safety are two key factors that must be considered.
2. Many factors come into play when calculating the cost of manufacturing a product.
3. Tradeoffs may be made between hiring highly skilled or experienced workers and keeping costs down.
4. The less time a part takes to make, the more potential profit is available.
5. Long term planning and investments may cost more up front but may provide additional savings in the future.

### **Knowledge and Skills**

*It is expected that students will:*

6. Recognize fixed and variable costs of manufacturing a product.
7. Identify direct and indirect costs of manufacturing a product.
8. Recognize costs of a manufacturing system
9. Classify typical costs of manufacturing a given product.
10. Design a manufacturing system with consideration to time and cost to produce a product.
11. Construct a model of a manufacturing system.

12. Construct a control program to operate a model factory.
13. Compare the efficiencies of multiple manufacturing systems.

## **Unit 2: Manufacturing Processes (11 weeks)**

### **Lesson 2.1: Designing for Manufacturability (3 weeks)**

#### **Understandings**

1. Design is a process that is used to systematically solve problems.
2. Many considerations must be made when manufacturing a quality part.
3. Analyzing case studies of engineering failures is a good way for engineers to avoid future failures.
4. Manufacturers have an ethical responsibility to create safe products and to provide a safe work environment.
5. Manufacturers have a legal responsibility to provide safety information about their products.
6. Many engineering disciplines have a code of conduct or code of ethics that their members are expected to follow.
7. Material properties must be considered as part of the design process.

#### **Knowledge and Skills**

*It is expected that students will:*

1. Describe steps in a design process.
2. Describe factors which affect a design.
3. Identify principles of engineering ethics.
4. Outline how mass properties impact manufacturing decisions.
5. Analyze how adequate product fulfills a function.
6. Summarize how a product can be modified to fulfill of function.
7. Apply the engineering code of ethics when considering a design.
8. Model an object using a drawing.
9. Show the volume, mass, surface area of a model.
10. a mathematical model to describe a manufacturing function.
11. Calculate costs and physical requirements impacted by product physical properties.
12. Explain how ethics impact engineering decisions.

### **Lesson 2.2: How We Make Things (1 week)**

#### **Understandings**

1. Prototyping is part of a design process where a physical model can be evaluated to refine the design.

2. Before raw material can be used in manufacturing, it must undergo primary processing.
3. The separating process is one of the oldest manufacturing processes.
4. Milling and shearing utilize the subtractive process to create products.
5. Electrochemical Machining (ECM), Electrical Discharge Machining (EDM), water-cutting, and laser-cutting are using newer technologies to enhance the accuracy and efficiency of material removal.
6. Metals, plastics, and ceramics are types of materials that are well suited to the manufacturing process.
7. The way in which a product is made is dependent upon the properties of the material that will be used.

### **Knowledge and Skills**

*It is expected that students will:*

1. Describe common prototyping techniques.
2. Explain the difference between primary and secondary manufacturing processes.
3. Describe common manufacturing processes.
4. Analyze common prototyping techniques.
5. Identify how manufacturing processes can be used to produce a product.

### **Lesson 2.3: Product Development (7 weeks)**

#### **Understandings**

1. Many machines exist to perform manufacturing processes.
2. Products manufactured today have been greatly influenced by the advancement of machines and technology.
3. Machine code is an essential tool used to communicate with some machines.
4. Computer Aided Manufacturing (CAM) programming tools make it possible to manufacture physical models using Computer Aided Design (CAD) programs.
5. Several variables in machining operations affect the final product in manufacturing.
6. Jigs and fixtures are essential in maintaining consistency and quality control.
7. Profit margins are essential to a company's survival in a competitive market.
8. Prototyping is a major step in the design cycle of manufactured goods and has been greatly advanced with the advent and use of rapid prototyping processes.

#### **Knowledge and Skills**

*It is expected that students will:*

1. List examples of common CNC machines.

2. List common robot applications used in manufacturing.
3. Identify common cutting tools.
4. Describe parts and functions of common machines used in manufacturing.
5. Select formulas which are used to determine milling machine settings.
6. Describe common G & M Codes.
7. Describe a procedure to operate a milling machine.
8. Identify a machine which can be used to perform a process.
9. Calculate settings needed for a milling machine.
10. Interpret the actions that will be performed given a sample of machine code.
11. Manually create machine code required to manufacture a product.
12. Create machine code to manufacture a product using Computer Aided Manufacturing (CAM) program.
13. Test machine code accuracy using simulation software.
14. Create a model using Computer Aided Design (CAD) software.
15. Create a product using a CNC milling machine.

### **Unit 3: Elements of Automation (9 weeks)**

#### **Lesson 3.1: Introduction to Robotic Automation (3.5 weeks)**

##### **Understandings**

1. There are many factors that influence the evolution of automation.
2. Robots are widely used in industry to assist in the production of manufactured goods.
3. Robots have distinct advantages over humans in some industrial settings.
4. A variety of automation careers exist.
5. Robots and machines communicate and coordinate their activities through a process called handshaking.

##### **Knowledge and Skills**

*It is expected that students will:*

1. Identify common robot types.
2. Define accuracy and repeatability.
3. Describe components of a robotic work cell.
4. Describe roll angle.
5. List characteristics of robots in a manufacturing environment.
6. Describe methods for materials to be handled in a manufacturing environment.

7. Distinguish between accuracy and repeatability.
8. Describe the development of robot technology and application.
9. Create a program to control a robotic arm.
10. Calculate roll angle for robotic arm movement.
11. Create a program for robotic arm to communicate with another device.
12. Analyze factors that impact robots in a manufacturing environment.
13. Explain how materials handling impacts a manufacturing environment.

### **Lesson 3.2: Elements of Automation Power (2 weeks)**

#### **Understandings**

1. Power is produced in many ways and transmitted through various forms (e.g. electrical, pneumatic, hydraulic, and motion).
2. Fluid power is inversely proportional to the area upon which the force is being applied.
3. Pneumatics is one form of fluid power that can be used to operate machines and products.
4. Sensors provide feedback to control systems and products used by consumers.

#### **Knowledge and Skills**

*It is expected that students will:*

1. Define torque, pressure, work and power.
2. Identify equations of torque, pressure, work and power.
3. Apply torque, pressure, work and power equations to engineering problems.
4. Design a system to perform a task using fluid power.
5. Construct a fluid power system.
6. Create a program to operate a fluid power system.

### **Lesson 3.3: Robotic Programming and Usage (3.5 weeks)**

#### **Understandings**

1. Many everyday products use microcontrollers.
2. Robots are used to perform diverse functions and work in diverse environments.
3. A variety of robots and unique programming languages are used in the manufacturing industry.
4. Basic programming skills include variable declaration, loops, and debugging.
5. The size of a robot is based on the work envelope and payload needed to perform the task.

## **Knowledge and Skills**

*It is expected that students will:*

1. Describe robot components including drive systems, electrical components.
2. Describe the envelope of common robot types.
3. Describe how robot geometry affects robot motion.
4. Identify elements of a robotic program.
5. Match robot type to application.
6. Predict robot motion resulting from movement of an actuator.
7. Create a program to control a robotic arm.
8. Create programs for a robotic arm to communicate with a related machine.

## **Unit 4: Integration of Manufacturing Elements (9 weeks)**

### **Lesson 4.1: CIM Systems (2 weeks)**

#### **Understandings**

1. The process of mass production is used when the same product is created repeatedly.
2. A workcell is a group of machines in which each individual machine has its own specialty.
3. A flexible manufacturing system is one that can adapt to a wide variety of products.
4. Manufacturing and automation careers are varied in scope and location.
5. Tradeoffs are made when one system is utilized over another.
6. Process flow design has a major impact on overall production time and product profit.
7. During the design and development process, flowcharting is used to plan and depict the detailed process flow for an entire system and all of its subsystems.
8. Flowcharting can be used to illustrate the phases of the product development process.

## **Knowledge and Skills**

*It is expected that students will:*

1. Describe common CIM systems.
2. Recognize machines and processes in a manufacturing setting.
3. Compare and contrast common CIM systems
4. Breakdown a manufacturing system into machines and processes.
5. Organize and express thoughts and information in a clear and concise manner.

6. Explain factors that effect a manufacturing career.

## **Lesson 4.2: Integration of Manufacturing Elements (7 weeks)**

### **Understandings**

1. Process flow design has a major impact on overall production time and product profit.
2. During the design and development process, flowcharting is used to plan and depict the detailed process flow for an entire system as well as all of its subsystems.
3. Flowcharting can be used to illustrate the overall phases of the product development process.
4. Proper sequencing of automated operations is important in factory design.
5. Safe operating procedures must be addressed in a CIM environment at all times to avoid serious injury.
6. Tradeoffs occur between efficiency and cost when choosing a manufacturing system.
7. Engineers choose appropriate sensors to ensure high quality part production.
8. Identification of correct electrical and fluid power systems is required to complete the desired manufacturing system.

### **Knowledge and Skills**

*It is expected that students will:*

1. Recognize process symbols.
2. Identify the potential safety issues with a CIM system.
3. Identify how functions of a computer program can be applied to perform a task.
4. Outline a process for a manufacturing process.
5. Design a system to manufacture a part.
6. Construct a system to manufacture a part.
7. Create a flowchart or pseudo code to perform a task.
8. Construct a control program to accomplish a goal.
9. Evaluate the effectiveness of a system to accomplish a goal.
10. Identify strategies to resolve team conflict.

## PASSAIC COUNTY TECHNICAL INSTITUTE

### VIII. STUDENT HANDOUT

#### PROJECT LEAD THE WAY 4

##### **COURSE OVERVIEW**

Project Lead the Way IV (Computer Integrated Manufacturing™) is a full year course developed by Project Lead the Way Inc., the nation's leading pre-engineering middle and high school program. The purpose of Project Lead the Way is to increase the quality and quantity of engineers and engineering technologists graduating from a college program. Computer Integrated Manufacturing™ is a preparation course for entrance into a college engineering/engineering technology program.

Computer Integrated Manufacturing™ is a fourth year course designed to expose students to the fundamentals of computerized manufacturing technology. The course is built around several key concepts:

- Computer Modeling – using a three dimensional, solid modeling software package with mass property analysis.
- CNC Equipment – understanding the machine tools and its operating and programming aspects.
- CAM Software – converting computer generated geometry into a program to drive CNC machine tools.
- Robotics – using a robot for materials handling and assembly operations.
- Flexible Manufacturing Systems – students working in teams to design manufacturing workcells and table top factory simulations.

The skills acquired by the students included problem solving, critical thinking, communication, hands-on experience and teamwork which can be applied to many other fields of study.

Through activity, project and problem based activities, students enhance computer modeling skills by applying principles of robotics and automation to the creation of models of three-dimensional designs.

## **PROFICIENCIES**

1. The students will be able to demonstrate computer modeling.
2. The student will be able to identify the design process.
3. Students will be able to document work.
4. The student will be able to define and demonstrate time management.
5. Students will write concisely using technical writing skills.
6. Students will be able to identify Computer Numeric Control (CNC) machine characteristics.
7. Students will be able to create basic programs for CNC machines.
8. Students will be able to safely operate a CNC machine.
9. Students will be able to make precision measurements.
10. Students will use Computer Assisted Manufacturing (CAM) software.
11. Students will develop be able to identify robot characteristics.
12. Students will develop be able to understand the basic components of robot controllers.
13. Students will develop be able to program a robot.
14. Students will develop be able to understand individual components of a flexible manufacturing system.
15. Students will develop be able to recognize the working relationship between the CNC mill and the robot.
16. Students will develop be able to explore, analyze and select components for a CIM system for a specific industrial application.
17. Students will be able to document the project process in an engineering notebook.