Westerville City Schools
Project Lead the Way (PLTW) Computer Integrated Manufacturing
Course of Study
Course Number: SC437

Course Description

Recommended Grade Level:	11 or 12
Course Length:	Full Year, 1 Period
Credits:	1.0
Course Weighting:	1.125

Computer Integrated Manufacturing (CIM) is an elective science course of the Project Lead the Way Engineering Program that follows Introduction to Engineering and Design (IED) and Principles of Engineering (POE). Manufacturing transforms ideas into products. Students build upon their Computer Aided Design (CAD) experience through the use of Computer Aided Manufacturing (CAM) software. Learning about manufacturing processes, product design, robotics, and automation, students develop their knowledge and CAD and CAM skills to produce products using a Computer Numerical Controlled (CNC) mill. 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. They apply the knowledge and skills gained in this course as they collaborate to design, build, and program factory system models. CIM deepens the skills and knowledge of an engineering student within the context of efficiently creating the products all around us.

Course Rationale

To uphold the district's mission and foster college and career readiness, Project Lead the Way's (PLTW) Computer Integrated Manufacturing (CIM) provides opportunities to develop highly transferable skills in collaboration, communication, creativity, and critical thinking which are relevant for any postsecondary coursework or career. CIM will enable students to continue to use cutting-edge advanced manufacturing techniques while solving problems that matter. It will improve students' abilities to innovate, enhance math and science skills, strengthen students' communication abilities, and foster interest in future engineering courses.

CIM is an elective course that follows Introduction to Engineering Design (IED) and Principles of Engineering (POE) in a pathway of Engineering Design courses. SC437 is an additional elective engineering course.

Considerations for Cultural Relevancy, Inclusivity, and Diversity:

Where possible teachers will create opportunities to incorporate the histories, values, beliefs and perspectives of people from different cultural backgrounds to meet the needs of all learners. Strategies for meeting the needs of all learners including gifted students, English Language Learners and students with disabilities can be found at this ODEW site.

Considerations for Intervention and Acceleration:

This rigorous and highly relevant curriculum is built upon high quality, research-based instructional strategies.Teachers may need to provide targeted Tier II support (e.g., remediation of particular skills and concepts, as well as scaffolded or supplemental instruction) beyond the Tier I level of universal instruction to underachieving students. Intensive and individualized Tier III instruction (e.g., skill-specific intervention, one-on-one support).

Scope and Sequence

Unit	Lesson	Approximate Length (days)
1 Principles of Manufacturing	1.1 History of Manufacturing	8
	1.2 Control Systems	10
	1.3 Costs of Manufacturing	14
2 Manufacturing Process	2.1 Designing for Manufacturability	10
	2.2 How We Make Things	6
	2.3 Product Development	38
3 Elements of Automation	3.1 Introduction to Robotic Automation	19
	3.2 Introduction to Automation Power	10
	3.3 Robotic Programming and Usage	17
4 Integration of Manufacturing Elements	4.1 CIM Systems	10
	4.2 Integration of Manufacturing	37

Portrait of a Graduate

Westerville students participating in the Engineering Pathway:

Will graduate with the following skills:

- organization and time management
- collaboration
- critical thinking (analysis of parts and the system, review of others' ideas, logical application)
- problem solving, including learning specialized software or technical tools that can be applied to new problems
- verbal and written communication through a variety of media and with multiple audiences

Will master the following content:

- design and implementation as part of the engineering process
- math concepts throughout Algebra and Geometry
- technical writing and reading
- technical sketching and drawing
- effects of engineering as related to economics, ethics, society and environmental impact

Will have the following attitudes/personal attributes:

- strong work ethic
- responsibility
- pride in their work
- perseverance
- growth mindset
- empathy
- flexibility
- curiosity
- creativity
- risk-taker

And will have the following experiences:

- solving authentic, open-ended problems all the way to resolution and implementation
- participating in competitions or challenges to showcase skills and talents
- working with equipment used in industry
- participating in field experiences: job shadowing, mentorship, learning from industry professionals, and summer job opportunities

Project Lead the Way Content Standards

Unit 1: Principles of Manufacturing

Expectations for Learning:
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.

<table>
<tr><td colspan="2">Lesson 1.1 History of Manufacturing (approximately 8 days)</td></tr>
<tr><td colspan="2">Content Elaboration:
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.</td></tr>
<tr><td>Enduring Understandings:
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.
Manufacturing is essential to a healthy economy.
Manufacturing in the United States avoids health risks that are accepted in other countries.
There are many careers associated with manufacturing.
A variety of processes are used in the creation of products.</td><td>Essential Questions:
How can a product be manufactured efficiently?
How does manufacturing impact the economy and society?</td></tr>
</table>

Learning Targets:

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

Essential Vocabulary: Automated Guidance Vehicle, Automated Retrieval System, Automation, Computer Aided Design, Computer Aided Manufacturing, Computer Integrated Manufacturing, Dependent Variable, Independent Variable, Just in Time, Kaizen, Lean Manufacturing, Manufacturing, Robotics, Six SIGMA, Variable

Assessments:
Teacher created Unit Assessments with guidance from Project Lead the Way (PLTW) Teacher Community

Lesson 1.2 Control Systems (approximately 10 days)

Content Elaboration:
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.

Enduring Understandings:
- Everyday products including cars, microwaves, ovens, hair dryers, coffee pots, and washing machines all use control systems to manage their operation.
- A flowcharting and pseudocode are powerful tools used by technicians, computer programmers, engineers, and professionals in a variety of roles and responsibilities.
- During the design and development process, a flowchart or pseudocode is used to plan and depict the process flow for an entire system and all of its subsystems.
- Computer programmers use a flowchart and pseudocode to organize the flow of program control, including all inputs, outputs, and conditions that may occur.

Essential Questions:
- How can mechanical, electrical and software systems be integrated to solve a problem?
- How can a tool such as a flowchart or pseudocode be adapted to design a solution to a problem?
- How can a team be diversified to enhance a design process?
- How does a design process optimize a solution to a problem?
- How does the effectiveness of a presentation affect the acceptability of a solution?

Learning Targets:
- Identify open and closed loop systems.
- Describe how input and output devices are part of an open and closed loop system.
- Explain the purpose of a flowchart or pseudocode.
- Describe functions of a computer program.
- Identify how functions of a computer program can be applied to perform a task.
- Operate output devices to perform a function.
- Relate sensor input to the environment being measured.
- Create a flowchart or pseudocode to perform a task.
- Construct a control program to accomplish an objective such as a motor reacting to the environment.
- Modify an open loop system to be a closed loop system using sensors.

Essential Vocabulary: Automation, Closed Loop, Control System, Decision Block, Flow Chart, Flow Lines, Input/Output Block, Interface, Iterative, Open Loop, Potentiometer, Process Block, Schematic, Sequential, Simulation

Assessments:
Teacher created Unit Assessments with guidance from Project Lead the Way (PLTW) Teacher Community

Lesson 1.3 Costs of Manufacturing (approximately 14 days)	
Content Elaboration: 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.	
Enduring Understandings: ● When designing a control system, cost and safety are two key factors that must be considered. ● Many factors come into play when calculating the cost of manufacturing a product. ● Tradeoffs may be made between hiring highly skilled or experienced workers and keeping costs down. ● The less time a part takes to make, the more potential profit is available. ● Long term planning and investments may cost more up front but may provide additional savings in the future.	**Essential Questions:** ● How do decisions related to cost, product quality and safety interrelate? ● How can a model be used to develop a full scale system?
Learning Targets: ● Recognize fixed and variable costs of manufacturing a product. ● Identify direct and indirect costs of manufacturing a product. ● Recognize costs of a manufacturing system. ● Classify typical costs of manufacturing a given product. ● Design a manufacturing system with consideration to time and cost to produce a product. ● Construct a model of a manufacturing system. ● Construct a control program to operate a model factory. ● Compare the efficiencies of multiple manufacturing systems.	
Essential Vocabulary: Fixed Costs, Non-Value Added (NVA), Overhead, Profit, Raw Materials, Value-Added, Variable Cost	
Assessments: Teacher created Unit Assessments with guidance from Project Lead the Way (PLTW) Teacher Community	

Unit 2: Manufacturing Processes

Expectations for Learning:
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.

Lesson 2.1 Designing for Manufacturability (approximately 10 days)	
Content Elaboration: The goal of this lesson is to 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.	
Enduring Understandings: ● Design is a process that is used to systematically solve problems. ● Many considerations must be made when manufacturing a quality part. ● Analyzing case studies of engineering failures is a good way for engineers to avoid future failures. ● Manufacturers have an ethical responsibility to create safe products and to provide a safe work environment. ● Manufacturers have a legal responsibility to provide safety information about their products. ● Many engineering disciplines have a code of conduct or code of ethics that their members are expected to follow. ● Material properties must be considered as part of the design process.	**Essential Questions:** ● How can a product be improved? ● How can mathematical models be applied to manufacturing? ● How do engineers apply a code of ethics? ● How to apply a code of ethics to your personal conduct?
Learning Targets: ● Describe steps in a design process. ● Describe factors which affect a design. ● Identify principles of engineering ethics. ● Outline how mass properties impact manufacturing decisions. ● Analyze how adequate product fulfills a function.	

• Summarize how a product can be modified to fulfill its function. • Apply the engineering code of ethics when considering a design. • Model an object using a drawing. • Show the volume, mass, surface area of a model. • Create a mathematical model to describe a manufacturing function. • Calculate costs and physical requirements impacted by product physical properties. • Explain how ethics impact engineering decisions.
Essential Vocabulary: Competent, Defective, Design Flaws, Durability, Economics, Ethics, Functionality, Morality, Purpose, Quality Control
Assessments: Teacher created Unit Assessments with guidance from Project Lead the Way (PLTW) Teacher Community

Lesson 2.2 How We Make Things (approximately 6 days)

Content Elaboration:
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.

Enduring Understandings:

- Prototyping is part of a design process where a physical model can be evaluated to refine the design.
- Before raw material can be used in manufacturing, it must undergo primary processing.
- The separating process is one of the oldest manufacturing processes.
- Milling and shearing utilize the subtractive process to create products.
- 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.
- Metals, plastics, and ceramics are types of materials that are well suited to the manufacturing process.
- The way in which a product is made is dependent upon the properties of the material that will be used.

Essential Questions:

- How can a product be efficiently manufactured?
- How can a prototype be used in a design process?

Learning Targets:

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

Essential Vocabulary: 3D Printing, ABS, Acrylonitrile Butadiene Styrene, Additive Process, Assembling, Build Time, Casting, Ceramics, Concept Model, Conditioning Process, Die Casting, Electrical Discharge Machining (EDM), Electrochemical Machining (ECM), Exhaustible Resources, Finishing Process, Forging, Forming Process, Fused Deposition Modeling (FDM), Grinding, Industrial Material, Injection Molding, Laminated Object Manufacturing (LOM), Metals, Molding, Plastics, Photopolymer, Polylactic Acid (PLA), Post Processing, Primary Processing, Prototype, Rapid Prototyping, Renewable Resources, Sand Casting, Secondary Processing, Separating, Selective Laser Sintering (SLS), Stereolithography (SLA), Subtractive Process, Vacuum Forming, Water Jet Cutting

Assessments:
Teacher created Unit Assessments with guidance from Project Lead the Way (PLTW) Teacher Community

Lesson 2.3 Product Development (approximately 38 days)

Content Elaboration:
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.

Enduring Understandings:
- Many machines exist to perform manufacturing processes.
- Products manufactured today have been greatly influenced by the advancement of machines and technology.
- Machine code is an essential tool used to communicate with some machines.
- Computer Aided Manufacturing (CAM) programming tools make it possible to manufacture physical models using Computer Aided Design (CAD) programs.
- Several variables in machining operations affect the final product in manufacturing.
- Jigs and fixtures are essential in maintaining consistency and quality control.
- Profit margins are essential to a company's survival in a competitive market.
- 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

Essential Questions:
- How does manufacturability affect the design of a product?
- How does the capability of a machine affect a manufacturing process?
- How does material selection affect a manufacturing process?

Learning Targets:
- List examples of common CNC machines.
- List common robot applications used in manufacturing.
- Identify common cutting tools.
- Describe parts and functions of common machines used in manufacturing.
- Select formulas which are used to determine milling machine settings.
- Describe common G & M Codes.
- Describe a procedure to operate a milling machine.
- Identify a machine which can be used to perform a process.

- Calculate settings needed for a milling machine.
- Interpret the actions that will be performed given a sample of machine code.
- Manually create machine code required to manufacture a product.
- Create machine code to manufacture a product using Computer Aided Manufacturing (CAM) program.
- Test machine code accuracy using simulation software.
- Create a model using Computer Aided Design (CAD) software.
- Create a product using a CNC milling machine.

Essential Vocabulary: Absolute, Address Character, Block, Bench Grinder, Clearance Fit, Feed, Fixture, G Code, G & M Codes, Incremental, Interference Fit, Jig, Laser, Lathe, Machinability, M Code, Milling Machine, Modal, Numerical Control (NC), Parameter, Part Program, Preparatory Code, Spindle Speed, Tolerance, V-Block, Word

Assessments:
Teacher created Unit Assessments with guidance from Project Lead the Way (PLTW) Teacher Community

Unit 3: Elements of Automation

Expectations for Learning:
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.

<table>
<tr><td colspan="2">Lesson 3.1 Introduction to Robotic Automation (approximately 19 days)</td></tr>
<tr><td colspan="2">Content Elaboration:
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.</td></tr>
<tr><td>Enduring Understandings:
● There are many factors that influence the evolution of automation.
● Robots are widely used in industry to assist in the production of manufactured goods.
● Robots have distinct advantages over humans in some industrial settings.
● A variety of automation careers exist.
● Robots and machines communicate and coordinate their activities through a process called handshaking.</td><td>Essential Questions:
● How is manufacturing affected by robots?
● How can a simulation be used to design a physical system?</td></tr>
<tr><td colspan="2">Learning Targets:
● Identify common robot types.
● Define accuracy and repeatability.
● Describe components of a robotic work cell.
● Describe roll angle.
● List characteristics of robots in a manufacturing environment.
● Describe methods for materials to be handled in a manufacturing environment.
● Distinguish between accuracy and repeatability.
● Describe the development of robot technology and application.
● Create a program to control a robotic arm.</td></tr>
</table>

- Calculate roll angle for robotic arm movement.
- Create a program for a robotic arm to communicate with another device.
- Analyze factors that impact robots in a manufacturing environment.
- Explain how materials handling impacts a manufacturing environment.

Essential Vocabulary: Automated Guided Vehicle (AGV), Automated Storage and Retrieval System (ASRS), Automation, Computer Aided Manufacturing (CAM), Degrees of Freedom, Flexible Manufacturing System, Gripper, Inventory Control, Materials Handling, Robot, Robotics, Servo Motor, Stepper Motor, Roll, Pitch, Yaw

Assessments:
Teacher created Unit Assessments with guidance from Project Lead the Way (PLTW) Teacher Community

Lesson 3.2 Introduction to Automation Power (approximately 10 days)

Content Elaboration:
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.

Enduring Understandings:	**Essential Questions:**
● Power is produced in many ways and transmitted through various forms (e.g. electrical, pneumatic, hydraulic, and motion). ● Fluid power is inversely proportional to the area upon which the force is being applied. ● Pneumatics is one form of fluid power that can be used to operate machines and products. ● Sensors provide feedback to control systems and products used by consumers.	● How can power be transformed into other forms? ● How can a system be improved? ● How can team effectiveness be improved?

Learning Targets:
- Define torque, pressure, work and power.
- Identify equations of torque, pressure, work and power.
- Apply torque, pressure, work and power equations to engineering problems.
- Design a system to perform a task using fluid power.
- Construct a fluid power system.
- Create a program to operate a fluid power system.

Essential Vocabulary: Ampere (referred to as amp and symbolized as A), Energy, Electrical Current (symbolized as I), Fluid Power, Force, Horsepower (symbolized as hp), Hydraulic, Joule (symbolized as J), Pressure, Pounds per Square Inch (symbolized as psi), Pneumatic, Power, Revolutions per Minute (symbolized as rpm), Torque, Velocity (also known as linear velocity), Viscosity, Volt symbolized as V), Voltage (measured in volts), Watt, Work

Assessments:
Teacher created Unit Assessments with guidance from Project Lead the Way (PLTW) Teacher Community

Lesson 3.3 Design Problem - Robotic Programming and Usage (approximately 17 days)

Content Elaboration:
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.

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

Essential Questions:
- How can communication between systems be used to solve a problem?
- How can a robotic system be part of a solution to a problem?
- How can a physical system be simulated as part of a design process?

Learning Targets:
- Describe robot components including drive systems, electrical components.
- Describe the envelope of common robot types.
- Describe how robot geometry affects robot motion.
- Identify elements of a robotic program.
- Match robot type to application.
- Predict robot motion resulting from movement of an actuator.
- Create a program to control a robotic arm.
- Create programs for a robotic arm to communicate with a related machine.

Essential Vocabulary: Absolute Encoder, Accuracy, Debug, End Effector, Handshaking, Home, Incremental Encoder, Input, Joint, Kinematics, Loop, Microcontroller, Optoisolators, Output, Payload, Precision, Relay, Reliability, Repeatability, Robotic Control System, Roll, Servo Motor, Stepper Motor, Subroutine, Syntax, Work Envelope

Assessments:
Teacher created Unit Assessments with guidance from Project Lead the Way (PLTW) Teacher Community

Unit 4: Integration of Manufacturing Elements

Expectations for Learning:
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.

Lesson 4.1 CIM Systems (approximately 10 days)

Content Elaboration:
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.

Enduring Understandings:
- The process of mass production is used when the same product is created repeatedly.
- A workcell is a group of machines in which each individual machine has its own specialty.
- A flexible manufacturing system is one that can adapt to a wide variety of products.
- Manufacturing and automation careers are varied in scope and location.
- Tradeoffs are made when one system is utilized over another.
- Process flow design has a major impact on overall production time and product profit.
- 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.
- Flowcharting can be used to illustrate the phases of the product development process

Essential Questions:
- What should be considered when designing a manufacturing system?
- Who are reliable sources for career advice?
- What resources are available to develop a career plan?
- When should a career plan be started?
- How often should a career plan be updated?

Learning Targets:
- Describe common CIM systems.
- Recognize machines and processes in a manufacturing setting.
- Compare and contrast common CIM systems.
- Breakdown a manufacturing system into machines and processes.
- Organize and express thoughts and information in a clear and concise manner.
- Explain factors that affect a manufacturing career.

Essential Vocabulary: Process Design Chart, Stand-alone

Assessments:
Teacher created Unit Assessments with guidance from Project Lead the Way (PLTW) Teacher Community

Lesson 4.2 Integration of Manufacturing (approximately 37 days)

Content Elaboration:
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.

Enduring Understandings:
- Process flow design has a major impact on overall production time and product profit.
- 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.
- Flowcharting can be used to illustrate the overall phases of the product development process.
- Proper sequencing of automated operations is important in factory design.
- Safe operating procedures must be addressed in a CIM environment at all times to avoid serious injury.
- Trade-offs occur between efficiency and cost when choosing a manufacturing system.
- Engineers choose appropriate sensors to ensure high quality part production.
- Identification of correct electrical and fluid power systems is required to complete the desired manufacturing system.

Essential Questions:
- How can a team be diversified to enhance a design process?
- How is the design process used to optimize a solution to a problem?
- How does the effectiveness of a presentation affect the acceptance of a solution?

Learning Targets:
- Recognize process symbols.
- Identify the potential safety issues with a CIM system.
- Identify how functions of a computer program can be applied to perform a task.
- Outline a process for a manufacturing process.
- Design a system to manufacture a part.
- Construct a system to manufacture a part.
- Create a flowchart or pseudocode to perform a task.
- Construct a control program to accomplish a goal.
- Evaluate the effectiveness of a system to accomplish a goal.
- Identify strategies to resolve team conflict.

Essential Vocabulary: Delay, Flow Process Chart, Inspection, Quality Control, Operation, Process Flow, Storage, Transportation
Assessments: Teacher created Unit Assessments with guidance from Project Lead the Way (PLTW) Teacher Community

Common Core State Standards - English/Language Arts

Teachers should incorporate the English/Language Arts Common Core State Standards throughout the course.

Reading

Key Ideas

1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
2. Determine the central ideas or conclusions of a text. Provide an objective summary of the central ideas of a text, paraphrasing complex concepts, processes, or information by presenting them in simpler but still accurate terms.
3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

Craft and Structure

1. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics.
2. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.
3. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

Integration of Knowledge and Ideas

1. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
2. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
3. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible

Writing

Text Types and Purposes

1. Write arguments focused on discipline-specific content.
   a. Establish a clear and thorough thesis to present a complex argument.
   b. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.
   c. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases.
   d. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

e. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.
f. Provide a concluding statement or section that follows from or supports the argument presented.

2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
   a. Establish a clear and thorough thesis to present and explain information.
   b. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.
   c. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.
   d. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.
   e. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.
   f. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

Production and Distribution of Writing
1. Produce clear, coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
2. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
3. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

Research to Build and Present Knowledge
1. Conduct short as well as more sustained research projects to answer a question or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
2. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
3. Draw evidence from informational texts to support analysis, reflection, and research.

Considerations for Intervention and Acceleration

The rigorous and highly relevant PLTW Computer Integrated Manufacturing curriculum is built upon high quality, research-based instructional strategies. Teachers may need to provide targeted Tier II support (e.g., remediation of particular skills and concepts, as well as scaffolded or supplemental instruction) beyond the Tier I level of universal instruction to underachieving students. Intensive and individualized Tier III instruction (e.g., skill-specific intervention, one-on-one teaching, enrichment activities) may be necessary for students with significant underachievement or learners who are excelling through the standard curriculum and need additional educational challenges.

Considerations for Cultural Diversity, Inclusivity and Relevancy

Where possible teachers will create opportunities to incorporate the histories, values, beliefs and perspectives of people from different cultural backgrounds to meet the needs of all our learners.

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