Texas Education Agency

Computer Integrated Manufacturing

PEIMS Code: N1303748

Abbreviation: CIM

Grade Level(s): 9-12

Award of Credit: 1.0

Approved Innovative Course

- Districts must have local board approval to implement innovative courses.
- In accordance with Texas Administrative Code (TAC) §74.27, school districts must provide instruction in all essential knowledge and skills identified in this innovative course.
- Innovative courses may only satisfy elective credit toward graduation requirements.
- Please refer to TAC §74.13 for guidance on endorsements.

Course Description:

PLTW 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 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.

Essential Knowledge and Skills:

(a) General Requirements. This course is recommended for students in Grade 9-12. It is recommended that students are concurrently enrolled in college preparatory mathematics and science courses and have successfully completed the Introduction to Engineering Design course.

(b) Introduction.

(1) CTE instruction provides content aligned with challenging academic standards and relevant technical knowledge and skills for students to further their education and succeed in current or emerging professions.

(2) The Science, Technology, Engineering, and Mathematics (STEM) Career Cluster focuses on planning, managing and providing scientific research and professional and technical services (e.g., physical science, social science, engineering) including laboratory and testing services, and research and development services.

(3) Computer Integrated Manufacturing deepens the skills and knowledge of an engineering student within the context of efficiently creating the products 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

(4) Students are encouraged to participate in extended learning experiences such as career and technical student organizations and other leadership or extracurricular organizations.

(c) Knowledge and Skills.

(1) CIM Profession & Employability: The student investigates the manufacturing engineering profession and the standards of professional conduct in the industry, including the history of manufacturing, manufacturing careers, teamwork, project management, problem-solving, technical writing and presentation, and the ethical and legal responsibilities of manufacturers. The student is expected to:

(A) describe how 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,

(B) investigate the careers associated with manufacturing,

(C) categorize how components of a typical manufacturing system such as customer, knowledge and processes represent manufacturing activities,

(D) explain how manufacturing is essential to a healthy economy,

(E) apply safe-operating procedures in a CIM environment at all times to avoid serious injury,

(F) identify strategies to resolve team conflict,

(G) research safety laws surrounding the use of a CIM systems,

(H) describe why and how manufacturing evolved,

(I) organize and express thoughts and information in a clear and concise manner, and

(J) explain factors that affect a manufacturing career.

(2) Design for Manufacturability: The student applies product manufacturing procedures and processes to the production of a manufactured object, including an engineering design process, computer-aided design (CAD), material properties and selection, machine and tool capabilities, product life, design flaws, and cost calculations. The student is expected to:

(A) justify the use of prototyping as part of a design process,

(B) analyze and describe common prototyping techniques, and

(C) illustrate the overall phases of the product development process using flowcharting techniques,

(D) explain mass production and its relationships to product variation, quantity, and cost, and

(E) describe the tradeoffs that occur between efficiency and cost when choosing a manufacturing system.

(3) Manufacturing Economics & Planning: The student demonstrates the abilities to determine the costs to manufacture an object, including fixed, variable, capital, and labor costs, direct and indirect costs, production tradeoffs, health and safety costs, and worker characteristics. The student is expected to:

(A) explain how flowcharting and pseudocode are powerful tools used by technicians, computer programmers, engineers, and professionals in a variety of roles and responsibilities,

(B) use a flowchart and pseudocode to organize the flow of program control, including all inputs, outputs, and conditions that may occur,

(C) describe why process flow design has a major impact on overall production time and product profit,

(D) apply the concepts of flowcharting and flow processing analysis during the design and development process,

(E) describe how tradeoffs may be made between hiring highly skilled or experienced workers and keeping costs down, and

(F) describe the relationship between production time and profit.

(4) Manufacturing Processes, Tools, Machines, and Materials: The student demonstrates the abilities to propose and justify the design of a manufacturing system to produce manufactured objects, including the selection of materials and machines, machine set-up (jigs and fixtures), tool selection, and tool path verification. The student is expected to:

(A) describe characteristics of raw materials,

(B) explain the difference between primary and secondary manufacturing processes,

(C) describe the primary processing that raw materials must undergo before they can be used in manufacturing,

(D) describe the history and types of separating processes,

(E) describe electrochemical machining (ECM), electrical discharge machining (EDM), water cutting, and laser cutting including their accuracy and efficiency compared to other processes,

(F) explain why metals, plastics, and ceramics are types of materials that are well suited to the manufacturing process,

(G) describe the various machines and their applications used in manufacturing processes,

(H) list examples of common CNC machines,

(I) describe how Computer Aided Manufacturing (CAM) programming tools make it possible to manufacture physical models using Computer Aided Design (CAD) programs,

(J) select formulas, which are used to determine milling machine settings,

(K) describe parts and functions of common machines used in manufacturing, and

(L) identify, describe and measure the common variables in machining operations that affect the final product in manufacturing.

(5) Computer Control Systems: The student designs, programs, and evaluates computer control systems used to automate the production of objects, including control system design, machine to machine communication (handshaking), automation and robot programming languages. The student is expected to:

(A) describe how everyday products including cars, microwaves, ovens, hair dryers, coffee pots, and washing machines all use control systems to manage their operation,

(B) identify the devices that use microcontrollers,

(C) identify open and closed loop systems,

(D) describe how input and output devices are part of an open and closed loop system,

(E) operate output devices to perform a function,

(F) relate sensor input to the environment being measured,

(G) apply basic programming skills, include variable declaration, loops, and debugging, to the design of a control system,

(H) design a control system that incorporates issues related to cost and safety,

(I) describe functions of a computer program,

(J) explain how functions of a computer program can be applied to perform a task,

(K) construct a control program to accomplish an objective such as motor reacting to the environment, and

(L) convert an open loop system to be a closed loop system using sensors.

(6) Power Systems: The student demonstrates the abilities to design, construct, and troubleshoot fluid and electrical power systems used in manufacturing, including hydraulic, pneumatic, and electrical systems. The student is expected to:

(A) explain how power is produced and transmitted through various forms (e.g. electrical, pneumatic, hydraulic, and motion),

(B) apply the principals of fluid power to the design of a processing system,

(C) define torque, pressure, work and power,

(D) identify equations of torque, pressure, work and power,

(E) apply torque, pressure, work and power equations to engineering problems,

(F) design a system to perform a task using fluid power,

(G) construct a fluid power system, and

(H) create a program to operate a fluid power system.

(7) Robotics & Automation: The student explains the characteristics and operation of automated robotic systems, including robot types and applications, advantages and disadvantages of automation, work cells, envelopes and payloads, robot geometry, accuracy and repeatability, and programming languages. The student is expected to:

(A) describe the factors that influenced the evolution of automation,

(B) explain why robots have distinct advantages over humans in some industrial settings,

(C) describe the types of robots and their applications, including environments and functions,

(D) describe and apply the concepts related to a robot's work envelope and payload needed to perform a designated task,

(E) determine proper sequencing of automated operations in a factory design,

(F) explain why machine code is an essential tool used to communicate with some machines,

(G) describe how robot geometry affects robot motion,

(H) create a program for robotic arm to communicate with another device,

(I) predict robot motion resulting from movement of an actuator,

(J) create a program to control a robotic arm, and

(K) create programs for a robotic arm to communicate with a related machine.

(8) Computation and Analytical: The student demonstrates the abilities to apply computational and analytical skills to manufacturing problems, including financial principles, engineering equations, power system requirements, speed and feed calculations, creating and optimizing tool paths, analyzing product and process requirements, analyzing a product's life cycle, computer-aided design (CAD) and computer-aided manufacturing (CAM) programs, and G & M coding. The student is expected to:

(A) calculate milling speed and feeds and plunge rates,

(B) apply financial principles to manufacturing problems,

(C) calculate power requirements,

(D) use 3D CAD modeling software to create parts to be manufactured,

(E) use CAM software, including tool selection, to create machined objects,

(F) develop robot and automation control programs, and

(G) apply troubleshooting techniques to correct programming errors.

(9) Computer Integrated Manufacturing & Modeling: The student demonstrates the abilities to develop a complex physical model to simulate the automated production of objects, including sequencing of machines, safe machine operation, selection of sensors and actuators, control system programming, and troubleshooting. The student is expected to:

(A) describe common CIM systems,

(B) compare and contrast common CIM systems,

(C) identify machines and processes in a manufacturing setting,

(D) divide a manufacturing system into machines and processes, and

(E) explain the use of work cells in manufacturing.

Recommended Resources and Materials:

The most current version of the PLTW curriculum must be used for instruction. Teacher and student resources are developed by PLTW and can only be accessed by trained teachers, authorized district personnel, and rostered students through the PLTW Learning Management System. Access to PLTW resources is through myPLTW.org after the appropriate training or authorization has been completed.

https://mypltw.org.

In addition to the instructional equipment and materials required for the specific activities, projects and problems, each student in a class must have access to a computer that meets PLTW's specifications and is furnished with the appropriate software for the course. These requirements are listed at:

https://www.pltw.org/get-involved/register-pltw/program-support/equipment-and-supplies

Recommended Course Activities:

Computational and Analytical Skills

- Apply financial principles to manufacturing scenarios
- Calculate power requirements
- Calculate milling speed and feed rates
- Develop and apply formulas to solve to manufacturing dilemmas
- Analyze a product and propose manufacturing processes used to produce
- Analyze a product life cycle

Manufacturing Engineering and Design Experience

- Collaborate effectively with peers to solve problems using a design process
- Apply an engineering design process to solve a problem
- Design, build, and test a manufacturing system model
- Design and test a program to control a system
- Select material for an application
- Design a part using CAD modeling software
- Select tooling and create tool paths using CAM software
- Optimize tooling, tool paths and feed rates to safely and efficiently mill a part
- Operate a mill to produce a part
- Evaluate prototyping techniques and choose the appropriate method for a product
- Create programs for devices to communicate with a simulated manufacturing system
- Investigate manufacturing engineering career

Professional Skills

- Team collaboration
- Project management
- Problem-solving
- Communication skills
- Presentation skills
- Technical writing

Course Knowledge

- Manufacturing
    - Historical evolution of manufacturing systems
    - Modern manufacturing systems
    - Manufacturing processes

- Manufacturing system design
- Designing for manufacturability
- Prototyping techniques
- Cost of manufacturing and efficiency
- Manufacturing system power
- Integration of manufacturing elements
- Manufacturing automation
- Robots in manufacturing

- Manufacturing Software and Tools
  - Software programing and troubleshooting
  - Milling machine tooling
  - Milling machine speed and feed rates
  - Milling machine operation
  - Communication between devices
  - CAD software
  - CAM software
- Engineering
  - Engineering code of ethics
  - Engineering design process
  - Project management tools
  - Product life cycle
  - Manufacturing engineering careers
  - Material selection
  - Power systems

Suggested methods for evaluating student outcomes:

PLTW Engineering assessments play an important role in providing meaningful feedback to students, teachers, administrators, and PLTW. Through assessments, students identify what they are doing well and what they need help with, and teachers are able to provide individualized direction and guidance to each student.

PLTW supports a balanced approach to assessment for all programs, integrating both formative and summative assessments. Through a balanced approach, assessment is an ongoing activity. Students demonstrate their knowledge throughout the course by completing activities, projects, and problems using a variety of assessment tools, such as performance rubrics and reflective questioning, to deepen and expand their knowledge and skills.

PLTW applies industry best practices and methods to design, test, and implement End of Course assessments for its schools. They receive valid and reliable scores on overall student performance within the course. The End of Course assessment gives students an objective evaluation of their achievement, and school administrators obtain data on program performance. Many colleges, universities, and other organizations use students' PLTW EoC scores for student recognition and recruitment opportunities.

Teacher qualifications:

An assignment for Computer Integrated Manufacturing is allowed with one of the following certificates as well as successful completion of the Project Lead The Way's Core Training requirements for Computer Integrated Manufacturing.

PLTW Core Training:

PLTW's Core Training requires approximately 90 hours of instruction led by PLTW approved Master Teachers. Course mastery is demonstrated by the submission and approval of a course portfolio that meet's PLTW's requirements. After successful completion of Core Training, teachers receive access to the National PLTW Engineering Professional Learning Community, course-specific student and classroom instructional resources, and Ongoing Training resources through the PLTW Content Management System.

- Secondary Industrial Arts (Grades 6-12).
- Secondary Industrial Technology (Grades 6-12).
- Technology Education: Grades 6-12.
- Trade and Industrial Education: Grades 6-12. This assignment requires appropriate work approval.
- Trade and Industrial Education: Grades 8-12. This assignment requires appropriate work approval.
- Vocational Trades and Industry. This assignment requires appropriate work approval.
- Vocational Trades and Industry (Grades 6-12). This assignment requires appropriate work approval.
- Vocational Trades and Industry Pre-Employment Laboratory (Grades 6-12). This assignment requires appropriate work approval.
- Vocational Trades and Industry Co-op (Grades 6-12). This assignment requires appropriate work approval.
- Technology Applications: Grades EC-12
- Technology Applications: Grades 8-12

Additional information:

Districts may use these courses only with the approval of Project Lead The Way. All requirements of Project Lead The Way must be met. Please contact Project Lead The Way directly for these requirements:

Project Lead The Way
Solution Center
Toll Free: 877.335.PLTW (7589)
solutioncenter@pltw.org