

Advanced Manufacturing 1

COURSE OUTLINE - UC

DESCRIPTION:

Advanced manufacturing is designed to prepare students for employment in the manufacturing industry. Students will engage in interdisciplinary learning of Science, Technology, Engineering, Art, and Math through a hands-on, project-based approach. Students will receive introductory level exploratory instruction on topics including proper use of hand tools, machinery tools, print reading, robotics, pneumatics, electrical control, basic concepts of mechanical and electrical engineering, designing and creating models using a CNC machine and Computer-Aided Design (CAD), and real world applications of classroom concepts. Depth of knowledge will be demonstrated through a series of projects starting with research and initial design and culminating with the completion of a build project that is geared toward solving real-world problems. Activities in this course include work-based learning that connects students to industry and the local community.

INFORMATION:

PRE-REQUISITE:	None
LENGTH:	One Year
SECTOR:	Manufacturing and Product Development
PATHWAY:	Product Innovation and Design
ARTICULATED:	Yes
UC A-G APPROVAL:	Yes: College-Preparatory Elective (G) – Interdisciplinary Requirement

O*NET SOC CODES:

49-9041.00	Industrial Machinery Mechanics
51-4011.00	Computer-Controlled Machine Tool Operators, Metal and Plastic
51-4041.00	Machinists

Orientation
<ul style="list-style-type: none"> A. Introduce the course and facilities. B. Discuss the syllabus and major objectives. C. Explain applicable classroom management procedures, the ROP Student Rules of Conduct, and any operational guidelines. D. Review instructor/student expectations. E. Explain enrollment and attendance requirements and procedures. F. Review grading and student evaluation procedures. G. Discuss the community classroom aspect of the program if applicable. H. Discuss the “next steps” related to additional education, training, and employment. I. Review classroom safety, emergency and disaster procedures.
1. Communication Skills
<ul style="list-style-type: none"> A. Demonstrate positive verbal communication skills using appropriate vocabulary, demeanor, and vocal tone in the classroom and/or worksite. B. Read and interpret written information and directions. C. Practice various forms of written communication appropriate to the occupation. D. Practice positive body language skills. E. Practice professional verbal skills for resolving a conflict. F. Demonstrate active listening skills including techniques for checking for understanding, and for obtaining clarification of directions.
2. Interpersonal Skills
<ul style="list-style-type: none"> A. Demonstrate positive teamwork skills by contributing to a group effort. B. Practice the importance of diversity awareness and sensitivity in the workplace. C. Define sexual harassment in the workplace and identify the employee’s role and responsibility. D. Practice participation skills. E. Identify different personality types and strategies for working effectively with each type. F. Practice business and social etiquette skills appropriate to the occupation. G. Discuss the role of business and personal ethics in the decision-making process. H. Evaluate various job-related scenarios and justify decisions based on ethics. I. Demonstrate flexibility and adaptability in working with others. J. Demonstrate the use of time management skills.

3. Employability Skills
<ul style="list-style-type: none"> A. Demonstrate appropriate attendance and punctuality practices for the classroom and worksite if applicable. B. Prepare a resume, cover letter, and job application forms. C. Demonstrate interviewing techniques using appropriate tone and body language. D. Demonstrate appropriate dress and grooming standards in seeking employment and for the workplace. E. Identify strategies for employment retention. F. Analyze the impact of social networking on employability. G. Identify the need for continuing education, professional development, and professional growth in chosen field. H. Identify appropriate procedures for leaving a job. I. Identify sources of job information, including electronic sources. J. Review company policies and current trends in employee compatibility screening, drug screening, and background checks.
4. Leadership
<ul style="list-style-type: none"> A. Define leadership and identify the responsibilities, competencies, and behaviors of successful leaders. B. Work with peers to promote divergent and creative perspectives. C. Demonstrate how to organize and structure work, individually and in teams, for effective performance and the attainment of goals. D. Explain multiple approaches to conflict resolution and their appropriateness for a variety of situations in the workplace. E. Employ ethical behaviors and actions that positively influence others. F. Use a variety of means to positively impact the direction and actions of a team or organization. G. Analyze the short-term and long-term effects a leader's actions and attitudes can have on productivity, morale, and organizational culture.
5. Personal and Occupational Safety
<ul style="list-style-type: none"> A. Demonstrate procedures to be followed in the case of emergencies. B. Discuss ways to report a potential safety hazard to a supervisor. C. Identify and discuss cyber ethics, cyber safety, and cyber security. D. Apply personal safety practices to and from the job. E. Describe the procedure for reporting a work-related hazard or injury. F. Recognize the effects of substance abuse in the workplace.
6. Introduction to Manufacturing
<ul style="list-style-type: none"> A. Track the evolution of manufacturing and its impact on society. B. Identify the various career opportunities within manufacturing.

- C. Describe the relationship between manufacturing and the environment.
- D. Explain the difference between traditional and digital manufacturing.
- E. Describe the training and educational requirements for various manufacturing positions and fields.
- F. Explain the importance of professional development and continuing education.
- G. Explain the interaction between manufacturing industries and social change.
- H. Explain how manufacturing made the United States a world leader.
- I. Identify global manufacturing hotspots and their impact on the industry.

7. Evolution of Manufacturing

- A. Identify past, present, and future pioneers of the manufacturing industry.
- B. Describe the effect that automation has had on manufacturing.
- C. Identify key historical events and their impact on manufacturing.
- D. List key persons who have contributed to change in manufacturing.
- E. Describe the Industrial Revolution and its impact on manufacturing.

8. Materials

- A. Describe the seven basic technological resources.
- B. Explain how materials are classified.
- C. Compare and contrast the advantages and disadvantages of organic materials, metals, polymers, ceramics, and composites based on physical properties.
- D. Describe the differences of the destructive and non-destructive tests used to analyze material properties.
- E. Describe the properties of manufacturing materials.
- F. List, measure, and compare common mechanical properties of select materials.
- G. List sources and costs of various materials used in manufacturing.
- H. Calculate production cost analysis.
- I. Determine the production processes used to create products from categories of materials.
- J. Evaluate types and magnitude of stresses and forces.

9. Manufacturing Systems and Process

- A. List the steps of a typical manufacturing process.
- B. Describe the primary and secondary manufacturing processes.
- C. Describe assembling processes.
- D. Explain the importance of quality control and assurance.
- E. Identify components of a typical physical manufacturing system.
- F. Identify the seven types of waste in production identified as "MUDA."

- G. Define the manufacturing life cycle of a product.
- H. List secondary manufacturing processes.
- I. Define the terms “separating” and “forming” as they relate to manufacturing.
- J. Identify separating processes – traditional and non-traditional.
- K. Identify forming processes including casting, molding, compression, stretching, and conditioning.
- L. Differentiate between combining processes such as mixing, bonding, coating, and mechanical filtering.
- M. Explain the importance of finishing processes.
- N. Identify the planning and process procedures for production (e.g., forecasting, corrective preventive actions, audit documentation, Process Failure Mode Effect Analysis [PFMEA]).
- O. Analyze various “Lean Manufacturing” methodologies.

10. Manufacturing Math

- A. Define basic math and geometric terms and symbols used in manufacturing.
- B. Explain math concepts and formulas related to manufacturing.
- C. Convert values between different units of measure.
- D. Solve equations involving decimals, fractions, and percent.
- E. Demonstrate how to measure volume, surface area, and bounding box of geometric shapes.
- F. Solve basic math equations with integers, including addition, subtraction, multiplication, and division.
- G. Analyze dimensional tolerances.

11. Measuring and Measurement Tools

- A. Demonstrate proper safety precautions when using various measurement tools.
- B. Demonstrate the proper selection, use, and maintenance of various measurement tools.
- C. Convert between metric and US Customary units.
- D. Identify various systems and methods of measurement used in manufacturing.
- E. Demonstrate the ability to measure accurately down to 1/64 of an inch or 0.5mm.
- F. Demonstrate the proper use of calipers and micrometers down to 0.001 mm or 0.0001 inch.

12. Mechanical Fabrication (Hand Tools)

- A. Demonstrate proper safety precautions when using various hand tools.
- B. Demonstrate the proper selection, use, and maintenance of various hand tools.
- C. Identify various types of hand tools, how they are sized, and their use. (e.g., screwdrivers, hex key wrenches).
- D. List common hand tools used in the maintenance, installation, and repair of equipment.
- E. Identify various types of fasteners and their uses.
- F. Identify various screw and bolt types, sizes, thread pitch, and their function in manufacturing.

G. Demonstrate the proper assembly of various manufacturing parts and components.

13. Machine Tools (Power Tools)

- A. Demonstrate proper safety precautions when using various machine tools.
- B. Demonstrate the proper selection, use, and maintenance of various machine tools.
- C. Demonstrate various layout techniques.
- D. Identify commonly used power tools.
- E. Identify common cutting tools and their use.
- F. Describe parts and functions of common machines used in manufacturing.
- G. Select formulas which are used to determine milling machine settings.
- H. Define common G & M Codes for milling.
- I. Demonstrate proper use and safety precautions when operating a milling machine.
- J. Calculate settings needed for a milling machine.
- K. Interpret the actions that will be performed given a sample of machine code.

14. Computer Aided Design

- A. Convert a 2D model into a 3D model.
- B. Translate a three-dimensional drawing or model into corresponding orthographic drawing views.
- C. Produce a reverse-engineered drawing from a solid object.
- D. Identify common equipment used in CNC manufacturing.
- E. Sketch a fully-dimensional, multi-view drawing.
- F. Evaluate a sketch and generate a model utilizing three-dimensional modeling software and techniques.
- G. Create a schematic of an electric control system utilizing three-dimensional modeling software and techniques.
- H. Apply manufacturing processes (e.g., casting, molding, forming, separating, conditioning, assembling, finishing, rapid prototyping).
- I. Compare and contrast conceptual, physical, and mathematical design models used to check proper design.
- J. Perform part manipulation during the creation of an assembly model.
- K. Analyze assembly constraints to successfully construct a multipart object.
- L. Utilize part libraries effectively during the assembly modeling process.
- M. Employ subassemblies during the production of assemblies.
- N. Verify drive constraints that simulate the motion of parts in assemblies.
- O. Create and interpret auxiliary views, orthographic projections, isometric drawings, oblique drawings and perspective drawings.
- P. Illustrate the types of breaks and symbols used in drawing sectional views.
- Q. Add technical elements (e.g., parts lists, titles, finishes, tolerances, specifications, hidden surfaces) to drawings.
- R. Compare and contrast the additive and subtractive methods of manufacturing.
- S. Identify various 3D printing processes.
- T. Identify advantages and disadvantages of various materials used in the 3D printing process.
- U. Identify common computerized numerical control (CNC) machines and their function.

15. Automation and Robotics

- A. Demonstrate proper safety precautions when using robotics.
- B. Design and program a robot using basic commands.
- C. Identify common robot characteristics and types used in manufacturing.
- D. Describe components of a robotic work cell.
- E. Describe roll angle.
- F. Analyze factors that impact robots in a manufacturing environment.
- G. Explain how materials handling impacts a manufacturing environment.
- H. Define torque, pressure, work, and power.
- I. Identify equations of torque, pressure, work, and power.
- J. Describe robot components including drive systems and electrical components.
- K. Describe how robot geometry affects robot motion.
- L. Identify elements of a robotic program.
- M. Design and fabricate a digital I/O interface for a robot.

16. Pneumatics

- A. Demonstrate proper safety precautions when using pneumatic equipment.
- B. Calculate force using Pascal's Law.
- C. Calculate pressure and volume using Boyle's Law.
- D. Analyze and interpret a schematic of a pneumatic control system.
- E. Design a pneumatic control system with pressure regulator and a cylinder or motor.
- F. Sketch a schematic of a pneumatic control system.
- G. Size a cylinder given force requirements.
- H. Fabricate a pneumatic power system.
- I. Calculate pressure difference in a system across multiple components.
- J. Install and use pneumatic components.

17. Electric Control Logic

- A. Demonstrate proper safety precautions when using electronic equipment and tools.
- B. Demonstrate the proper use of a multi-meter.
- C. Explain the difference and application of alternating current (AC) and direct current (DC).
- D. Demonstrate the use of logic elements including AND, OR, NOT, NOR, NAND, and MEMORY.
- E. List the sequence of operation of an electric control system.
- F. Analyze and interpret a schematic of an electric control system.
- G. Calculate power usage and size circuit protection.

- H. Design and fabricate an electrical system.
- I. Install switches and outlets.
- J. Install circuit protection.
- K. Compare and contrast conductors and insulators.
- L. Construct and install regulated power supplies.
- M. Select and install fuses and circuit breakers.
- N. Select and construct half-wave, full wave, and bridge rectifiers.
- O. Select and install power conditioning, isolation transformers, surge suppressors, uninterruptible power supplies.

Key Assignments

Assignment	Competencies	Career Ready Practices	Anchor Standards	Pathway Standards	CCSS
1. Students will participate in mock interviews that represent current industry practices (e.g., skills demonstrations, resumes, applications, portfolios, personal websites, etc.).	1A, B, D 3B, C, D, I, J	2 3	2 3		LS 11-12.6 SLS 11-12.2
2. Students will maintain a professional engineering notebook for the entire year. Students will use their engineering notebooks to record ideas, inventions, experimentation records, observations and all work details. Students will learn how to properly enter information, edit mistakes, and sign completed pages. Students will record information for every project and other key assignments for the entire year into the notebook. To ensure proper use of the engineering notebook, they will be collected and graded after every major assignment assessing organization, essential questions, data table, sketches, CAD drawings, content of entries, and reflective written entries.	1B, C 2J 4C 5D, F 9A-D 10A-G	1 2 5 11	1 2 5 11	D1.0 D2.0	LS 11-12.6 WS 11-12.7
3. Students will use a table saw, band saw, drill press, jigsaw, circular saw, reciprocating saw, lathe, and manual mill. Using basic layout techniques, students will manufacture a part that includes four different ways to create a hole in order to fasten parts together. Students will design and create their own pen. They will finish off with a household item replica project in which they have to re-create a common household item out of wood, plastic, or metal using any of the power tools above.	5D, F, L 13A-K	4 5 10	1 4 10	D1.0	SEP 1-6

Assignment	Competencies	Career Ready Practices	Anchor Standards	Pathway Standards	CCSS
<p>4. Students will create 3D models using industry standard SolidWorks software. Students will open and change views of a solid model, identify features on a solid model, use the sketch entity tools to create a 2D solid model, and use the boss and extrude command to make the 2D solid model into a 3D model. Students will then make solid models of common household items and export those items into a CNC machine and manufacture the part using industry standard SolidCAM software.</p>	<p>1B 9A, D 10A-G 14A-U</p>	<p>1 4 5 10</p>	<p>4 5 10</p>	<p>D1.0 D4.0 D5.0</p>	<p>CC 3 CC 6 SEP 1-6</p>
<p>5. Given a Pegasus Robotic Arm, students will control the robot manually with a teach pendant. Students will move material from one point to another by programming the robot. Students will finish by interfacing the robot with other devices in order to unload an automatic machine through multiple input and output devices.</p>	<p>5D, F, L</p>	<p>1 4 5</p>	<p>4 5 10</p>	<p>B8.0</p>	<p>SEP 1, 3-6</p>
<p>6. Students will hook up a pressure regulator, filter, quick connect hoses, and couplings. Students will transfer air pressure from one device to another using a 3-way directional control valve, two pistons, and a pneumatic motor. Students will calculate the output force and retracting force of an extending cylinder, verify Pascal's law, calculate pressure and volume problems using Boyle's Law, and calculate the pressure difference in a system across multiple components.</p>	<p>5D, F, L 10B-D 16A-J</p>	<p>1 4</p>	<p>4 10</p>	<p>B5.0 B6.0</p>	<p>CC 5 SEP 1-5, 8</p>

Assignment	Competencies	Career Ready Practices	Anchor Standards	Pathway Standards	CCSS
<p>7. Students will work in small groups to connect various logic elements including AND, OR, NOT, NOR, NAND, and MEMORY logic. Students will progress to more advanced systems such as pneumatic solenoids, timers, and relays. Students will draw electrical control schematics for those circuits.</p> <p>Students will design a continuous cycle cylinder reciprocation circuit with a safety interlock. Students must be able to correctly wire 2 push buttons, 2 relays, 2 LED indicator lights, 4 limit switches, 2 pneumatic valves, and a safety "drop-dead switch" for 2 cylinders that reciprocate back and forth. Students will produce a schematic of the circuit they produce.</p>	17A-O	1 4 9	4 5 9 10	D1.0 D2.0 D3.0 B3.0 B5.0	CC 2 CC 5 PS 3.C SEP 1-8
<p>8. Students will design and create an automatic can crusher as the year 1 capstone project.</p>	1A-F 2A, B, D-G, I, J 5A, D-F, I, J, L 9C, 10A, C, D, N 12A-H, K 13A-G 14A-G 15A-F 16A-G 17A-F 18D, E, G, U 19A, B, M 20A, E-H, J 21B, C, E-J, L	1 2 4 5 10 11	1 2 4 5 6 7 10 11	D3.0 D4.0 D5.0 D10.0 B10.0	LS 11-12.6 RLST 11-12.4 SLS 11-12.1 WS 11-12.7 PS 3.C SEP 1-8

Standards Assessed in this Program

Career Ready Practices

1. Apply appropriate technical skills and academic knowledge.
2. Communicate clearly, effectively, and with reason.
3. Develop an education and career plan aligned to personal goals.
4. Apply technology to enhance productivity.
5. Utilize critical thinking to make sense of problems and persevere in solving them.
6. Practice personal health and understand financial well-being.
7. Act as a responsible citizen in the workplace and the community.
8. Model integrity, ethical leadership, and effective management.
9. Work productively in teams while integrating cultural/global competence.
10. Demonstrate creativity and innovation.
11. Employ valid and reliable research strategies.
12. Understand the environmental, social, and economic impacts of decisions.

Anchor Standards

2.0 Communications

- Acquire and use accurately sector terminology and protocols at the career and college readiness level for communicating effectively in oral, written, and multimedia formats.

3.0 Career Planning and Management

- Integrate multiple sources of career information from diverse formats to make informed career decisions, solve problems, and manage personal career plans.

4.0 Technology

- Use existing and emerging technology, to investigate, research, and produce products and services, including new information, as required in the sector workplace environment.

5.0 Problem Solving and Critical Thinking

- Conduct short, as well as more sustained, research to create alternative solutions to answer a question or solve a problem unique to the sector using critical and creative thinking, logical reasoning, analysis, inquiry, and problem-solving techniques.

6.0 Health and Safety

- Demonstrate health and safety procedures, regulations, and personal health practices and determine the meaning of symbols, key terms, and domain-specific words and phrases as related to the sector workplace environment.

7.0 Responsibility and Flexibility

- Initiate, and participate in, a range of collaborations demonstrating behaviors that reflect personal and professional responsibility, flexibility, and respect in the sector workplace environment and community settings.

8.0 Ethics and Legal Responsibilities

- Practice professional, ethical, and legal behavior, responding thoughtfully to diverse perspectives and resolving contradictions when possible, consistent with applicable laws, regulations, and organizational norms.

9.0 Leadership and Teamwork

- Work with peers to promote divergent and creative perspectives, effective leadership, group dynamics, team and individual decision making, benefits of workforce diversity, and conflict resolution.

10.0 Technical Knowledge and Skills

- Apply essential technical knowledge and skills common to all pathways in the sector following procedures when carrying out experiments or performing technical tasks.

Pathway Standards

Manufacturing and Product Development - Product Innovation and Design Pathway

D1.0 Understand the basic product design and development process as it relates to the design of a product, line of products, system design, or services.

D2.0 Understand and apply research methodologies as a means to identify a need, problem, or opportunity for a new product, product line, system design, or service.

D3.0 Understand and apply various ideation techniques to develop ideas and concepts.

D4.0 Apply various two-dimensional (2-D) graphic and/or three-dimensional (3-D) modeling techniques to development concept.

D5.0 Develop the concept into a well-defined product for prototyping.

D10.0 Produce a presentation of the product, product line, system design, or service.

Engineering and Architecture – Engineering Technology Pathway

B3.0 Identify the fundamentals of the theory, measurement, control, and applications of electrical energy, including alternating and direct currents.

B5.0 Understand how the principles of force, work, rate, power, energy, and resistance relate to mechanical, electrical, fluid, and thermal engineering systems.

B6.0 Employ the design process to solve analysis and design problems.

B8.0 Understand fundamental control system design and develop systems that complete preprogrammed tasks.

B10.0 Design and construct a culminating project effectively using engineering technology.

Common Core State Standards

ENGLISH LANGUAGE ARTS

Language Standards

LS 11-12.6: Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the (career and college) readiness level, demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Speaking and Listening Standards

SLS 11-12.2: Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions, and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data.

SCIENCE

Scientific and Engineering Practices

- SEP1.** Asking questions (for science) and defining problems (for engineering)
- SEP2.** Developing and using models
- SEP3.** Planning and carrying out investigations
- SEP4.** Analyzing and interpreting data
- SEP5.** Using mathematics and computational thinking
- SEP6.** Constructing explanations (for science) and designing solutions (for engineering)
- SEP7.** Engaging in argument from evidence
- SEP8.** Obtaining, evaluating, and communicating information

Crosscutting Concept

- CC2:** Cause and effect: Mechanism and explanation
- CC3:** Scale, proportion, and quantity
- CC5:** Energy and matter: Flows, cycles, and conservation
- CC6:** Structure and function

Physical Sciences

- PS3.C:** Relationship Between Energy and Forces