FOLSOM CORDOVA UNIFIED SCHOOL DISTRICT

INTRODUCTION TO PRODUCT INNOVATION DESIGN AND MANUFACTURING

Date: January 2017                                                  Course Length: 1 year
Proposed Grade Level(s): 9-12                                      Subject Area: Career Technical Education
Grading: A-F                                                  Credits: 5.0 per semester
CTE Sector / Pathway: Manufacturing and Product Development / Product Innovation and Design

Prerequisite(s): None

Intent to Pursue ‘A-G’ College Prep Status: Yes

COURSE DESCRIPTION:

This course represents a contextualized, laboratory-based, integrated curriculum for students to learn about communication, transportation, energy, production, biotechnology, and integrated technology systems and processes that affect their lives. Students develop critical thinking skills through a variety of multimodal, problem-solving techniques. 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 3D printing, CNC machine and Computer-Aided Design (CAD). Integrated content focuses in an age of rapidly advancing technology; and provides students with the basis for making wise academic and career choices.

GENERAL GOALS/ESSENTIAL QUESTIONS:

Goals:

- Students will maintain a professional-caliber 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. The 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 based on a 4 point rubric assessing organization, essential questions, data table, sketches, CAD drawings, content of entries, and reflection writing.
- Students will demonstrate their use of machine tools by creating a household item replica project in which they re-create a common household item out of wood, plastic, or metal using any of the power tools learned in this unit.
- Students will be required to demonstrate their knowledge of measurement by using the correct tools to measure a variety of objects. In addition, they will show their knowledge of measurement conversion by converting each measurement between metric and US Customary units.
- Students will use industry standard software to design models, and machine and manufacture the part using industry standard software. Students’ completed projects will demonstrate knowledge of both product design and manufacturing.
- Students will demonstrate their knowledge of robotics by safely programming a robot to automatically operate a function. This will help prepare them for the culminating assignment of the course.
- Students will demonstrate their knowledge of pneumatics by utilizing a cylinder to complete an operation. The output and retracing force must be enough to complete an operation. This will help prepare students for the culminating assignments of the course during which this process will be automated.
• Students will design a continuous cycle cylinder reciprocation circuit with a safety interlock. During this assignment 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. The students will then produce a schematic of the circuit they produced. Students will learn how all of the above devices interact with one another, how power can be maintained or switched from one device to another, and the basic logic behind all electronically controlled devices.

• Students will complete a final culminating project that correlates all learning objective for the year.

**Essential Questions:**

- Can the students maintain a professional-caliber notebook for the entire academic year?
- Can students create a household item replica from various materials?
- Can students accurately measure and convert between metric and US Customary units?
- Can students program a robot?
- Can students complete an operation using pneumatics?
- Can students create and operate a reciprocation circuit switch?

**COMMON CORE STATE ANCHOR STANDARDS FOR READING (K-12):**

**Key Ideas and Details**
1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
2. Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.
3. Analyze how and why individuals, events, or ideas develop and interact over the course of a text.

**Craft and Structure**
4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.
5. Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.
6. Assess how point of view or purpose shapes the content and style of a text.

**Integration of Knowledge and Ideas**
7. Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words.
8. Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.
9. Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

**Reading Range / Text Complexity**
10. Read and comprehend complex literary and informational texts independently and proficiently.

**COMMON CORE STATE ANCHOR STANDARDS FOR WRITING (K-12):**

**Text Types and Purposes**
1. Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.
2. Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.
3. Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details and well-structured event sequences.

**Production and Distribution of Writing**
4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.
6. Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

**Research to Build Knowledge**
7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.
8. Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.
9. Draw evidence from literary or informational texts to support analysis, reflection, and research.

**Range of Writing**
10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

**COMMON CORE STATE ANCHOR STANDARDS FOR SPEAKING AND LISTENING (K-12):**

**Comprehension and Collaboration**
1. Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.
2. Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.
3. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric.

**Presentation of Knowledge and Ideas**
4. Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and ensure that the organization, development, and style are appropriate to task, purpose, and audience.
5. Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.
6. Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate.

**CTE STANDARDS FOR CAREER READY PRACTICE:**

1. **Apply appropriate technical skills and academic knowledge.** Career-ready individuals readily access and use the knowledge and skills acquired through experience and education. They make connections between abstract concepts with real-world applications and recognize the value of academic preparation for solving problems, communicating with others, calculating measures, and other work-related practices.
2. **Communicate clearly, effectively, and with reason.** Career-ready individuals communicate thoughts, ideas, and action plans with clarity, using written, verbal, electronic, and/or visual methods. They are skilled at interacting with others, are active listeners who speak clearly and with purpose, and are comfortable with the terminology common to the
workplace environment. Career-ready individuals consider the audience for their communication and prepare accordingly to ensure the desired outcome.

3. **Develop an education and career plan aligned with personal goals.**
   Career-ready individuals take personal ownership of their own educational and career goals and manage their individual plan to attain these goals. They recognize the value of each step in the educational and experiential process and understand that nearly all career paths require ongoing education and experience to adapt to practices, procedures, and expectations of an ever-changing work environment. They seek counselors, mentors, and other experts to assist in the planning and execution of education and career plans.

4. **Apply technology to enhance productivity.**
   Career-ready individuals find and maximize the productive value of existing and new technology to accomplish workplace tasks and solve workplace problems. They are flexible and adaptive in acquiring and using new technology. They understand the inherent risks—personal and organizational—of technology applications and they take actions to prevent or mitigate these risks.

5. **Utilize critical thinking to make sense of problems and persevere in solving them.**
   Career-ready individuals recognize problems in the workplace, understand the nature of the problems, and devise effective plans to solve the problems. They thoughtfully investigate the root cause of a problem prior to introducing solutions. They carefully consider options to solve the problem and, once agreed upon, follow through to ensure the problem is resolved.

6. **Practice personal health and understand financial literacy.**
   Career-ready individuals understand the relationship between personal health and workplace performance. They contribute to their personal well-being through a healthy diet, regular exercise, and mental health activities. Career-ready individuals also understand that financial literacy leads to a secure future that enables career success.

7. **Act as a responsible citizen in the workplace and the community.**
   Career-ready individuals understand the obligations and responsibilities of being a member of a community and demonstrate this understanding every day through their interactions with others. They are aware of the impacts of their decisions on others and the environment around them and think about the short-term and long-term consequences of their actions. They are reliable and consistent in going beyond minimum expectations and in participating in activities that serve the greater good.

8. **Model integrity, ethical leadership, and effective management.**
   Career-ready individuals consistently act in ways that align with personal and community-held ideals and principles. They employ ethical behaviors and actions that positively influence others. They have a clear understanding of integrity and act on this understanding in every decision. They use a variety of means to positively impact the direction and actions of a team or organization, and they recognize the short-term and long-term effects that management’s actions and attitudes can have on productivity, morale, and organizational culture.

9. **Work productively in teams while integrating cultural and global competence.**
   Career-ready individuals positively contribute to every team as both team leaders and team members. They apply an awareness of cultural differences to avoid barriers to productive and positive interaction. They interact effectively and sensitively with all members of the team and find ways to increase the engagement and contribution of other members.

10. **Demonstrate creativity and innovation.**
    Career-ready individuals recommend ideas that solve problems in new and different ways and contribute to the improvement of the organization. They consider unconventional ideas and suggestions by others as solutions to issues, tasks, or problems. They discern which ideas and suggestions may have the greatest value. They seek new methods, practices, and ideas from a variety of sources and apply those ideas to their own workplace practices.
11. **Employ valid and reliable research strategies.**
Career-ready individuals employ research practices to plan and carry out investigations, create solutions, and keep abreast of the most current findings related to workplace environments and practices. They use a reliable research process to search for new information and confirm the validity of sources when considering the use and adoption of external information or practices.

12. **Understand the environmental, social, and economic impacts of decisions.**
Career-ready individuals understand the interrelated nature of their actions and regularly make decisions that positively impact other people, organizations, the workplace, and the environment. They are aware of and utilize new technologies, understandings, procedures, and materials and adhere to regulations affecting the nature of their work. They are cognizant of impacts on the social condition, environment, workplace, and profitability of the organization.

**CTE KNOWLEDGE AND PERFORMANCE ANCHOR STANDARDS:**

1.0 **Academics:** Students will analyze and apply appropriate academic standards required for successful industry sector pathway completion leading to postsecondary education and employment.

2.0 **Communications:** Students will acquire and accurately use Manufacturing and Product Design 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:** Students will integrate multiple sources of career information from diverse formats to make informed career decisions, solve problems, and manage personal career plans.

4.0 **Technology:** Students will use existing and emerging technology, to investigate, research, and produce products and services, including new information, as required in the Manufacturing and Product Design sector workplace environment.

5.0 **Problem Solving and Critical Thinking:** Students will conduct short, as well as more sustained, research to create alternative solutions to answer a question or solve a problem unique to the Manufacturing and Product Design sector using critical and creative thinking, logical reasoning, analysis, inquiry, and problem-solving techniques.

6.0 **Health and Safety:** Students 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 Manufacturing and Product Design sector workplace environment.

7.0 **Responsibility and Flexibility:** Students will initiate, and participate in, a range of collaborations demonstrating behaviors that reflect personal and professional responsibility, flexibility, and respect in the Manufacturing and Product Design sector workplace environment and community settings.

8.0 **Ethics and Legal responsibilities:** Students will 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:** Students will 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 as practiced in the SkillsUSA career technical student organizations.

10.0 **Technical Knowledge and Skills:** Students will apply essential technical knowledge and skills common to all pathways in the Manufacturing and Product Design sector, following procedures when carrying out experiments or performing technical tasks.

11.0 **Demonstration and Application:** Students demonstrate and apply the knowledge and skills contained in the Manufacturing and Product Design anchor standards, pathway standards, and performance indicators in classroom, laboratory, and workplace settings.
DETAILED UNITS OF INSTRUCTION:

Unit 1- Mechanical Fabrication
This unit is an introduction to basic hand tools and threaded fasteners. Students will be able to distinguish between flathead and Phillips screwdriver and describe how each one is sized. They will be able to describe and used fixed, adjustable, and Allen wrenches. They will be able to identify screw types and bolt types when given a sample. They will be able to describe the characteristics of a bolt which include type (metric or US customary), bolt size, and thread pitch. They will demonstrate that they can properly assemble a hinge assembly using screwdrivers, wrenches, screws, bolts, washers, and flat washers. This unit is foundational for the projects in the class because each project requires some assembly using one or more of the tools listed above.

Unit 2- Machine Tools
Machine Tools are an introduction to power tools and safety procedures associated with them. Students will learn how to use a table saw, band saw, drill press, jig saw, circular saw, reciprocating saw, lathe, and manual mill. The students will learn basic layout techniques and manufacture a part that includes 4 different ways to create a hole in order to fasten parts together.

Unit 3- Measurement Tools (Pneumatics)
Students will learn basic measurement techniques in both US customary units and metric units with rulers and measuring tape and be able to measure down to 1/64 of an inch or .55mm. They will learn how to convert between metric and US customary units. Students will then progress to precision measurement using calipers and micrometers which measure down to .001 mm or .0001 inch. These are basic skills that students will use throughout the rest of the course in order to create projects.

Unit 4- Computer Aided Design
Students will learn how to create 3D models using industry standard software. They will be able to 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 a solid model of common household items and export those items into a CNC machine and manufacture the parting using industry standard software.

Unit 5- Robotics
Students will learn robot safety and be able to manually control the robot with a teach pendant. Students will progress to basic robot programming where they teach the robot points and are able to move material from one point to another by programming the robot. Students will finish the station by interfacing the robot with other devices to unload an automatic machine through multiple input and output devices.

Unit 6- Pneumatics
Students will learn the safety rules associated with pneumatic power and how to hook up a pressure regulator, filter, and quick connect hoses and couplings. Students will learn how to transfer air pressure from one device to another using a 3-way directional control valve, 2 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.

Unit 7- Electrical Control Logic
Students will work in small groups with a hands-on-trainer to connect various electrical control logic elements including AND, OR, NOT, NOR, NAND, and MEMORY logic. An example of AND logic would be a circuit that will only function when button 1 AND button 2 are pressed. All of these logic elements work off the premise of an “if...then” statement. Students will then progress to more advanced systems such as pneumatic solenoids, timers, and relays. Pneumatic solenoids control movement of pistons; timers control how much time is delayed in between different functions, and relays switch the current from one device to another. Once students learn the different logic elements and the more advanced devices, they will learn how to draw electrical control schematics for those circuits. This unit leads students to a master project in which they must hook up a power supply, set up relays and limit switches, and hook up pneumatic solenoids in order to complete their culminating project.
**Unit 8- Culminating Project Design**

Students will work in teams to combine the knowledge they have learned throughout each unit to design and create an original product. Before design and building begins, students will have to do a research paper on their desired focus. During the production portion, students will design a report that focuses on the problems encountered, how each team member worked through each problem, the bill of materials that were used to build the project, and an explanation of why the final design was chosen. Students will be expected to give a detailed group presentation on their project.

**TEXTBOOKS AND RESOURCE MATERIALS:**

**Textbooks**

*Mastercam Software Handbook*
*Precision Machining Technology*; Hoffman, et al; 2012
*Operations Manual for Machine Tool Technology*; Oliver: 1982

*No student textbook is required*

**Resource Materials**

Teacher recommended resource materials

**CTE PATHWAY STANDARDS TO BE ADDRESSED:**

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.
   D1.1 Identify the variations in the product design and development process as it relates to the designing of a product, product line, system design, or service.
   D1.2 Apply and identify the various phases of the product design development process to an existing product, product line, system design, or service.

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.
   D2.1 Employ research methodologies, using primary research and electronic reference materials, to gather information relevant to the topic or area of opportunity.
   D2.2 Organize information to identify and define an area of opportunity, need, or problem that can be resolved through design.
   D2.3 Identify potential design areas (e.g., product, product line, system design, or service) that would address the need, problem, or opportunity.
   D2.4 Research and identify the user demographic for the product, product line, system design, or service (local, national, global market).

D3.0 Understand and apply various ideation techniques to develop ideas and concepts.
   D3.1 Apply ideation techniques to explore and produce multiple concepts.
   D3.2 Edit concepts and identify key idea(s) that solve the problem, fulfill a need, or address an opportunity.
   D3.3 Assess the environmental impact of the design solution and other sustainability issues and product life cycle considerations.
   D3.4 Synthesize information and experiment with nontraditional possibilities for innovative design solutions.

D4.0 Apply various two-dimensional (2-D) graphic and/or three-dimensional (3-D) modeling techniques to development concept.
   D4.1 Create a preliminary design of a product concept utilizing drawing, computer software (graphic or CAD), and/or conceptual model fabrication techniques.
D4.2 Identify materials, mechanisms, technologies, and other requirements (e.g., safety, manufacturing, sustainability) the concept may require.

D4.3 Analyze and assess the strengths and weaknesses in the design, function, ergonomics, features, and benefits and identify possible resolutions for improvement.

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

D5.1 Produce technical drawings and other specifications required for the prototyping or manufacturing of the product.

D5.2 Recognize the safety issues related to the reliability, functionality, and use of the product.

D5.3 Communicate and collaborate with fabricators, manufacturers, engineers, technologists, or other industry experts to review requirements and specifications and to validate the design.

D6.0 Produce a prototype of a product.

D6.1 Build a looks-like, works-like prototype of the model using the appropriate fabrication, manufacturing, or reproduction techniques or technologies.

D6.2 Assess the outcome of the prototype product and analyze any issues that need redesigning or refining related to function, construction, or other factors.

D6.3 Resolve and/or redesign issues with a prototype.

D7.0 Evaluate the prototype to determine if it meets the requirements and objectives.

D7.1 Create a performance criteria and a quality standard to measure and evaluate a prototype.

D7.2 Test the functionality and other features of the prototype against the performance criteria and quality standard and evaluate the results.

D7.3 Identify any redesigning or additional corrections required to improve the overall quality, look, and performance of the prototype model.

D8.0 Understand and apply basic business and entrepreneurial principles and identify potential markets and/or other business opportunities for distribution of the product.

D8.1 Apply research methodologies to identify potential investors or business opportunities to market the product.

D8.2 Create a marketing plan for the product that includes target consumer, price, product name, brand, and product positioning in the retail market.

D9.0 Produce a package design concept for a product or line of products.

D9.1 Understand physical packaging construction and materials used; e.g., chipboard, cardboard, PVC, plastic blisters, etc. as it relates to protecting the product, costs, and logistic requirements.

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

D10.1 Create a presentation of the design solution (e.g., product, product line, system design, or service) that effectively communicates its features and benefits.

DISTRICT ESLRS TO BE ADDRESSED:

- **Self-Directed Learners:** Students will utilize their knowledge of design and manufacturing to effectively complete learning goals and objectives. This will require students to apply multiple attempts to test and verify concepts through application.

- **Constructive Thinkers:** Design and product development will need to be accomplished with a group setting where communication and group accountability will be critical for success. Students will also learn how to effectively apply learned curriculum to real world applications; how best to research and request information, interpret, and display information correctly.

- **Effective Communicators:** Students will be expected to design original products, and students will provide information on designing and developing creative and efficient ways to develop products.

- **Collaborative Workers:** Using curriculum fundamentals of designing and manufacturing, students will collaboratively work in groups to design and develop original products; as a team
they will need to develop their own unique product. They will establish group responsibilities and processes to function effectively and develop within a timely manner.

- **Quality Producers/Performers:** Students will use knowledge from the course to safely and appropriately design and develop original products.

- **Responsible Citizens:** Students will develop and practice processes to develop products within their groups.