

# FOLSOM CORDOVA UNIFIED SCHOOL DISTRICT

## Honors Principles of Engineering

**Date:** March 2018

**Proposed Grade Level(s):** 10-12

**Grading:** A-F

**Course Length:** One Year/Term

**Subject Area:** Career Technical Education

**Credits:** 5.0 per semester

**CTE Sector / Pathway:** Engineering and Architecture/Engineering Technology

**Prerequisite(s):** Grade C or better in Integrated Math 1

**Intent to Pursue 'A-G' College Prep Status:** Yes

**A-G Course Identifier:** G: College-prepatory elective

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### **COURSE DESCRIPTION:**

Students in Honors Principles of Engineering explore a broad range of engineering topics, including mechanisms, energy and power, materials and structures, automation, statistics, and kinematics. Students investigate thermal energy and alternative energy applications and explore solar hydrogen systems. They use analysis of beam deflection as a context for learning about material properties and calculating the internal and external forces on an object. Students learn to control mechanical systems by investigating computer inputs and outputs and understanding hydraulic and pneumatic fluid power. Students design a projectile motion device to use as a basis for data collection, organization, and interpretation of results.

### **GENERAL GOALS:**

Students will acquire and demonstrate the following skills:

#### **Computational and Analytical Skills:**

- Sketch a free body diagram with more than one pair of forces
- Justify the validity of entries in a given decision matrix
- Solve for unknown variables in a combination circuit given other components
- Calculate the location of a shape's centroid
- Solve for the magnitude of a vector
- Solve for external and internal forces in a given truss
- Determine the modulus of elasticity and elastic limit from tensile test data
- Determine the yield, tensile, and ultimate strengths from tensile test data
- Analyze graphical data from beam deflection
- Use Kirchhoff's Law to calculate current, resistance, and voltage in a circuit
- Write programming code for a project involving a sequence or system of tasks
- Use a variety of methods for identifying and correcting bugs in a program code
- Calculate the unknown variable for a system that has been subject to a change of state using the gas laws
- Use Bayes' theorem to calculate the probability of an event based on past events
- Calculate the initial velocity of a projectile and the angle it is launched
- Determine an unknown quantity in a formula when most of the other variable values are provided and one value requires an additional calculation such as addition, unit conversion, or rearrangement of the formula

### Engineering Design Experience:

- Exhibit professional skills needed to successfully contribute to work in a team
- Determine how to proceed through possible alternate routes of a design process
- Improve a system design that converts electrical energy to mechanical energy
- Modify the design of a fuel cell project to increase the efficiency of the system
- Defend an insulation design considering the three modes of heat transfer
- Interpret data to make conclusions about insulation design effectiveness
- Justify material choice in the design of a solution
- Improve the efficiency of a solution by modifying hardware and software
- Justify the use of either a hydraulic or pneumatic system in a problem

### Tools and Software

- VEX Robotics platform
- Logger Pro- Data collection and analysis software
- ROBOTC- Robot programming language

### Professional Skills

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

## **DETAILED UNITS OF INSTRUCTION:**

### Unit 1: Energy and Power:

Students examine the mechanisms, energy sources, and alternative energy applications and gain an understanding of mechanisms through the application of theory-based calculations accompanied by lab experimentation. They will learn that as energy and power are transferred and transformed, losses to friction in the system will occur. Students determine that such losses affect the overall efficiency of the system and investigate thermal energy and alternative energy applications. Students explore and gain experiences relating to solar hydrogen systems and thermal energy transfer through materials.

### UNIT 2: Materials and Structures:

Students examine beam deflection and forces on truss structures, and they learn to identify forces acting on those structures and then gain the ability to calculate internal and external forces acting on those structures. The students learn about material properties, which lead them to appropriately identify material for a given task. The primary way students study material properties in this unit is through destructive and non-destructive material testing on various materials. Tensile testing is the major destructive test. Students research how machines perform these tests and use either a classroom machine or a simulation to further their understanding of these processes. This unit concludes with a design problem whereby students, working in teams, follow the design process to solve a design problem.

### UNIT 3: Control Systems:

Students learn how to control mechanical processes using computer software and hardware and how software communicates through a hardware interface with different inputs and outputs. They are introduced to both pneumatic and hydraulic power and explore the basic components of each system and how they are designed to manipulate components through work and power. Students apply what they have learned to a design problem

using the design process as their guide. They work in teams to solve a design problem that focuses on control systems and use the knowledge and understanding gained throughout the course to create a solution to the problem.

#### **UNIT 4: Statistics and Kinematics:**

Students use statistics to evaluate an experiment and begin a study of dynamics, specifically kinematics, and apply statistical skills to study free fall motion. They use theoretical and experimental data as a basis for learning statistical analysis by collecting, organizing, and interpreting the data, students build the skills needed to understand data results. They further use these new skills and knowledge to design a vehicle that will propel itself and address the problem of designing a machine to accurately launch an object a specified distance, while examining, measuring, and documenting projectile motion data.

#### **Honors Final Exam Details:**

EoC (End of Course) Assessment. EoCs serve as an indicator of a student's overall achievement in the course. PLTW's assessment and curriculum experts collaborate with PLTW pilot teachers and use industry best practices to develop and test EoC assessments. The assessment is timed, unless an authorization for more time is on record with an IEP/504.

### **TEXTBOOKS AND RESOURCE MATERIALS:**

#### **Textbook**

*There is no required textbook for this class*

#### **Resource Materials**

Students must have a computer that meets the PLTW hardware requirements and provides access to the course materials via the PLTW website ([www.pltw.org](http://www.pltw.org)), and their individual accounts. Student computers must be loaded with all the required software as specified by PLTW which may change as the curriculum is updated.

### **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 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 Engineering and Architecture 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 Engineering and Architecture 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 Engineering and Architecture 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 Engineering and Architecture 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 Engineering and Architecture 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 Engineering and Architecture anchor standards, pathway standards, and performance indicators in classroom, laboratory, and workplace settings.

### **CTE PATHWAY STANDARDS TO BE ADDRESSED:**

- B1.0 Communicate and interpret information clearly in industry-standard visual and written formats.
  - B1.1 Explain the classification and use of various components, symbols, abbreviations, and media common to technical drawings.
  - B1.2 Describe the current industry standards for illustration and layout.
  - B1.3 Draw flat layouts of a variety of objects by using the correct drafting tools, techniques, and media.
  - B1.4 Organize and complete an assembly drawing using information collected from detailed drawings.
  - B1.5 Create reports and data sheets for writing specifications.
- B2.0 Demonstrate the sketching process used in concept development.
  - B2.1 Understand the process of producing proportional two- and three-dimensional sketches and designs.
  - B2.2 Apply sketching techniques to a variety of architectural and engineering models.
  - B2.3 Present conceptual ideas, analysis, and design concepts using freehand graphic communication techniques.
- B3.0 Identify the fundamentals of the theory, measurement, control, and applications of electrical energy, including alternating and direct currents.
  - B3.1 Understand the characteristics of alternating current (AC) and how it is generated; the characteristics of the sine wave; and of AC, tuned, and resonant circuits; and the nature of the frequency spectrum.
  - B3.2 Analyze relationships between voltage, current, resistance, and power related to direct current (DC) circuits.
  - B3.3 Calculate, construct, measure, and interpret both AC and DC circuits.
  - B3.4 Understand how electrical control and protection devices are used in electrical systems.
  - B3.5 Calculate loads, currents, and circuit-operating parameters.
  - B3.6 Classify and use various electrical components, symbols, abbreviations, media, and standards of electrical drawings.
  - B3.7 Analyze, repair, or measure electrical and electronic systems, circuits, or components using appropriate electronic instruments.
  - B3.8 Predict the effects of circuit conditions on the basis of measurements and calculations of voltage, current, resistance, and power.
- B4.0 Understand the concepts of physics that are fundamental to engineering technology.
  - B4.1 Describe Newton's laws and how they affect and define the movement of objects.
  - B4.2 Explain how the laws of conservation of energy and momentum provide a way to predict and describe the movement of objects.
  - B4.3 Compare the effects and applications of heat transfer and thermal dynamic processes.
  - B4.4 Explore the fundamentals and properties of waveforms and how waveforms may be used to carry energy.
  - B4.5 Analyze how electric and magnetic phenomena are related and know common practical applications.
- B5.0 Understand how the principles of force, work, rate, power, energy, and resistance relate to mechanical, electrical, fluid, and thermal engineering systems.
  - B5.1 Differentiate between scalars and vectors.
  - B5.2 Solve problems by using the concept of vectoring to predict resultants.
  - B5.3 Compare and explore the six simple machines and their applications.

- B5.4 Evaluate how energy is transferred and predict the effects of resistance in mechanical, electrical, fluid, and thermal systems.
- B5.5 Formulate and solve problems by using the appropriate units applied in mechanical, electrical, fluid, and thermal engineering systems.
- B6.0 Employ the design process to solve analysis and design problems.
  - B6.1 Understand the steps in the design process.
  - B6.2 Determine what information and principles are relevant to a problem and its analysis.
  - B6.3 Choose between alternate solutions in solving a problem and be able to justify the choices made in determining a solution.
  - B6.4 Translate word problems into mathematical statements when appropriate.
  - B6.5 Demonstrate the process of developing multiple details, within design constraints, into a single solution.
  - B6.6 Construct a prototype from plans and test it.
  - B6.7 Evaluate and redesign a prototype on the basis of collected test data.
- B7.0 Understand industrial engineering processes, including the use of tools and equipment, methods of measurement, and quality assurance.
  - B7.1 Know the structure and processes of a quality assurance cycle.
  - B7.2 Describe the major manufacturing processes.
  - B7.3 Use tools, fasteners, and joining systems employed in selected engineering processes.
  - B7.4 Estimate and measure the size of objects in both Standard International and United States units.
  - B7.5 Apply appropriate geometric dimensioning and tolerancing (GD&T) practices.
  - B7.6 Calibrate precision measurement tools and instruments to measure objects.
- B8.0 Understand fundamental control system design and develop systems that complete preprogrammed tasks.
  - B8.1 Identify the elements and processes necessary to develop a controlled system that performs a task.
  - B8.2 Demonstrate the use of sensors for data collection and process correction in controlled systems.
  - B8.3 Perform tests, collect data, analyze relationships, and display data in a simulated or modeled system using appropriate tools and technology.
  - B8.4 Program a computing device to control systems or process.
  - B8.5 Use motors, solenoids, and similar devices as output mechanisms in controlled systems.
  - B8.6 Assemble input, processing, and output devices to create controlled systems capable of accurately completing a preprogrammed task.
- B9.0 Understand the fundamentals of systems and market influences on products as they are developed and released to production.
  - B9.1 Understand the process of product development.
  - B9.2 Understand decision matrices and the use of graphic tools in illustrating the development of a product and the processes involved.
- B10.0 Design and construct a culminating project effectively using engineering technology.
  - B10.1 Use methods and techniques for employing all engineering technology equipment appropriately.
  - B10.2 Apply conventional engineering technology processes and procedures accurately, appropriately, and safely.
  - B10.3 Apply the concepts of engineering technology to the tools, equipment, projects, and procedures of the Engineering Technology Pathway.
- B11.0 Understand the methods of creating both written and digital portfolios.
  - B11.1 Develop a binder or digital portfolio representative of student work for presentation.
  - B11.2 Give an effective oral presentation of a portfolio.

### **DISTRICT ESLRS TO BE ADDRESSED:**

- **Self-Directed Learners:** Students will utilize their knowledge of engineering concepts to effectively complete learning goals and objectives. This will require students to apply multiple attempts to test and verify concepts through application.
- **Constructive Thinkers:** Students will be expected to design original projects, and provide information on designing and developing creative and efficient ways to test their designs.



- **Effective Communicators:** Engineering projects will need to be accomplished in 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.
- **Collaborative Workers:** Using curriculum fundamentals, students will work collaboratively in groups to design and develop original projects; as a team they will need to develop their own unique project. They will establish group responsibilities and processes to function effectively and develop projects within a timely manner.
- **Quality Producers/Performers:** Students will use knowledge from the course to safely and appropriately design and develop original projects.
- **Responsible Citizens:** Students will develop and practice processes to develop projects within their groups.

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