Escondido Union High School District

Pre-Engineering & Design

EUHSD Board Approval Date: 2/13/18
The EUHSD Pre-Engineering & Design curriculum document identifies what students should be able to know by grade level in a comprehensive standards-based course of study. The curriculum document is updated annually based on student academic achievement data, research and best practices, and input from stakeholders. The EUHSD curriculum document contains the following documents and/or information:

A. Course Description
B. Course Guidelines/Requirements - graduation credit information, transcript information, adopted materials, adopted technology, assessment outline
C. Instructional Materials References
D. Scope and Sequence Map with Essential Standards outlined by Unit
E. References to key essential design and implementation documents

A comprehensive course of study and/or program is designed so that all students have access to the rigorous curriculum necessary to graduate high school demonstrating college and career readiness skills. Student-centered learning provides opportunity for collaboration, communication, and a robust learning environment and provides opportunities for all students to meet the goals of the district’s Instructional Focus at the time of this writing: “All students communicate their thinking, ideas and understanding by effectively using oral, written and/or non-verbal expression.” A key design consideration in the transition to the updated California State Standards is a focus on changes to pedagogy with an emphasis on ensuring students are engaged via relevant learning experiences.

A key design consideration in the transition to the new California State Standards is a focus on changes to pedagogy. The CA Learning Standards describe key instructional shifts, which guide classroom teaching and learning and provide a foundation of curriculum and instructional design based on student inquiry and a focus on rigorous literacy tasks. These instructional shifts are described on the California Department of Education’s website at the following URL: https://www.cde.ca.gov/Re/cc/

The curriculum document is aligned to the California Learning Standards and—more specifically—the Model Career Technical Education Standards, the CTE Knowledge and Performance Anchor Standards, and the Pathway Standards specific to this course of study. All CTE standards are located here: https://www.cde.ca.gov/ci/ct/sf/
**Pre-Engineering & Design Course Description**

The Pre-Engineering & Design course provides students a foundation in the Engineering and Architecture Pathway with an emphasis on engineering and design. Students engage in instructional experiences that integrate academic and technical preparation and emphasize career awareness, exploration, and exposure focused on employment in the fields of civil engineering, industrial engineering, and architecture. This course provides preparation in the design process, research and analysis, collaborative project-based workflow practices, effective communication methods, technical documentation, and a variety of other industry related concepts and skills. Specific technical practices include but are not limited to introductory technical sketching and drawing, measurement and statistics, dimension and tolerance design, advanced modeling, reverse engineering, visual analysis, functional and structural analysis, and product improvement by design. In addition to acquiring professional and technical skills, students also research and explore the positive and negative impacts of the industry on society and the environment and how specific challenges may be addressed through engineering and design application.

<table>
<thead>
<tr>
<th><strong>Course Requirements</strong></th>
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<tbody>
<tr>
<td><strong>Course Length:</strong> Year Long</td>
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<tr>
<td><strong>UC/CSU Requirement:</strong> Meets UC/CSU “g” requirements</td>
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<tr>
<td><strong>Course Number (Semester A):</strong> 4592</td>
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<tr>
<td><strong>Course Number (Semester B):</strong> 4593</td>
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<tr>
<td><strong>Credits (Semester A):</strong> 5 CTE or Elective</td>
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<tr>
<td><strong>Required Prerequisite(s):</strong> None</td>
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<td><strong>Industry Sector:</strong> Engineering and Architecture</td>
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<tr>
<td><strong>Board Approval Date (Curriculum):</strong> 2/13/18</td>
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<tr>
<td><strong>Core Instructional Material(s):</strong> Each unit of study requires a different set of Open Education Resources (OERs). There is no single core instructional book for this course.</td>
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<td><strong>Technology Resource(s):</strong> Students utilize a variety of technical equipment in the work/lab space including architectural drawing tools and machines, drafting worktables, computer workstations with content specific software, and additional equipment as called upon by the learning tasks.</td>
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<tr>
<td><strong>Meeting the Needs of ELs:</strong></td>
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<tr>
<td>• Our student information system is used by site leaders and instructors to acquire the language levels of EUHSD English Learners to ensure they are identified and their specific needs are met.</td>
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<tr>
<td>• Our approach to supporting English learners is based on the CA Department of Education (CDE) adopted language level proficiency descriptors and updated ELD Learning Standards. Visit the following website to learn more about those new descriptors and corresponding standards: <a href="http://www.cde.ca.gov/sp/el/er/documents/eldstdnspub14.pdf">http://www.cde.ca.gov/sp/el/er/documents/eldstdnspub14.pdf</a></td>
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<tr>
<td>• EUHSD uses the ELA-ELD Framework to inform pedagogical practices related to supporting English Learners. Visit the following URL to learn more about the new frameworks which describe in detail specific best practices used to support English Learners: <a href="http://www.cde.ca.gov/ci/rl/cf/documents/elaeldfwchapter11.pdf">http://www.cde.ca.gov/ci/rl/cf/documents/elaeldfwchapter11.pdf</a></td>
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<tr>
<td><strong>Instructional Resources:</strong></td>
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<tr>
<td>• Drafting textbook</td>
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<td>• Performance Rubrics</td>
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<td>• Product Examples</td>
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<td>• Digital and print images</td>
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<td>• Internet Research</td>
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<td>• CA Colleges Website</td>
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<tr>
<td>• Architectural tools including drawing tools, machines, drafting work tables, etc.</td>
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<tr>
<td>• Computer labs and industry-related websites and software</td>
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<tr>
<td>• Workstations</td>
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<tr>
<td>• A variety of industry-related hardware/tools</td>
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</table>


Scope and Sequence Guide

The Scope and Sequence Guide for this course is informed by the California Learning Standards and delineates the concepts and skills students are expected to acquire in order to meet College and Career Readiness expectations set for by the state and local board approved guidelines. Each unit of study is designed to build upon the previous unit and/or prerequisite coursework in support of student mastery of specific standards based skills. This Scope and Sequence document provides guidelines for instructors to ensure they have the necessary information related to content and pedagogy to guarantee students can meet the learning objectives of the course. The document is updated as needed based on input from all stakeholders to ensure it meets the needs of students.

All Career Technical Education coursework in the EUHSD is based on a series of state-adopted CTE standards which include the CTE Knowledge and Performance Anchor Standards, the California Standards for Career Ready Practice, and the CTE Model Curriculum Pathway Specific Standards. Not everyone standard and its related learning objective is included in the Scope and Sequence Guide since this document provides the essential focus standards and key learning objectives and the related assignments and assessments so teachers can exercise their best judgment and use formative assessment data to inform and guide their instruction. However, all of the CTE model Curriculum Pathway Standards are embedded in the student tasks throughout the course with specific standards emphasized in particular units-of-study. Please refer to the CTE Career Ready and Model Pathway Standards below.

The CTE Standards for Career Ready Practice and CTE Model Curriculum Pathway Specific Standards are integrated throughout the units and describe the fundamental knowledge and skills that a career ready student needs in order to prepare for transition to postsecondary education, career training, or the workforce. These standards are not exclusive to a career pathway, a CTE program of study, a particular discipline, or level of education. Standards for Career Ready Practice are taught and reinforced in all career exploration and preparation programs with increasingly higher levels of complexity and expectation as a student advances through a program of study.

<table>
<thead>
<tr>
<th>CTE Standards for Career Ready Practice</th>
<th>CTE Model Curriculum Pathway Specific Standards</th>
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<tbody>
<tr>
<td>1. Apply appropriate technical skills and academic knowledge.</td>
<td>1.0 Academics: Analyze and apply appropriate academic standards...</td>
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<tr>
<td>2. Communicate clearly, effectively, and with reason [both in writing and verbally].</td>
<td>2.0 Communications: Acquire and accurately use general academic and domain specific words...</td>
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<tr>
<td>3. Develop an education and career plan aligned with personal goals.</td>
<td>3.0 Career Planning and Management: Integrate multiple sources of information...</td>
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<tr>
<td>4. Apply technology to enhance productivity.</td>
<td>4.0 Technology: Use technology, including the Internet, to produce, publish, and update writing...</td>
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<tr>
<td>5. Utilize critical thinking to make sense of problems and persevere in solving them.</td>
<td>5.0 Problem Solving and Critical Thinking: Conduct short as well as more sustained research...</td>
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</table>
| 6. Practice personal health and understand financial literacy. | 6.0 Health and Safety: Determine the meaning of symbols, key words [related to health and safety...]
| 7. Act as a responsible citizen in the workplace and the community. | 7.0 Responsibility and Flexibility: Initiate and participate in a range of collaborative discussions... |
| 8. Model integrity, ethical leadership, and effective management. | 8.0 Ethics and Legal Responsibilities: Respond thoughtfully to diverse perspectives... |
| 9. Work productively in teams while integrating cultural and global competence. | 9.0 Leadership and Teamwork: Work with peers...[to] set clear goals,...establish individual roles... |
| 10. Demonstrate creativity and innovation. | 10.0Technical Knowledge and Skills: Use technology...to produce, publish, and update...products... |
| 11. Employ valid and reliable research strategies. | 11.0Demonstration and Application: Demonstrate and apply the knowledge and skills contained in the industry-sector anchor standards, pathway standards, and performance indicators... |
| 12. Understand the environmental, social, and economic impacts of decisions. | |
## Pre-Engineering & Design Scope and Sequence
### Unit 1 – Introduction and History of Engineering
#### Length: 3-4 Weeks

<table>
<thead>
<tr>
<th>Unit Description:</th>
<th>In Unit 1, students explore—through function and methodology—civil, structural, electrical, mechanical, manufacturing, cyber world, and 3D-prototyping. They learn how each branch of engineering has its own related field of math and order. Students analyze and create digital presentations regarding historic engineering accomplishments. They carefully explore the historical and societal impact on transportation, trade, economics, etc. Students also engage in research related to the engineering field by researching and exploring specific occupations within the field of their choice; they report their findings via a formal presentation that requires them to write and present their research verbally and via multimedia format.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus Architectural Design Pathway Standards:</td>
<td>A1.0 Understand how history shaped architecture and know significant events in the history of architectural design. A3.0 Understand the sketching processes used in concept development. A4.0 Understand the use of computer-aided drafting (CAD) in developing architectural designs.</td>
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<tr>
<td>Focus Engineering Technology Pathway Standards:</td>
<td>B1.0 Communicate and interpret information clearly in industry-standard visual and written formats. B2.0 Demonstrate the sketching process used in concept development.</td>
</tr>
<tr>
<td>Manufacturing and Product Development Knowledge and Performance Anchor Standards:</td>
<td>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 Manufacturing and 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 Manufacturing and Product</td>
</tr>
<tr>
<td>Key Learning Objectives and Tasks:</td>
<td>Students will…</td>
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<tr>
<td></td>
<td>• Understand many design processes that guide professionals in developing solutions to problems. • Identify design processes including brainstorming, defining a problem, researching, identifying requirements, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing, refining, making, and communicating results. • Design in teams using brainstorming techniques to generate large numbers of ideas in short time periods. • Understand the use of an engineer’s notebook to chronologically document all aspects of a design project. • Create sketches to quickly record, communicate, and investigate ideas. • Use pictorials and tonal shading techniques in combination to give sketched objects a realistic look. • Use isometric, oblique, perspective, and multi-view sketching to maintain an object’s visual proportions. • Produce multi-view projections as a method of communicating the shape and size of an object that is intended for manufacture. • Understand measurement systems were developed out of the need for standardization. • Apply dimensions to drawings to communicate size information. • Understand manufactured parts are often created in different countries, where dimensional values are often converted from one standard unit to another. • Understand that the amount of variation that can be measured depends on the precision of the measuring tool. • Present statistical analysis of measurements that can help to verify the quality of a design or process. • Use graphics to communicate patterns in recorded data.</td>
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<tr>
<td>Key Unit Assignments and Assessments:</td>
<td>• Students will demonstrate competency related to the sketching process by producing proportional sketches and designs including graphs as well as begin their notebooks and portfolio work. • Performance Task #1: Students perform research related to a specific famous engineer and at least one of his/her historical engineering works. Students will produce a text (2 pages) on a selected engineering topic and create a twenty-slide digital presentation, which they will present to an audience. • Performance Task #2: Sketch or trace a famous architectural work from scratch. Note: This presentation may not only use an imported model but, rather, a CAD generated model by the student. The produced hand-sketch and 3D CAD model will provide material for the students’ end-of-the-semester portfolios. • Performance Task #3: Safety select response assessment. Review of safe model building with X-acto knives and Glue guns. Students need to pass quiz to be allowed use of equipment. Students also complete general CTE and facility safety review &amp; quiz.</td>
</tr>
</tbody>
</table>
| Design sector workplace environment and community settings. (Direct alignment with SLS 9-10, 11-12.1) | Present three-dimensional forms derived from two-dimensional shapes.  
Understand the results of the design process are commonly displayed as a physical model.  
Develop models to communicate and evaluate possible solutions.  
Understand geometric and numeric constraints are used to define the shape and size of objects in Computer Aided Design (CAD) modeling systems.  
Use CAD modeling systems to quickly generate and annotate working drawings.  
Understand packaging not only protects a product, but also contributes to that product’s commercial success.  

Suggested End-of-Unit Reflection Task: Students begin the construction of a Coursework Portfolio that includes learning artifacts from this unit. For this unit, they write an informative presentation describing one major challenge engineering and design practice has solved as well as one current challenge such as overcrowding, water shortage, disease spread, etc. that may be solved or partially solved by practitioners in the industry. |
Focus Engineering Technology Pathway Standards:

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.
B5.0 Understand how the principles of force, work, rate, power, energy, and resistance relate to mechanical, electrical, fluid, and thermal engineering systems.
B5.4 Evaluate how energy is transferred and predict the effects of resistance in mechanical, electrical, fluid, and thermal 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.
B6.6 Construct a prototype from plans and test it.
B6.7 Evaluate and redesign a prototype on the basis of collected test data.

Manufacturing and Product Development Knowledge and Performance Anchor Standards:

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 Manufacturing and Product Design sector using critical and creative thinking, logical reasoning, analysis, inquiry, and problem-solving techniques. (Direct alignment with WS 11-12.7)

Key Learning Objectives and Tasks:

Students will…
- Present geometric shapes to describe the two or three-dimensional contours that characterize an object.
- Understand that properties of volume and surface area are common to all designed objects and provide useful information to the engineer.
- Use CAD systems to increase productivity and reduce design costs.
- Understand solid CAD models are the result of both additive and subtractive processes.
- Present working drawings that contain only the dimensions that are necessary to build and inspect an object.
- Understand object features require specialized dimensions and symbols to communicate technical information, such as size.
- Understand there is always a degree of variation between the actual manufactured object and its dimensioned drawing.
- Specify tolerances to indicate the amount of dimensional variation that may occur without adversely affecting an object’s function.
- Understand tolerances for mating part features are determined by the type of fit.
- Understand solid modeling programs allow the designer to create quality designs for production in far less time than traditional design methods.
- Use CAD models, assemblies, and animations to check for design problems, verify the functional qualities of a design, and communicate information to other professionals and clients.
- Understand auxiliary views allow the engineer to communicate information about an object’s inclined surfaces that appear foreshortened in basic multi-view drawings.
- Use sectional views to communicate an object’s interior features that may be difficult to visualize from the outside.

Key Unit Assignments and Assessments:

- Students present a variety of working drawings that contain only the specific dimensions necessary to build and inspect an object.
- **Performance Task #1:** Students build a balsa stick bridge trusses designed to hold the most weight. The bridge is tested in competition. After destructive testing, students generate a technical report and write formal reflections of the task and engineering learnings.
- **Performance Task #2:** Students work in groups or with a partner to discuss a real world-engineering problem. Brainstorm possible solutions and hypothesize the effects of implementation of a proposed solution. Communicate findings both orally and written form.
- **Performance Task #3:** Students design a facility improvement for the high school, including photovoltaics, new pedestrian bridges, and metal gate designs. Practice sketching and design skills, and use CAD software to prepare working drawings. Students also present their work and the accompanying rationale in writing.

Suggested End-of-Unit Reflection Task: Students continue the construction of a Coursework Portfolio that includes learning artifacts from this unit. They...
• Understand as individual objects are assembled together, their degrees of freedom are systematically removed.
• Create mathematical formulas to establish geometric and functional relationships within their designs.
• Produce a title block to provide the engineer and manufacturer with important information about an object and its creator.
• Understand parts list and balloons are used to identify individual components in an assembly drawing.
• Understand design solutions can be created as an individual or in teams.
• Understand engineers use design briefs to explain the problem, identify solution expectations, and establish project constraints.
• Understand that teamwork requires constant communication to achieve the goal at hand.
• Research to develop knowledge base, stimulate creative ideas, and make informed decisions.
• Use a design process to create solutions to existing problems.
• Use CAD modeling systems to quickly generate and annotate working drawings.
• Understand Fluid Power Concepts that could be used to enhance design solutions.

write an end-of-unit reflective informative/explanatory text in which they describe the key concepts and skills they have acquired related to the design process including how this process will be helpful throughout the remainder of the course and how principles related to it may be applied more broadly in their personal and academic work. They include this as an artifact in their Coursework Portfolio.
Pre-Engineering & Design Scope and Sequence
Unit 3 – Basic 2D Drawing – Introduction to CAD
Length: 3-4 Weeks

**Unit Description:** In Unit 3, students learn about the demands of technical drawings including the need for all elements to be drawn at a specific scale. They begin the process using engineer’s scales, paper and pencil. Students learn both the metric and imperial units-of-measurement and convert drawings accurately as well as produce drawings at specific scales. Students measure and calculate scale factors and use drafting instruments to approximate sizes on drawings for later input into CAD systems. Conversion between different measurement systems and calculation methods for application to land planning and architecture are also partly addressed.

<table>
<thead>
<tr>
<th>Focus Engineering and Architecture Anchor Standards:</th>
<th>Key Learning Objectives and Tasks:</th>
<th>Key Unit Assignments and Assessments:</th>
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</thead>
<tbody>
<tr>
<td><strong>Architectural Design Pathway Standards:</strong></td>
<td>Students will...</td>
<td>• Students measure machine parts and create accurate drawings in CAD based on real objects.</td>
</tr>
<tr>
<td>A6.0 Understand methods used to analyze simple structures.</td>
<td>• Understand visual design principles and elements constitute an aesthetic vocabulary that is used to describe any object independent of its formal title, structural, and functional qualities.</td>
<td>• Students progress to CAD and create drawings at full scale in CAD, and learn how to control printing options to print out drawings at specific scales such as 1” = 1'-0&quot;, or 1/8” = 1’0&quot;, or 1” = 100'.</td>
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<tr>
<td>A6.1 Understand load transfer mechanisms.</td>
<td>• Understand tangible design elements are manipulated according to conceptual design principles.</td>
<td><strong>Performance Task #1:</strong> Students will create drawings on paper with an engineer’s scale at a specified scale that is of a different view and different from a scale of a drawing that is provided to them. The object may be provided in a 3D view, and students will need to generate top, right, and left views. This will teach both drawing to scale through the use of measuring instruments as well as cultivate 3D conceptual ability and exercise reasoning ability. CAD functions include User Interface, Draw &amp; Modify commands, Measure and Scale commands, Text &amp; Dimensions entry; Properties, Technical Drawing; Geometry review and properties of solids. Area and Volume calculations exercise students’ application of known math to applied problems.</td>
</tr>
<tr>
<td>A6.3 Interpret structural design considerations, including load-bearing relationships of shear walls, columns, and beams.</td>
<td>• Understand aesthetic appeal results from the interplay between design principles and elements.</td>
<td><strong>Performance Task # 2:</strong> Presentation drawings: Students prepare Title Blocks format and edit text and size of graphics. Presentation drawings, one-point and two-point perspectives, client-ready drawings, for project progression.</td>
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<tr>
<td>A7.0 Understand the properties of structural materials.</td>
<td>• Understand a design’s visual characteristics, which are influenced by its structural and functional requirements.</td>
<td><strong>Performance Task #3:</strong> Raised-floor foundation detail with dimensions and text. Students create title block, add annotations to drawing, print to scale. --&gt;Alternate P.#2: Retaining wall detail and data table for re-bar specifications. Students calculate rebar requirements by reading a chart,</td>
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<tr>
<td>A7.1 Understand the integration of architectural factors, such as soil mechanics, foundation design, engineering materials, and structure design.</td>
<td>• Understand visual appeal influences a design’s commercial success.</td>
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<tr>
<td><strong>Engineering Design Pathway Standards:</strong></td>
<td>• Understand graphic designers are concerned with developing visual messages that make people in a target audience respond in a predictable and favorable manner.</td>
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<tr>
<td>C3.0 Understand the sketching process used in concept development.</td>
<td>• Examine that mechanisms use simple machines to move loads through the input of applied effort forces.</td>
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<tr>
<td>C3.1 Apply sketching techniques to a variety of architectural models.</td>
<td>• Perform reverse engineering on products to study their visual, functional, and structural qualities.</td>
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<tr>
<td>C3.2 Produce proportional two- and three-dimensional sketches and designs.</td>
<td>• Examine through observation and analysis, a product’s function can be divided into a sequence of operations.</td>
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<tr>
<td>C4.0 Understand measurement systems as they apply to engineering design.</td>
<td>• Understand products operate as systems, with identifiable inputs and outputs.</td>
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<tr>
<td>C4.1 Know how the various measurement systems are used in engineering drawings.</td>
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<tr>
<td>C4.2 Understand the degree of accuracy necessary for engineering design.</td>
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<tr>
<td>C5.0 Use proper projection techniques to develop orthographic drawings.</td>
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<tr>
<td>C5.1 Understand the concepts and procedures necessary for producing drawings.</td>
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<tr>
<td>C5.2</td>
<td>Develop multi-view drawings using the orthographic projection process.</td>
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<tr>
<td>C5.3</td>
<td>Understand the various techniques for viewing objects.</td>
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<tr>
<td>C5.4</td>
<td>Use the concepts of geometric construction in the development of design drawings.</td>
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<tr>
<td>C5.5</td>
<td>Apply pictorial drawings derived from orthographic multi-view drawings and sketches.</td>
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<tr>
<td>C8.0</td>
<td>Understand and apply proper dimensioning standards to drawings.</td>
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<tr>
<td>C8.1</td>
<td>Know a variety of drafting applications and understand the proper dimensioning standards for each.</td>
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<tr>
<td>C8.2</td>
<td>Apply dimension to various objects and features.</td>
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<tr>
<td>C10.0</td>
<td>Understand the methods of applying text to a drawing.</td>
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<tr>
<td>C10.1</td>
<td>Describe the processes of lettering and/or text editing.</td>
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<tr>
<td>C10.2</td>
<td>Implement standard methods of title block creation and use.</td>
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<tr>
<td>C10.3</td>
<td>Develop drawings using notes and specifications.</td>
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<tr>
<td>C10.4</td>
<td>Plan, prepare, and interpret drawings and models through traditional drafting or computer-aided design (CAD) techniques.</td>
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</table>

- Understand objects are held together by means of joinery, fasteners, or adhesives.
- Use measurement tools and techniques to accurately record an object’s geometry.
- Examine operational conditions, material properties, and manufacturing methods to help determine the material makeup of a design.
- Use reference sources and computer-aided design (CAD) systems to calculate the mass properties of designed objects.
- Analyze designs to identify shortcomings and opportunities for innovation.
- Work in design teams to generate large numbers of ideas in short time periods.
- Use decision matrices to help make design decisions that are based on analysis and logic.
- Write technical reports to explain project information to various audiences.

- Performance Task #4: Machine & Mechanical Parts drawings in title blocks. Students exercise geometric perception and hand drafting and CAD commands while producing drawings for machine parts with actual dimensions and text annotation.

**Suggested End-of-Unit Reflection Task:** Students continue the construction of their Coursework Portfolio that includes learning artifacts from this unit. They write an end-of-unit reflective informative/explanatory text in which they describe the key concepts and skills they have acquired. After this unit, they add an argumentative piece in which they argue what practices in the unit they found to be most important to their work in the design/engineering process along with evidence to support their claim.
Pre-Engineering & Design Scope and Sequence
Unit 4 – Basic 3D CAD
Length: 3-4 Weeks

Unit Description: In Unit 4, students draw objects in 3D in CAD, including editing in the X, Y & Z planes. Students use defined dimensions and create scaled drawings using simple geometric forms including the following: box, sphere, pyramid, cylinder, torus, and wedge. They also practice subtracting solids from each other for simple and quick 3D prototyping. Students review geometry concepts and prepare volume calculations. Students use a variety of CAD commands to complete virtual 3D models of objects, which may be printed to paper in a title block and/or printed using a 3D printer for prototyping purposes.

Focus Engineering Design Pathway Standards:
C4.0 Understand measurement systems as they apply to engineering design.
C4.1 Know how the various measurement systems are used in engineering drawings.
C5.0 Use proper projection techniques to develop orthographic drawings.
C5.1 Understand the concepts and procedures necessary for producing drawings.
C5.2 Develop multi-view drawings using the orthographic projection process.
C5.3 Understand the various techniques for viewing objects.
C5.4 Use the concepts of geometric construction in the development of design drawings.
C5.5 Apply pictorial drawings derived from orthographic multi-view drawings and sketches.
C10.4 Plan, prepare, and interpret drawings and models through traditional drafting or computer-aided design (CAD) techniques.

Key Learning Objectives and Tasks:
Students will…
- Understand the material of a product, how the material is prepared for use, its durability, and ease of recycling all impact a product’s design, marketability, and life expectancy.
- Understand all products made, regardless of material type, may have both positive and negative impacts.
- Understand in addition to economics and resources, manufacturers must consider human and global impacts of various manufacturing process options.
- Understand laws and guidelines to protect humans and the global environment.
- Investigate the recyclable uses of materials, which play a vital role in the future of landfills and the environment.
- Establish group norms through brainstorming and consensus to regulate proper and acceptable behavior by and between team members.
- Develop charts to plan, manage, and control a design team’s actions on projects that have definite beginning and end dates.
- Understand virtual teams rely on communications other than face-to-face contact to work effectively to solve problems.
- Understand each team member’s strengths are a support mechanism for the other team members’ weaknesses.
- Understand conflict between team members is a normal occurrence, and can be addressed using formal conflict resolution strategies.

Key Unit Assignments and Assessments:
- Students research and analyze examples of how materials are used in a variety of engineered products and how they have positive and negative impacts on the design of the product as well as beyond the product (environment, etc.).
- Students design and plan team-based collaborative approaches to the design and engineering practice.
- Students develop charts to plan, manage, and control a design team’s actions.
- Performance Task: Create a 3D object in CAD of your choice. Prepare multiple views of object. Front, top, left side, right side, perspective view. Title blocks, layouts, print, and 3D prototype.

Suggested End-of-Unit Reflection Task: Students continue the construction of their Coursework Portfolio that includes learning artifacts from this unit. They write an end-of-unit explanatory text, which describes why the use of CAD is vital to the work of an engineer in today’s world. They also include a brief summary of research regarding how technology has changed the industry.
Pre-Engineering & Design Scope and Sequence  
Unit 5 – Materials  
Length: 3-4 Weeks

**Unit Description:** In Unit 5, students will explore many different materials and their properties. Students perform comparative analysis on materials, and use logic and calculation to compare and contrast material properties. Students explore and define density, elasticity, brittleness, hardness, alloy composition, strength, and ductility. Properties of common building materials are reviewed and explained why they are used for their purpose. Students perform research with density tables, computation of volume and weight related to density and with summation. Students calculate theoretical weight for known element densities and volumes.

<table>
<thead>
<tr>
<th>Focus Architectural Design Pathway Standards:</th>
<th>Key Learning Objectives and Tasks:</th>
<th>Key Unit Assignments and Assessments:</th>
</tr>
</thead>
</table>
| A7.0 Understand the properties of structural materials.  
A7.1 Understand the integration of architectural factors, such as soil mechanics, foundation design, engineering materials, and structure design.  
A7.2 Develop a stress analysis chart of typical structural components.  
A7.3 Evaluate available building materials (e.g., steel, concrete, and wood) by considering their properties and their effect on building form. | Students will…  
- Explore and understand the various properties of specific structural materials.  
- Perform comparative analyses on materials.  
- Calculate to compare and contrast material properties.  
- Define and research density, elasticity, brittleness, hardness, alloy composition, strength, and ductility.  
- Explore the various properties of common building material.  
- Perform research using specific tools and information including density tables, volume computation and weight.  
- Calculate theoretical weights for known element densities and volumes. | Students develop a stress analysis chart related to specific structural materials and components; they relate the learning back to their bridge creation task.  
**Performance Task:** Students research various engineering materials and apply their findings to answer questions about materials and their properties. They present their findings by creating a digital slide presentation focusing on one specific material. Use a density chart to answer questions and prepare calculations that solve for missing variables like volume and mass. |
# Pre-Engineering & Design Scope and Sequence

## Unit 6 – Forces

**Length:** 3-4 Weeks

### Unit Description:
In Unit 6, students review and research concepts of physics and Newton’s Laws in order to review, build, and maintain the conceptual foundations that underlay the best practices in the industry. They research, explore and illustrate practical applications of engineering and real-world structures related to the following key concepts: gravity, tension and compression, truss design, seismic design, lateral resistance, structural design, foundation planning, framing planning, load-transfer details, and engineering member sizing.

### Focus Environmental Engineering Pathway Standards:
- A1.0 Understand how history shaped architecture and know significant events in the history of architectural design.
- D5.0 Understand how the principles of force, work, rate, power, energy, and resistance relate to mechanical, electrical, fluid, and thermal engineering systems.
- D5.3 Understand scalars and vectors.
- D5.4 Solve problems by using the concept of vectoring to predict the resultant forces.
- D5.5 Solve problems by using the appropriate units applied in mechanical, electrical, fluid, and thermal engineering systems.

### Key Learning Objectives and Tasks:
**Students will...**
- Describe in practical terms a variety of physics related engineering concepts including force, work, rate, power, energy, and resistance relating to mechanical, electrical, fluid, and thermal engineering systems.
- Research and illustrate practical applications of gravity, tension and compression, truss design, seismic design, lateral resistance, structural design, foundation planning, framing planning, load-transfer details, and member sizing.

### Key Unit Assignments and Assessments:
- Research and explain—both verbally, in writing and via illustrative demonstrations— how various physical theories and concepts relate in practical ways to engineering.
- **Performance Task #1:** Students prepare specifications for shear walls on a two-story house using prescriptive CA Residential Building Code standards and 2013 California Building Code.
- **Performance Task #2:** Students design and calculate forces and identification of vectors related to truss design. The analysis of tension and compression as elements of truss design provide foundational math and algebra review. Summation of vectors and vector diagram production illustrates conceptual understanding.
- **Performance Task #3:** Build trusses with balsa sticks and hot glue. Hands on drawing of truss, and construction from drawings. Extension and cross-reference to units’ forces on balsa bridge design.

### Suggested End-of-Unit Reflection Task:
Students research and explain—both verbally, in writing and via illustrative demonstrations— how various physical theories and concepts relate in practical ways to engineering. They cite evidence from PT’s 1-3 to support their claims. They include this as an artifact in their Coursework Portfolio.
### Pre-Engineering & Design Scope and Sequence

**Unit 7 – Use of Simple Machines**

**Length:** 3-4 Weeks

<table>
<thead>
<tr>
<th>Unit Description:</th>
<th>In Unit 7, students are introduced to each of the following simple machines: wedge, pulley, screw, lever, wheel and axle, inclined plane. They research and create verbal, written and illustrative/computational explanations of mechanical advantages and examples of these machines in real world applications. Students explore practical applications of simple machines in everyday life and how work can be made easier with machines. They also research historical societal impacts and inquiry into the nature of each invention.</th>
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<tbody>
<tr>
<td>Focus Engineering Design Pathway Standards:</td>
<td>Key Learning Objectives and Tasks:</td>
</tr>
<tr>
<td>C4.0 Understand measurement systems as they apply to engineering design.</td>
<td>Students will…</td>
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<tr>
<td>C4.1 Know how the various measurement systems are used in engineering drawings.</td>
<td>• Understand and describe the various kinds of simple machines.</td>
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<tr>
<td>C4.2 Understand the degree of accuracy necessary for engineering design.</td>
<td>• Research and create verbal, written and computational explanations of the mechanical advantages of simple machines.</td>
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<tr>
<td>C5.1 Understand the concepts and procedures necessary for producing drawings.</td>
<td>• Describe and illustrate real world, practical applications of simple machines in engineering related tasks.</td>
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<td>• Understand and describe the historical impacts of these machines.</td>
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<td>Key Unit Assignments and Assessments:</td>
<td>Suggested End-of-Unit Reflection Task: Students create an informative/explanatory written and verbal presentation in which they use the models of simple machines they have generated in 3D CAD, etc. to explain the key principles to an audience of young learners. They present their presentation live or via digital means to the audience and field questions as possible. They include this as an artifact in their Coursework Portfolio.</td>
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<tr>
<td>• Performance Task # 1: Research simple machines and answer a variety of questions related to each simple machine to demonstrate a clear understanding of the mechanical advantage first conceptually, then mathematically.</td>
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<tr>
<td>• Performance Task # 2: Create models of simple machines in 3D CAD. 3D prototyping simple machines with 3D printer or CNC Router. Generating drawings of all six machines, and oral presentations about the machines.</td>
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</table>
# Pre-Engineering & Design Scope and Sequence

## Unit 8 – Aeronautics and Aerospace

**Length:** 3-4 Weeks

**Unit Description:** In Unit 8, students explore the history of flight and space travel and experience a thorough hands-on exploration of flight with a focus on the relationship of thrust and lift. They research and explore concepts and practical elements of flight using paper airplanes, model airplanes with propellers driven by rubber bands, and rockets. Students will use CAD to create and explore drawings of a lunar model, spaceship, or airplane of their own design.

### Focus Architectural Design Pathway Standards:
- A3.2 Produce proportional two- and three-dimensional sketches and designs.
- A3.3 Present conceptual ideas, analysis, and design concepts using freehand graphic communication techniques.

### Engineering Technology Pathway Standards:
- B1.0 Communicate and interpret information clearly in industry-standard visual and written formats.
- B1.4 Organize and complete an assembly drawing using information collected from detailed drawings.
- B4.0 Understand the concepts of physics that are fundamental to engineering technology.
- B6.0 Employ the design process to solve analysis and design problems.
- B6.3 Choose between alternate solutions in solving a problem and be able to justify the choices made in determining a solution.
- B6.6 Construct a prototype from plans and test it.
- B10.0 Design and construct a culminating project effectively using engineering technology.

### Engineering Design Pathway Standards:
- C5.3 Understand the various techniques for viewing objects.

### Key Learning Objectives and Tasks:

**Students will…**
- Understand and describe the fundamental elements of flight and space travel from the perspective of an engineer.
- Create and explore the fundamental concepts and elements of flight by creating and using various airplanes made from various materials including paper and simple machines.
- Create and explore digital models using CAD.
- Design and create a 3D model in using a 3D printer.

### Key Unit Assignments and Assessments:
- **Performance Task # 1:** Students create model airplanes from kits, and compete in flight events. Students can measure data and performance. Engineering Design Method of review of prototype and refining design.
- **Performance Task # 2:** Paper airplanes: students explore effects of flaps and fins, take data, and make diagrams. Prototyping Airplanes and summarizing the effects of flanges and flaps and fins.
- **Performance Task # 3:** Students will use CAD to create and explore drawings of a lunar model, spaceship, or airplane of their own design. Requirements include geometric solids in three dimensions’ challenge conceptual locations and coordination of specifications. 3D prototyping of designs with Maker Z18 3D printer available for students, at a rate of one per class per day. Designs shall have instructor approved sufficient integrity for stability prior to 3D printing or CNC milling.

### Suggested End-of-Unit Reflection Task:
Students present their 3D models to an audience with an accompanying informative/explanatory brochure describing its function as well as the creative processes used to design and manufacture it. They include this in their Coursework Portfolio.
Pre-Engineering & Design Scope and Sequence
Unit 9 – Career Exploration Extension and Course Conclusion
Length: 4-5 Weeks

Unit Description: In Unit 9, students will learn and practice career skills to prepare them for the workplace. As a part of a course summation, students prepare documents to apply for a job such as a resume, cover letter, and job application portfolio. They also research and practice interview skills, common workplace habits, and professional behavior. Students also learn more about safety protocols, workplace politics, and sexual harassment laws. Students perform industry research and explore trends and outlooks in the field of engineering.

Focus Unit Standards:

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.
- 3.1 Identify personal interests, aptitudes, information, and skills necessary for informed career decision making.
- 3.2 Evaluate personal character traits such as trust, respect, and responsibility and understand the impact they can have on career success.
- 3.3 Explore how information and communication technologies are used in career planning and decision-making.
- 3.4 Research the scope of career opportunities available and the requirements for education, training, certification, and licensure.
- 3.5 Integrate changing employment trends, societal needs, and economic conditions into career planning.
- 3.6 Recognize the role and function of professional organizations, industry associations, and organized labor in a productive society.
- 3.7 Recognize the importance of small business in the California and global economies.
- 3.8 Understand how digital media are used by potential employers and postsecondary agencies to evaluate candidates.
- 3.9 Develop a career plan that reflects career interests, pathways, and postsecondary options.

Key Learning Objectives and Tasks:

Students will...
- Create a business plan utilizing industry standards.
- Create a resume and cover letter showcasing experiencing in the Pre-Engineering & Design course as well as throughout their experience in the Engineering Design Pathway.
- Utilize grade level appropriate written and oral communication skills.
- Conduct research, analyzing primary source documents, synthesizing documents, and highlighting key ideas and details.
- Examine a variety of charts and graphs.
- Use rubrics to evaluate their own and others’ presentations and performance tasks based on success criteria.

Key Unit Assignments and Assessments:

- Performance Task #1: Students create a resume, cover letter, organize, and present their completed engineering portfolio (see PT #2). Students use templates and model prior examples as structural content to inform prospective employers of the concepts and skills they have mastered.
- Performance Task #2: Ongoing portfolio creation using best work from the year. Students keep a digital and hard copy for use in a summative document for interview examples of work.
- Performance Task #3: Prepare students how to react to interview questions, students review common interview questions, and oral communication techniques. Students practice proper presenting of one’s self to an employer and client and co-worker, to create a harmonious and prosperous future for all, through success in business that translates to prosperity.
- Performance Task #4: Review, finalize and present personal Coursework Portfolio of learning artifacts including end-of-unit reflections/work products as well as physical creations/products. Prepare the portfolio for use in mock job search based on actual job postings on the Internet. Present Coursework Portfolio for final evaluation and presentation of learning based on PT’s 1-3. Students are assessed on the following elements:
  - Presentation skills
  - Personal Written Reflections
  - Career Exploration Text/Essay
  - Product Development
  - Industry Feedback Form