EL DORADO UNION HIGH SCHOOL DISTRICT

EDUCATIONAL SERVICES

Course of Study Information Page

COURSE TITLE **Introduction to Engineering Design (IED)**	
DISTRICT COURSE NUMBER **#0535**	4-DIGIT STATE COURSE CODE (COMPLETED BY SILT) **5573**
Rationale:	The Project Lead the Way (PLTW) Pathway to Engineering program is a sequence of courses which follows a proven hands-on, real-world, problem-solving approach to learning. The program is designed to prepare students to pursue a post-secondary education and careers in Science, Technology, English & Math (STEM)-related fields.
Course Description that will be in the Course Directory:	The major focus of IED is the design process and its application. Through hands-on projects, students apply engineering standards and document their work. Students use industry standard 3D modeling software to help them design solutions to solve proposed problems, documents their work using an engineer's notebook, and communicate solutions to peers and members of the professional community.
How Does this Course align with or meet State and District content standards?	
NCLB Core Subjects:	*Select up to two that apply:* ☐ Arts ☐ Economics ☐ English ☐ Foreign Language ☐ Geography ☐ Civics and Government ☐ History ☐ Mathematics ☐ Reading / Language Arts ☐ Science ☒ Not Core Subject
CDE CALPADS Course Descriptors: (See Page 2 for Definitions)	CTE TECH PREP COURSE INDICATORS: ☐ Tech Prep (32) (Higher Ed) ☐ Tech Prep & ROP(33) (Higher Ed) ☐ ROP (30) ☒ N/A CTE COURSE CONTENT CODE: ☒ CTE Introductory (01) ☐ CTE Concentrator (02) ☐ CTE Completer (03) ☐ Voc Subject _____ ☐ N/A INSTRUCTIONAL LEVEL CODE: ☐ Remedial (35) ☐ Honors UC-Certified (39) ☐ Honors Non UC-Certified (34) ☐ College (40) ☒ N/A
Length of Course:	☒ Year ☐ Semester
Grade Level(s):	☒ 9 ☒ 10 ☐ 11 ☐ 12
Credit:	☒ Number of credits: **10** ☐ Meets graduation requirements (subject _____) ☒ Request for UC "a–g" requirements CSU/UC requirement **G** ☒ College Prep
Prerequisites:	None
Department(s):	Non-Department
District Sites:	UMHS
Board of Trustees COS Adoption Date:	
Textbooks / Instructional Materials:	

Funding Source:	
Board of Trustees Textbook Adoption Date:	

Definitions

CALPADS	California Longitudinal Pupil Achievement Data System
CTE Technical Prep	A course within a CTE technical career pathway or program that has been articulated with a postsecondary education or through an apprenticeship program of at least 2 years following secondary instruction.
Instructional Level Code	Represents a nonstandard instructional level at which the content of a specific course is either above or below a 'standard' course instructional level. These levels may be identified by the actual level of instruction or identified by equating the course content and level of instruction with a state or nationally recognized advanced course of study, such as IB or AP.
Instructional Level Honors, UC Certified	Includes all AP courses.
Instructional Level Honors, non UC Certified	Requires Board approval.
Instructional Level College	Includes ACE courses. Equivalent to college course and content, but not an AP course. Not related to section, but to course.

PLTW | Engineering

Introduction to Engineering

Course Outline

PROJECT LEAD THE WAY
PLTW

PLTW Engineering

Introduction to Engineering Design

Engineers make a world of difference!

Students are introduced to the engineering design process, applying math, science, and engineering standards to identify and design solutions to a variety of real problems. They work both individually and in collaborative teams to develop and document design solutions using engineering notebooks and 3D modeling software.

Are you ready to design the future?

Introduction to Engineering Design (IED) is a high school level foundation course in the PLTW Engineering Program. In IED students are introduced to the engineering profession and a common approach to the solution of engineering problems, an engineering design process. Utilizing the activity-project-problem-based (APB) teaching and learning pedagogy, students will progress from completing structured activities to solving open-ended projects and problems that require them to develop planning, documentation, communication, and other professional skills.

Through both individual and collaborative team activities, projects, and problems, students will solve problems as they practice common engineering design and development protocols such as project management and peer review. Students will develop skill in technical representation and documentation of design solutions according to accepted technical standards, and they will use current 3D design and modeling software to represent and communicate solutions. In addition the development of computational methods that are commonly used in engineering problem solving, including statistical analysis and mathematical modeling, are emphasized. Ethical issues related to professional practice and product development are also presented.

The following is a summary of the units of study that are included in the course for the 2014-2015 academic year. Alignment with NGSS, Common Core, and other standards will be available through the PLTW Alignment web-based tool. Activities, projects, and problems are provided to the teacher through the PLTW Learning Management System in the form of student-ready handouts, teacher notes, lesson planning resources, and supplementary materials.

The course requires a rigorous pace, and it is likely to contain more material than a skilled teacher new to the course will be able to complete in the first iteration. Building enthusiasm for and a real understanding of role, impact, and practice of engineering is a primary goal of the course.

IED Unit Summary

Unit 1..................Design Process
Unit 2..................Technical Sketching and Drawing
Unit 3..................Modeling Skills
Unit 4..................Measurement and Statistics
Unit 5..................Geometry of Design
Unit 6..................Reverse Engineering
Unit 7..................Documentation
Unit 8..................Advanced Computer Modeling
Unit 9..................Design Team
Unit 10................Design Challenges

Unit 1: Design Process

The goal of Unit 1 is to introduce students to the broad field of engineering and a design process that engineers use to develop innovative solutions to real problems. Students become familiar with the traditional big four disciplines of engineering and the extensive array of career opportunities and engineering problems addressed within each discipline. A design process is presented as a structured method for approaching and developing solutions to a problem. The art and skill of brainstorming is emphasized as students begin to develop skill in graphically representing ideas through concept sketching.

Unit 2: Technical Sketching and Drawing

The goal of Unit 2 is for students to develop an understanding of the purpose and practice of visual representations and communication within engineering in the form of technical sketching and drawing. Students build skill and gain experience in representing three-dimensional objects in two dimensions. Students will create various technical representations used in visualization, exploring, communicating, and documenting design ideas throughout the design process, and they will understand the appropriate use of specific drawing views (including isometric, oblique, perspective, and orthographic projections). They progress from creating free hand technical sketches using a pencil and paper to developing engineering drawings according to accepted standards and practices that allow for universal interpretation of their design.

Unit 3: Measurement and Statistics

The goal of Unit 3 is for students to become familiar with appropriate practices and the applications of measurement (using both U. S. Customary and SI units) and statistics within the discipline of engineering. Students will learn appropriate methods of making and recording measurements, including the use of dial calipers, as they come to understand the ideas of precision and accuracy of measurement and their implications on engineering design. The concepts of descriptive and inferential statistics are introduced as methods to mathematically represent information and data and are applied in the design process to improve product design, assess design solutions, and justify design decisions. Students are also provided with practice in unit conversion and the use of measurement units as an aid in solving practical problems involving quantities. A spreadsheet program is used to store, manipulate, represent, and analyze data, thereby enhancing and extending student application of these statistical concepts.

Unit 4: Modeling Skills

This unit introduces students to a variety of modeling methods and formats used to represent systems, components, processes, and other designs. Students are provided experience in interpreting and creating multiple forms of models common to engineering as they apply the design process to create a design solution. Students create graphical models of design ideas using sketches and engineering drawings and create graphs and charts to represent quantitative data. In this unit students are introduced to three-dimensional computer modeling. They learn to represent simple objects in a virtual 3D environment that allows for realistic interactions and animation. The modeling software is also used to provide an efficient method of creating technical documentation of objects. Students are provided the opportunity to create a physical model of a design solution to be used for testing purposes. Mathematical modeling is introduced, and students learn to find mathematical representations (in the form of linear functions) to represent relationships discovered during the testing phase of the design process.

Unit 5: Geometry of Design

In this unit students are provided opportunities to apply two- and three-dimensional geometric concepts and knowledge to problem solving and engineering design. Fluency in these geometric concepts is essential in every phase of the design process as problems are defined, potential solutions are generated to meet physical constraints, alternate design solutions are compared and selected, final designs are documented, and specifications are developed. Geometric concepts are also important in the appropriate application of geometric and dimensional relationships and constraints for effective use of three-dimensional computer modeling environments that employ parametric design functionality. In this unit students use geometric concepts and physical properties to solve a wide variety of problems, progressing from computations of surface area, weight, or volume in order to provide cost estimates to the identification of materials based on physical property observations. Students will also use 3D computer models to compute physical properties that can be used in problem solving and creation of design solutions.

Unit 6: Reverse Engineering

Unit 6 exposes students to the application of engineering principles and practices to reverse engineer a consumer product. Reverse engineering involves disassembling and analyzing a product or system in order to understand and document the visual, functional, and/or structural aspects of its design. In this unit students will have the opportunity to assess all three aspects of a product's design. Students will learn the visual design elements and principles and their application in design. They will perform a functional analysis to hypothesize the overall function and sequential operations of the product's component parts and assess the inputs and outputs of the process(es) involved in the operation of the product. Students will physically disassemble the product to document the constituent parts, their properties, and their interaction and operation. After carefully documenting these aspects of the visual, functional, and structural aspects of the product, students will assess the strengths and weaknesses of the product and the manufacturing process by which it was produced.

Unit 7: Documentation

In unit 7 students will enhance their basic knowledge of technical drawing representations learned earlier in the course to include the creation of alternate (section and auxiliary) views and appropriate dimensioning and annotation of technical drawings. Students will also be introduced to the reality of variation in dimensional properties of manufactured products. They will learn the appropriate use of dimensional tolerances and alternate dimensioning methods to specify acceptable ranges of the physical properties in order to meet design criteria. Students will apply this knowledge to create engineering working drawings that document measurements collected during a reverse engineering process. These skills will also allow students to effectively document a proposed new design. Students will use 3D computer modeling software to model the assembly of the consumer product, as such a model can be used to replicate functional operation and provide virtual testing of product design.

Unit 8: Advanced Computer Modeling

In this unit students will learn advanced 3D computer modeling skills. These advanced skills include creating exploded and animated assembly views of multi-part products. Students will learn to use mathematical functions to represent relationships in dimensional properties of a modeled object within the 3D environment. Students will develop and apply mathematical relationships to enforce appropriate dimensional and motion constraints. Students will reverse engineer and model a consumer product, providing appropriate parametric constraints to create a 3D model and realistic operation of the product.

Unit 9: Design Team

In this unit students will work as a collaborative team with geographically separate team members, thereby requiring virtual communications. Through the design process, the team will experience shared decision-making as they work to solve a new design challenge. They will reflect on the ethical responsibilities of engineers as they investigate different materials, manufacturing processes, and the short and long term impacts that their decision-making may potentially have on society or on the world.

Unit 10: Design Challenges

In this unit students will work in small collaborative teams, implement the design process, and use skill and knowledge gained during the course to solve a culminating design challenge and document and communicate their proposed solution.

IED Detailed Outline

Unit 1 Design Process
Time Days: 16 days

Understandings	Knowledge and Skills
An engineering design process involves a characteristic set of practices and steps.	• Identify and define the terminology used in engineering design and development. • Identify the steps in an engineering design process and summarize the activities involved in each step of the process. • Complete a design project utilizing all steps of a design process, and find a solution that meets specific design requirements.
Research derived from a variety of sources (including subject matter experts) is used to facilitate effective development and evaluation of a design problem and a successful solution to the problem.	• Utilize research tools and resources (such as the Internet; media centers; market research; professional journals; printed, electronic, and multimedia resources; etc.) to gather and interpret information to develop an effective design brief.
A problem and the requirements for a successful solution to the problem should be clearly communicated and justified.	• Define and justify a design problem, and express the concerns, needs, and desires of the primary stakeholders. • Present and justify design specifications, and clearly explain the criteria and constraints associated with a successful design solution. • Write a design brief to communicate the problem, problem constraints, and solution criteria.
Brainstorming may take many forms and is used to generate a large number of innovative, creative ideas in a short time.	• Generate and document multiple ideas or solution paths to a problem through brainstorming.
A solution path is selected and justified by evaluating and comparing competing design solutions based on jointly developed and agreed-upon design criteria and constraints.	• Clearly justify and validate a selected solution path.
Physical models are created to represent and evaluate possible solutions using prototyping technique(s) chosen based on the presentation and/or testing requirements of a potential solution.	• Construct a testable prototype of a problem solution.
Problem solutions are optimized through	• Describe the design process used in the solution of a particular problem and reflect on all steps of the design process.

evaluation and reflection and should be clearly communicated.	• Justify and validate a problem solution. • Identify limitations in the design process and the problem solution and recommend possible improvements or caveats.
The scientific method guides the testing and evaluation of prototypes of a problem solution.	• Analyze the performance of a design during testing and judge the solution as viable or non-viable with respect to meeting the design requirements.
Geometric shapes and forms are described and differentiated by their characteristic features.	• Explain the concept of proportion and how it relates to freehand sketching.
Hand sketching of multiple representations to fully and accurately detail simple objects or parts of objects is a technique used to convey visual and technical information about an object.	• Generate non-technical concept sketches to represent objects or convey design ideas.
Technical professionals clearly and accurately document and report their work using technical writing practice in multiple forms.	• Organize and express thoughts and information in a clear and concise manner. • Adjust voice and writing style to align with audience and purpose. • Support design ideas using a variety of convincing evidence. • Utilize an engineering notebook to clearly and accurately document the design process according to accepted standards and protocols to prove the origin and chronology of a design. • Document information sources using appropriate formats.
Specific oral communication techniques are used to effectively convey information and communicate with an audience.	• Deliver organized oral presentations of work tailored to the audience. • Establish objectives for the presentation that are appropriate for the audience. • Facilitate engaging and purposeful dialog with the audience.
Sketches, drawings, and images are used to record and convey specific types of information depending upon the audience and the purpose of the communication.	• Create drawings or diagrams as representations of objects, ideas, events, or systems. • Select and utilize technology (software and hardware) to create high impact visual aids. • Use presentation software effectively to support oral presentations.
Engineering has a global impact on society and the environment.	• Define and differentiate invention and innovation. • Assess the development of an engineered product and discuss its impact on society and the environment. • Identify and discuss a Grand Challenge for Engineering (as identified by the National Academy of Engineering) and its potential impact on society and the environment.
Engineering consists of a variety of specialist sub-fields, with each contributing in different ways to the design and development of solutions to different types of problems.	• Identify and differentiate between mechanical, electrical, civil, and chemical engineering fields. • Describe the contributions of engineers from different engineering fields in the design and development of a product, system, or technology. • Differentiate between the work of an engineer and the work of a scientist.
In order to be an effective team member, one must demonstrate positive team behaviors and act according to accepted norms,	• Demonstrate positive team behaviors and contribute to a positive team dynamic.

contribute to group goals according to assigned roles, and use appropriate conflict resolution strategies.	

Unit 2 Technical Sketching and Drawing
Time Days: 11 days

Understandings	Knowledge and Skills
Brainstorming may take many forms and is used to generate a large number of innovative, creative ideas in a short time.	• Generate and document multiple ideas or solution paths to a problem through brainstorming.
Two- and three-dimensional objects share visual relationships which allow interpretation of one perspective from the other.	• Identify flat patterns (nets) that fold into geometric solid forms.
Geometric shapes and forms are described and differentiated by their characteristic features.	• Explain the concept of proportion and how it relates to freehand sketching.
The style of the engineering graphics and the type of drawing views used to detail an object vary depending upon the intended use of the graphic.	• Identify and define technical drawing representations including isometric, orthographic projection, oblique, perspective, auxiliary, and section views. • Identify the proper use of each technical drawing representation including isometric, orthographic projection, oblique, perspective, auxiliary, and section views.
Technical drawings convey information according to an established set of drawing practices which allow for detailed and universal interpretation of the drawing.	• Identify line types (including construction lines, object lines, hidden lines, cutting plane lines, section lines, and center lines) used on a technical drawing per ANSI Line Conventions and Lettering Y14.2M-2008 and explain the purpose of each line. • Determine the minimum number and types of views necessary to fully detail a part. • Choose and justify the choice for the best orthographic projection of an object to use as a front view on technical drawings. • Apply tonal shading to enhance the appearance of a pictorial sketch and create a more realistic appearance of a sketched object.
Hand sketching of multiple representations to fully and accurately detail simple objects or parts of objects is a technique used to convey visual and technical information about an object.	• Hand sketch 1-point and 2-point perspective pictorial views of a simple object or part given the object, a detailed verbal description or the object, a pictorial view of the object, and/or a set of orthographic projections. • Hand sketch isometric views of a simple object or part at a given scale using the actual object, a detailed verbal description of the object, a pictorial view of the object, or a set of orthographic projections. • Hand sketch orthographic projections at a given scale and in the correct orientation to fully detail an object or part using the actual object, a detailed verbal description of the object, or a pictorial an isometric view of the object.
Sketches, drawings, and images are used to record	• Create drawings or diagrams as representations of objects, ideas, events, or systems.

and convey specific types of information depending upon the audience and the purpose of the communication.	

Unit 3 Measurement and Statistics
Time Days: 14 days

Understandings	Knowledge and Skills
An engineering design process involves a characteristic set of practices and steps.	• Identify and define the terminology used in engineering design and development. • Identify the steps in an engineering design process and summarize the activities involved in each step of the process. • Complete a design project utilizing all steps of a design process, and find a solution that meets specific design requirements.
Brainstorming may take many forms and is used to generate a large number of innovative, creative ideas in a short time.	• Generate and document multiple ideas or solution paths to a problem through brainstorming.
Physical models are created to represent and evaluate possible solutions using prototyping technique(s) chosen based on the presentation and/or testing requirements of a potential solution.	• Construct a testable prototype of a problem solution.
Problem solutions are optimized through evaluation and reflection and should be clearly communicated.	• Describe the design process used in the solution of a particular problem and reflect on all steps of the design process. • Identify limitations in the design process and the problem solution and recommend possible improvements or caveats.
The scientific method guides the testing and evaluation of prototypes of a problem solution.	• Analyze the performance of a design during testing and judge the solution as viable or non-viable with respect to meeting the design requirements.
Statistical analysis of uni-variate data facilitates understanding and interpretation of numerical data and can be used to inform, justify, and validate a design or process.	• Calculate statistics related to central tendency including mean, median, and mode. • Represent data with plots on the real number line (e.g., dot plots, histograms, and box plots). • Use statistics to quantify information, support design decisions, and justify problem solutions. • Distinguish between sample statistics and population statistics and know appropriate applications of each. • Calculate statistics related to variation of data including standard deviation, interquartile range, and range.
Spreadsheet programs can be used to store, manipulate, represent, and analyze data.	• Use a spreadsheet program to store and manipulate raw data. • Use a spreadsheet program to perform calculations using formulas. • Use a spreadsheet program to create and display a histogram to represent a set of data. • Use function tools within a spreadsheet program to calculate statistics for a set of data including mean, median, mode, quartiles,

	range, and standard deviation.
Units and quantitative reasoning can guide mathematical manipulation and the solution of problems involving quantities.	• Use units to guide the solution to multi-step problems through dimensional analysis and choose and interpret units consistently in formulas. • Choose a level of precision and accuracy appropriate to limitations on measurement when reporting quantities. • Convert quantities between units in the SI and the US Customary measurement systems. • Convert between different units within the same measurement system including the SI and US Customary measurement systems.
Error is unavoidable when measuring a physical property, and a measurement is characterized by the precision and accuracy of the measurement.	• Define accuracy and precision in measurement. • Evaluate and compare the accuracy and precision of different measuring devices. • Measure linear distances (including length, inside diameter, and hole depth) with accuracy using a scale, ruler, or dial caliper and report the measurement using an appropriate level of precision.
The style of the engineering graphics and the type of drawing views used to detail an object vary depending upon the intended use of the graphic.	• Identify and define technical drawing representations including isometric, orthographic projection, oblique, perspective, auxiliary, and section views.
Technical drawings convey information according to an established set of drawing practices which allow for detailed and universal interpretation of the drawing.	• Determine the minimum number and types of views necessary to fully detail a part. • Identify and correct errors and omissions in technical drawings including the line work, view selection, view orientation, appropriate scale, and annotations.
Dimensions, specific notes (such as hole and thread notes), and general notes (such as general tolerances) are included on technical drawings according to accepted practice and an established set of standards so as to convey size and location information about detailed parts, their features, and their configuration in assemblies.	• Dimension orthographic projections and section views of simple objects or parts according to a set of dimensioning standards and accepted practices. • Identify and correctly apply chain dimensioning or datum dimensioning methods to a technical drawing. • Identify and correct errors and omissions in the dimensions applied in a technical drawing based on accepted practice and a set of dimensioning rules.
Hand sketching of multiple representations to fully and accurately detail simple objects or parts of objects is a technique used to convey visual and technical information about an object.	• Hand sketch isometric views of a simple object or part at a given scale using the actual object, a detailed verbal description of the object, a pictorial view of the object, or a set of orthographic projections. • Hand sketch orthographic projections at a given scale and in the correct orientation to fully detail an object or part using the actual object, a detailed verbal description of the object, or a pictorial an isometric view of the object. • Generate non-technical concept sketches to represent objects or convey design ideas.
Technical professionals	• Organize and express thoughts and information in a clear and

clearly and accurately document and report their work using technical writing practice in multiple forms.	concise manner. • Adjust voice and writing style to align with audience and purpose. • Support design ideas using a variety of convincing evidence. • Utilize an engineering notebook to clearly and accurately document the design process according to accepted standards and protocols to prove the origin and chronology of a design.
Sketches, drawings, and images are used to record and convey specific types of information depending upon the audience and the purpose of the communication.	• Create drawings or diagrams as representations of objects, ideas, events, or systems.
In order to be an effective team member, one must demonstrate positive team behaviors and act according to accepted norms, contribute to group goals according to assigned roles, and use appropriate conflict resolution strategies.	• Demonstrate positive team behaviors and contribute to a positive team dynamic.

Unit 4 Modeling Skills
Time Days: 17 days

Understandings	Knowledge and Skills
An engineering design process involves a characteristic set of practices and steps.	• Identify and define the terminology used in engineering design and development. • Identify the steps in an engineering design process and summarize the activities involved in each step of the process. • Complete a design project utilizing all steps of a design process, and find a solution that meets specific design requirements.
Brainstorming may take many forms and is used to generate a large number of innovative, creative ideas in a short time.	• Describe a variety of brainstorming techniques and rules for brainstorming. • Generate and document multiple ideas or solution paths to a problem through brainstorming.
A solution path is selected and justified by evaluating and comparing competing design solutions based on jointly developed and agreed-upon design criteria and constraints.	• Clearly justify and validate a selected solution path.
Physical models are created to represent and evaluate possible solutions using prototyping technique(s) chosen based on the presentation and/or testing requirements of a potential solution.	• Construct a testable prototype of a problem solution.
Problem solutions are optimized through	• Describe the design process used in the solution of a particular problem and reflect on all steps of the design process.

evaluation and reflection and should be clearly communicated.	• Justify and validate a problem solution. • Identify limitations in the design process and the problem solution and recommend possible improvements or caveats.
The scientific method guides the testing and evaluation of prototypes of a problem solution.	• Analyze the performance of a design during testing and judge the solution as viable or non-viable with respect to meeting the design requirements.
Statistical analysis of uni-variate data facilitates understanding and interpretation of numerical data and can be used to inform, justify, and validate a design or process.	• Calculate statistics related to central tendency including mean, median, and mode. • Use statistics to quantify information, support design decisions, and justify problem solutions. • Calculate statistics related to variation of data including standard deviation, interquartile range, and range.
Spreadsheet programs can be used to store, manipulate, represent, and analyze data.	• Use a spreadsheet program to store and manipulate raw data. • Use a spreadsheet program to graph bi-variate data and determine an appropriate mathematical model using regression analysis. • Use function tools within a spreadsheet program to calculate statistics for a set of data including mean, median, mode, quartiles, range, **interquatile range,** and standard deviation. **Note: Interquatile range is included for continuous improvement beyond 2013-2014.**
An equation is a statement of equality between two quantities that can be use to describe real phenomenon and solve problems.	• Represent constraints with equations or inequalities. • Formulate equations and inequalities to represent linear relationships between quantities. • Compute (using technology) and interpret the correlation coefficient of a linear fit. • Construct a scatter plot to display bi-variate data, investigate patterns of association, and represent the association with a mathematical model (linear equation) when appropriate.
Solving mathematical equations and inequalities involves a logical process of reasoning and can be accomplished using a variety of strategies and technological tools.	• Solve equations for unknown quantities by determining appropriate substitutions for variables and manipulating the equations.
Functions describe a special relationship between two sets of data and can be used to represent real world relationships and to solve problems.	• Explain the term "function" and identify the set of inputs for the function as the domain and the set of outputs from the function as the range. • Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context. • Build a function that describes a relationship between two quantities given a graph, a description of a relationship, or two input-output pairs. • Interpret a function to solve problems in the context of the data. • Interpret the slope (rate of change) and the intercept (constant term) of a linear function in the context of data.
Technical drawings convey information according to an established set of drawing practices which allow for detailed and universal interpretation of the	• Identify line types (including construction lines, object lines, hidden lines, cutting plane lines, section lines, and center lines) used on a technical drawing per ANSI Line Conventions and Lettering Y14.2M-2008 and explain the purpose of each line. • Determine the minimum number and types of views necessary to fully detail a part.

drawing.	• Choose and justify the choice for the best orthographic projection of an object to use as a front view on technical drawings. • Identify and correct errors and omissions in technical drawings including the line work, view selection, view orientation, appropriate scale, and annotations. • Create a set of working drawings to detail a design project. • Fabricate a simple object from technical drawings that may include an isometric view, orthographic projections, and a section view.
Dimensions, specific notes (such as hole and thread notes), and general notes (such as general tolerances) are included on technical drawings according to accepted practice and an established set of standards so as to convey size and location information about detailed parts, their features, and their configuration in assemblies.	• Dimension orthographic projections and section views of simple objects or parts according to a set of dimensioning standards and accepted practices. • Identify and correct errors and omissions in the dimensions applied in a technical drawing based on accepted practice and a set of dimensioning rules.
Hand sketching of multiple representations to fully and accurately detail simple objects or parts of objects is a technique used to convey visual and technical information about an object.	• Hand sketch isometric views of a simple object or part at a given scale using the actual object, a detailed verbal description of the object, a pictorial view of the object, or a set of orthographic projections. • Hand sketch orthographic projections at a given scale and in the correct orientation to fully detail an object or part using the actual object, a detailed verbal description of the object, or a pictorial an isometric view of the object.
Computer aided drafting and design (CAD) software packages facilitate virtual modeling of parts and assemblies and the creation of technical drawings. They are used to efficiently and accurately detail parts and assemblies according to standard engineering practice.	• Create three-dimensional solid models of parts within CAD from sketches or dimensioned drawings using appropriate geometric and dimensional constraints. • Compare the efficiency of the modeling method of an object using different combinations of additive and subtractive methods. • Generate CAD multi-view technical drawings, including orthographic projections, sections view(s), detail view(s), auxiliary view(s) and pictorial views, as necessary, showing appropriate scale, appropriate view selection, and correct view orientation to fully describe a part according to standard engineering practice. • Dimension and annotate (including specific and general notes) working drawings according to accepted engineering practice. Include dimensioning according to a set of dimensioning rules, proper hole and thread notes, proper tolerance annotation, and the inclusion of other notes necessary to fully describe a part according to standard engineering practice. • Explain each assembly constraint (including mate, flush, insert, and tangent), its role in an assembly model, and the degrees of freedom that it removes from the movement between parts. • Create assemblies of parts in CAD and use appropriate assembly constraints to create an assembly that allows correct realistic movement among parts. Manipulate the assembly model to demonstrate the movement.
Technical professionals clearly and accurately document and report their work using technical writing	• Organize and express thoughts and information in a clear and concise manner. • Adjust voice and writing style to align with audience and purpose. • Support design ideas using a variety of convincing evidence..

practice in multiple forms.	• Utilize project portfolios to present and justify design projects.
Sketches, drawings, and images are used to record and convey specific types of information depending upon the audience and the purpose of the communication.	• Create drawings or diagrams as representations of objects, ideas, events, or systems.

Unit 5 Geometry of Design
Time Days: 13 days

Understandings	Knowledge and Skills
An engineering design process involves a characteristic set of practices and steps.	• Complete a design project utilizing all steps of a design process, and find a solution that meets specific design requirements.
A problem and the requirements for a successful solution to the problem should be clearly communicated and justified.	• Define and justify a design problem, and express the concerns, needs, and desires of the primary stakeholders.
Brainstorming may take many forms and is used to generate a large number of innovative, creative ideas in a short time.	• Generate and document multiple ideas or solution paths to a problem through brainstorming.
Physical models are created to represent and evaluate possible solutions using prototyping technique(s) chosen based on the presentation and/or testing requirements of a potential solution.	• Construct a testable prototype of a problem solution.
Problem solutions are optimized through evaluation and reflection and should be clearly communicated.	• Identify limitations in the design process and the problem solution and recommend possible improvements or caveats.
The scientific method guides the testing and evaluation of prototypes of a problem solution.	• Analyze the performance of a design during testing and judge the solution as viable or non-viable with respect to meeting the design requirements.
Spreadsheet programs can be used to store, manipulate, represent, and analyze data.	• Use a spreadsheet program to store and manipulate raw data. • Use a spreadsheet program to graph bi-variate data and determine an appropriate mathematical model using regression analysis. • Use function tools within a spreadsheet program to calculate statistics for a set of data including mean, median, mode, quartiles, range, and standard deviation.
An equation is a statement of equality between two quantities that can be used to describe real	• Construct a scatter plot to display bi-variate data, investigate patterns of association, and represent the association with a mathematical model (linear equation) when appropriate.

phenomenon and solve problems.	
Solving mathematical equations and inequalities involves a logical process of reasoning and can be accomplished using a variety of strategies and technological tools.	• Solve equations for unknown quantities by determining appropriate substitutions for variables and manipulating the equations.
Units and quantitative reasoning can guide mathematical manipulation and the solution of problems involving quantities.	• Convert quantities between units in the SI and the US Customary measurement systems. • Convert between different units within the same measurement system including the SI and US Customary measurement systems.
Error is unavoidable when measuring a physical property and a measurement is characterized by the precision and accuracy of the measurement.	• Measure linear distances (including length, inside diameter, and hole depth) with accuracy using a scale, ruler, or dial caliper and report the measurement using an appropriate level of precision. • Measure mass with accuracy using a scale and report the measurement using an appropriate level of precision. • Measure volume with accuracy and report the measurement with an appropriate level of precision.
Two- and three-dimensional objects share visual relationships which allow interpretation of one perspective from the other.	• Identify three dimensional objects generated by rotations of two-dimensional shapes and vice-versa.
Physical properties of objects are used to describe and model objects and can be used to define design requirements, as a means to compare potential solutions to a problem, and as a tool to specify final solutions.	• Define the term "physical property" and identify the properties of length, volume, mass, density, surface area, centroid, principle axes, and center of gravity as physical properties. • Solve volume problems using volume formulas for rectangular solids, cylinders, pyramids, cones, and spheres. • Solve real world and mathematical problems involving area and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, right prisms, cylinders and spheres. • Calculate a physical property indirectly using available data or perform appropriate measurements to gather the necessary data (e.g., determine area or volume using linear measurements or determine density using mass and volume measurements). • Use physical properties to solve design problems (e.g., design an object or structure to satisfy physical constraints or minimize cost).
Functions describe a special relationship between two sets of data and can be used to represent real world relationships and to solve problems.	• Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context. • Interpret the slope (rate of change) and the intercept (constant term) of a linear function in the context of data.
Geometric shapes and forms are described and differentiated by their characteristic features.	• Identify types of polygons including a square, rectangle, pentagon, hexagon, and octagon. • Identify and differentiate geometric constructions and constraints such as horizontal lines, vertical lines, parallel lines, perpendicular lines, colinear points, tangent lines, tangent circles, and concentric circles. • Identify types of angles including an acute angle, obtuse angle, straight angle, and right angle.

Computer aided drafting and design (CAD) software packages facilitate virtual modeling of parts and assemblies and the creation of technical drawings. They are used to efficiently and accurately detail parts and assemblies according to standard engineering practice.	• Create three-dimensional solid models of parts within CAD from sketches or dimensioned drawings using appropriate geometric and dimensional constraints.
Computer aided drafting and design (CAD) software packages allow virtual testing and analysis of designs using 3D models, assemblies, and animations.	• Assign a specific material (included in the software library) to a part and use the capabilities of the CAD software to determine the mass, volume, and surface area of an object for which a 3D solid model has been created. • Assign a density value to a new material (not included in the software library) and apply the material to a 3D solid model within CAD software in order to determine the physical properties of the object.
In order to be an effective team member, one must demonstrate positive team behaviors and act according to accepted norms, contribute to group goals according to assigned roles, and use appropriate conflict resolution strategies.	• Demonstrate positive team behaviors and contribute to a positive team dynamic.

Unit 6 Reverse Engineering
Time Days: 13 days

Understandings	Knowledge and Skills
Material and fastener choices used in a product design should be carefully chosen based on the impact to the product's design, cost, performance, marketability, environmental impact, and expected service life.	• Evaluate and compare multiple materials and fastener choices for a product design based on the impact on the design's cost, performance, marketability, environmental impact, and expected service life.
Error is unavoidable when measuring a physical property and a measurement is characterized by the precision and accuracy of the measurement.	• Measure linear distances (including length, inside diameter, and hole depth) with accuracy using a scale, ruler, or dial caliper and report the measurement using an appropriate level of precision. • Measure mass with accuracy using a scale and report the measurement using an appropriate level of precision.
Technical drawings convey information according to an established set of drawing practices which allow for detailed and universal interpretation of the	• Determine the minimum number and types of views necessary to fully detail a part. • Choose and justify the choice for the best orthographic projection of an object to use as a front view on technical drawings.

drawing.	
Hand sketching of multiple representations to fully and accurately detail simple objects or parts of objects is a technique used to convey visual and technical information about an object.	• Hand sketch isometric views of a simple object or part at a given scale using the actual object, a detailed verbal description of the object, a pictorial view of the object, or a set of orthographic projections. • Hand sketch orthographic projections at a given scale and in the correct orientation to fully detail an object or part using the actual object, a detailed verbal description of the object, or a pictorial an isometric view of the object.
Computer aided drafting and design (CAD) software packages facilitate virtual modeling of parts and assemblies and the creation of technical drawings. They are used to efficiently and accurately detail parts and assemblies according to standard engineering practice.	• Create three-dimensional solid models of parts within CAD from sketches or dimensioned drawings using appropriate geometric and dimensional constraints. • Generate CAD multi-view technical drawings, including orthographic projections, sections view(s), detail view(s), auxiliary view(s) and pictorial views, as necessary, showing appropriate scale, appropriate view selection, and correct view orientation to fully describe a part according to standard engineering practice.
Computer aided drafting and design (CAD) software packages allow virtual testing and analysis of designs using 3D models, assemblies, and animations.	• Assign a specific material (included in the software library) to a part and use the capabilities of the CAD software to determine the mass, volume, and surface area of an object for which a 3D solid model has been created.
Technical professionals clearly and accurately document and report their work using technical writing practice in multiple forms.	• Organize and express thoughts and information in a clear and concise manner. • Adjust voice and writing style to align with audience and purpose. • Utilize an engineering notebook to clearly and accurately document the design process according to accepted standards and protocols to prove the origin and chronology of a design.
Specific oral communication techniques are used to effectively convey information and communicate with an audience.	• Deliver organized oral presentations of work tailored to the audience.
Sketches, drawings, and images are used to record and convey specific types of information depending upon the audience and the purpose of the communication.	• Create drawings or diagrams as representations of objects, ideas, events, or systems. • Select and utilize technology (software and hardware) to create high impact visual aids.
Visual elements and principles of design are part of an aesthetic vocabulary that is used to describe the visual characteristics of an object, the application of which can affect the visual appeal of the object and its commercial success in the marketplace.	• Identify and describe the visual principles and elements of design apparent in a natural or man-made object. • Define aesthetics and explain how the visual elements and principles of design affect the aesthetics and commercial success of a product.
Reverse engineering	• Describe the process of reverse engineering.

involves disassembling and analyzing a product or system in order to understand and document the visual, functional, and/or structural aspects of its design.	• Justify the use of reverse engineering and explain the various reasons to employ reverse engineering, including discovery, documentation, investigation, and product improvement. • Perform a functional analysis of a product in order to determine the purpose, inputs and outputs, and the operation of a product or system. • Perform a structural analysis of a product in order to determine the materials used and the form of component parts as well as the configuration and interaction of component parts when assembled (if applicable). • Analyze information gathered during reverse engineering to identify shortcoming of the design and/or opportunities for improvement or innovation.
In order to be an effective team member, one must demonstrate positive team behaviors and act according to accepted norms, contribute to group goals according to assigned roles, and use appropriate conflict resolution strategies.	• Demonstrate positive team behaviors and contribute to a positive team dynamic.

Unit 7 Documentation
Time Days: 25 days

Understandings	Knowledge and Skills
An engineering design process involves a characteristic set of practices and steps.	• Identify the steps in an engineering design process and summarize the activities involved in each step of the process. • Complete a design project utilizing all steps of a design process, and find a solution that meets specific design requirements.
Research derived from a variety of sources (including subject matter experts) is used to facilitate effective development and evaluation of a design problem and a successful solution to the problem.	• Utilize research tools and resources (such as the Internet; media centers; market research; professional journals; printed, electronic, and multimedia resources; etc.) to gather and interpret information to develop an effective design brief. • Utilize research tools and resources (such as the Internet; media centers; market research; professional journals; printed, electronic, and multimedia resources; etc.) to validate design decisions and justify a problem solution.
A problem and the requirements for a successful solution to the problem should be clearly communicated and justified.	• Define and justify a design problem, and express the concerns, needs, and desires of the primary stakeholders. • Present and justify design specifications, and clearly explain the criteria and constraints associated with a successful design solution. • Write a design brief to communicate the problem, problem constraints, and solution criteria.
Brainstorming may take many forms and is used to generate a large number of innovative, creative ideas in a short time.	• Generate and document multiple ideas or solution paths to a problem through brainstorming.

A solution path is selected and justified by evaluating and comparing competing design solutions based on jointly developed and agreed-upon design criteria and constraints.	• Jointly develop a decision matrix based on accepted outcome criteria and constraints. • Clearly justify and validate a selected solution path.
Physical models are created to represent and evaluate possible solutions using prototyping technique(s) chosen based on the presentation and/or testing requirements of a potential solution.	• Construct a testable prototype of a problem solution.
Problem solutions are optimized through evaluation and reflection and should be clearly communicated.	• Describe the design process used in the solution of a particular problem and reflect on all steps of the design process. • Justify and validate a problem solution.
Two- and three-dimensional objects share visual relationships which allow interpretation of one perspective from the other.	• Identify the shapes of two-dimensional cross sections of three dimensional objects.
The scientific method guides the testing and evaluation of prototypes of a problem solution.	• Analyze the performance of a design during testing and judge the solution as viable or non-viable with respect to meeting the design requirements.
An equation is a statement of equality between two quantities that can be used to describe real phenomenon and solve problems.	• Represent constraints with equations or inequalities.
Technical drawings convey information according to an established set of drawing practices which allow for detailed and universal interpretation of the drawing.	• Determine the minimum number and types of views necessary to fully detail a part. • Choose and justify the choice for the best orthographic projection of an object to use as a front view on technical drawings. • Create a set of working drawings to detail a design project. • Create specific notes on a technical drawing to convey important information about a specific feature of a detailed object, and create general notes to convey details that pertains to information presented on the entire drawing (such as units, scale, patent details, etc.
Dimensions, specific notes (such as hole and thread notes), and general notes (such as general tolerances) are included on	• Dimension orthographic projections and section views of simple objects or parts according to a set of dimensioning standards and accepted practices. • Identify and correctly apply chain dimensioning or datum dimensioning methods to a technical drawing.

technical drawings according to accepted practice and an established set of standards so as to convey size and location information about detailed parts, their features, and their configuration in assemblies.	• Identify and differentiate between size dimensions and location dimensions. • Identify and correct errors and omissions in the dimensions applied in a technical drawing based on accepted practice and a set of dimensioning rules. • Read and interpret a hole note to identify the size and type of hole including through, clearance, blind, counter bore, and countersink holes. • Model and annotate (with a hole note) through, clearance, blind, counter bore, and countersink holes.
A degree of variation always exists between specified dimensions and the measurement of a manufactured object which is controlled by the use of tolerances on technical drawings.	• Identify and differentiate among limit dimensions, a unilateral tolerance, and a bilateral tolerance. • Define and determine the specified dimension, tolerance, upper limit, and lower limit for any given dimension and related tolerance (or any distance that is dependent on given dimensions) shown on a technical drawing. • Determine the allowance between two mating parts of an assembly based on dimensions given on a technical drawing. • Differentiate between clearance and interference fit and identify the type of fit given a drawing, a description, or a physical example of two mating parts. • Compare the effect of chain dimensioning and datum dimensioning on the tolerance of a particular specified dimension.
Hand sketching of multiple representations to fully and accurately detail simple objects or parts of objects is a technique used to convey visual and technical information about an object.	• Hand sketch orthographic projections at a given scale and in the correct orientation to fully detail an object or part using the actual object, a detailed verbal description of the object, or a pictorial an isometric view of the object. • Hand sketch a scaled full or half section view in the correct orientation to fully detail an object or part given the actual object, a detailed verbal description of the object, a pictorial view of the object or a set of orthographic projections.
Computer aided drafting and design (CAD) software packages facilitate virtual modeling of parts and assemblies and the creation of technical drawings. They are used to efficiently and accurately detail parts and assemblies according to standard engineering practice.	• Create three-dimensional solid models of parts within CAD from sketches or dimensioned drawings using appropriate geometric and dimensional constraints. • Generate CAD multi-view technical drawings, including orthographic projections, sections view(s), detail view(s), auxiliary view(s) and pictorial views, as necessary, showing appropriate scale, appropriate view selection, and correct view orientation to fully describe a part according to standard engineering practice. • Dimension and annotate (including specific and general notes) working drawings according to accepted engineering practice. Include dimensioning according to a set of dimensioning rules, proper hole and thread notes, proper tolerance annotation, and the inclusion of other notes necessary to fully describe a part according to standard engineering practice. • Explain each assembly constraint (including mate, flush, insert, and tangent), its role in an assembly model, and the degrees of freedom that it removes from the movement between parts. • Create assemblies of parts in CAD and use appropriate assembly

	constraints to create an assembly that allows correct realistic movement among parts. Manipulate the assembly model to demonstrate the movement. • Create a CAD assembly drawing. Identify each component of the assembly with identification numbers and create a parts list to detail each component using CAD.
Technical professionals clearly and accurately document and report their work using technical writing practice in multiple forms.	• Organize and express thoughts and information in a clear and concise manner. • Adjust voice and writing style to align with audience and purpose. • Support design ideas using a variety of convincing evidence. • Utilize an engineering notebook to clearly and accurately document the design process according to accepted standards and protocols to prove the origin and chronology of a design. • Create a technical report according to the American National Standards Institute (ANSI) technical report layout and format specifics.
Sketches, drawings, and images are used to record and convey specific types of information depending upon the audience and the purpose of the communication.	• Create drawings or diagrams as representations of objects, ideas, events, or systems.
Reverse engineering involves disassembling and analyzing a product or system in order to understand and document the visual, functional, and/or structural aspects of its design.	• Analyze information gathered during reverse engineering to identify shortcoming of the design and/or opportunities for improvement or innovation.
In order to be an effective team member, one must demonstrate positive team behaviors and act according to accepted norms, contribute to group goals according to assigned roles, and use appropriate conflict resolution strategies.	• Demonstrate positive team behaviors and contribute to a positive team dynamic.

Unit 8 Advanced Computer Modeling
Time Days: 12 days

Understandings	Knowledge and Skills
An engineering design process involves a characteristic set of	• Complete a design project utilizing all steps of a design process, and find a solution that meets specific design requirements.

practices and steps.	
Brainstorming may take many forms and is used to generate a large number of innovative, creative ideas in a short time.	• Generate and document multiple ideas or solution paths to a problem through brainstorming.
Physical models are created to represent and evaluate possible solutions using prototyping technique(s) chosen based on the presentation and/or testing requirements of a potential solution.	• Construct a testable prototype of a problem solution.
Problem solutions are optimized through evaluation and reflection and should be clearly communicated.	• Identify limitations in the design process and the problem solution and recommend possible improvements or caveats.
The scientific method guides the testing and evaluation of prototypes of a problem solution.	• Analyze the performance of a design during testing and judge the solution as viable or non-viable with respect to meeting the design requirements.
An equation is a statement of equality between two quantities that can be use to describe real phenomenon and solve problems.	• Formulate equations and inequalities to represent linear, relationships between quantities.
Solving mathematical equations and inequalities involves a logical process of reasoning and can be accomplished using a variety of strategies and technological tools.	• Solve equations for unknown quantities by determining appropriate substitutions for variables and manipulating the equations.
Two- and three-dimensional objects share visual relationships which allow interpretation of one perspective from the other.	• Identify three dimensional objects generated by rotations of two-dimensional shapes and vice-versa.
Geometric shapes and forms are described and differentiated by their characteristic features.	• Identify and differentiate geometric constructions and constraints such as horizontal lines, vertical lines, parallel lines, perpendicular lines, colinear points, tangent lines, tangent circles, and concentric circles.
The style of the engineering graphics and the type of drawing views used to detail an object vary depending upon the intended use of the graphic.	• Identify the proper use of each technical drawing representation including isometric, orthographic projection, oblique, perspective, auxiliary, and section views.
Technical drawings convey information according to an established set of drawing practices which allow for detailed and universal interpretation of the	• Determine the minimum number and types of views necessary to fully detail a part. • Choose and justify the choice for the best orthographic projection of an object to use as a front view on technical drawings. • Create a set of working drawings to detail a design project.

drawing.	• Create specific notes on a technical drawing to convey important information about a specific feature of a detailed object, and create general notes to convey details that pertains to information presented on the entire drawing (such as units, scale, patent details, etc.
Dimensions, specific notes (such as hole and thread notes), and general notes (such as general tolerances) are included on technical drawings according to accepted practice and an established set of standards so as to convey size and location information about detailed parts, their features, and their configuration in assemblies.	• Dimension orthographic projections and section views of simple objects or parts according to a set of dimensioning standards and accepted practices. • Identify and correctly apply chain dimensioning or datum dimensioning methods to a technical drawing. • Model and annotate (with a hole note) through, clearance, blind, counter bore, and countersink holes.
A degree of variation always exists between specified dimensions and the measurement of a manufactured object which is controlled by the use of tolerances on technical drawings.	• Identify and differentiate among limit dimensions, a unilateral tolerance, and a bilateral tolerance.
Hand sketching of multiple representations to fully and accurately detail simple objects or part of objects is a technique used to convey visual and technical information about an object.	• Hand sketch orthographic projections at a given scale and in the correct orientation to fully detail an object or part using the actual object, a detailed verbal description of the object, or a pictorial an isometric view of the object.
Computer aided drafting and design (CAD) software packages facilitate virtual modeling of parts and assemblies and the creation of technical drawings. They are used to efficiently and accurately detail parts and assemblies according to standard engineering practice.	• Create three-dimensional solid models of parts within CAD from sketches or dimensioned drawings using appropriate geometric and dimensional constraints. • Generate CAD multi-view technical drawings, including orthographic projections, sections view(s), detail view(s), auxiliary view(s) and pictorial views, as necessary, showing appropriate scale, appropriate view selection, and correct view orientation to fully describe a part according to standard engineering practice. • Create relationships among part features and dimensions using parametric formulas. • Dimension and annotate (including specific and general notes) working drawings according to accepted engineering practice. Include dimensioning according to a set of dimensioning rules, proper hole and thread notes, proper tolerance annotation, and the inclusion of other notes necessary to fully describe a part according to standard engineering practice. • Create sketch elements and relationships among part features in CAD using precise input (and an applicable coordinate system). • Explain each assembly constraint (including mate, flush, insert, and tangent), its role in an assembly model, and the degrees of freedom that it removes from the movement between parts. • Create assemblies of parts in CAD and use appropriate assembly constraints to create an assembly that allows correct realistic

	movement among parts. Manipulate the assembly model to demonstrate the movement. • Create a CAD assembly drawing. Identify each component of the assembly with identification numbers and create a parts list to detail each component using CAD. • Create an exploded view of a given assembly. Identify each component of the assembly with identification numbers, and create a parts list to detail each component using CAD. **(OPTIONAL)**
Technical professionals clearly and accurately document and report their work using technical writing practice in multiple forms.	• Utilize an engineering notebook to clearly and accurately document the design process according to accepted standards and protocols to prove the origin and chronology of a design.
Sketches, drawings, and images are used to record and convey specific types of information depending upon the audience and the purpose of the communication.	• Create drawings or diagrams as representations of objects, ideas, events, or systems.
In order to be an effective team member, one must demonstrate positive team behaviors and act according to accepted norms, contribute to group goals according to assigned roles, and use appropriate conflict resolution strategies.	• Demonstrate positive team behaviors and contribute to a positive team dynamic.

Unit 9 Design Team
Time Days: 33 days

Understandings	Knowledge and Skills
An engineering design process involves a characteristic set of practices and steps.	• Identify the steps in an engineering design process and summarize the activities involved in each step of the process. • Complete a design project utilizing all steps of a design process, and find a solution that meets specific design requirements.
Research derived from a variety of sources (including subject matter experts) is used to facilitate effective development and evaluation of a design problem and a successful solution to the problem..	• Utilize research tools and resources (such as the Internet; media centers; market research; professional journals; printed, electronic, and multimedia resources; etc.) to gather and interpret information to develop an effective design brief. • Utilize research tools and resources (such as the Internet; media centers; market research; professional journals; printed, electronic, and multimedia resources; etc.) to validate design decisions and justify a problem solution. • Summarize key ideas in information sources including scientific and engineering texts, tables, diagrams, and graphs.
A problem and the requirements for a successful solution to the problem should be clearly communicated and justified.	• Define and justify a design problem, and express the concerns, needs, and desires of the primary stakeholders. • Present and justify design specifications, and clearly explain the criteria and constraints associated with a successful design solution. • Explain design requirements and function claims using STEM principles and practices.

	• Write a design brief to communicate the problem, problem constraints, and solution criteria.
Brainstorming may take many forms and is used to generate a large number of innovative, creative ideas in a short time.	• Generate and document multiple ideas or solution paths to a problem through brainstorming.
A solution path is selected and justified by evaluating and comparing competing design solutions based on jointly developed and agreed-upon design criteria and constraints.	• Jointly develop a decision matrix based on accepted outcome criteria and constraints. • Use a decision matrix to evaluate and compare multiple design solutions in order to select a solution path that satisfies the design requirements. • Clearly justify and validate a selected solution path.
Problem solutions are optimized through evaluation and reflection and should be clearly communicated.	• Justify and validate a problem solution. • Identify limitations in the design process and the problem solution and recommend possible improvements or caveats.
Project planning tools and management skills are often used in the process of solving engineering design problems.	• Create and utilize a Gantt chart to plan, monitor, and control task completion during a design project.
The style of the engineering graphics and the type of drawing views used to detail an object vary depending upon the intended use of the graphic.	• Identify the proper use of each technical drawing representation including isometric, orthographic projection, oblique, perspective, auxiliary, and section views.
Technical drawings convey information according to an established set of drawing practices which allow for detailed and universal interpretation of the drawing.	• Determine the minimum number and types of views necessary to fully detail a part. • Choose and justify the choice for the best orthographic projection of an object to use as a front view on technical drawings. • Create a set of working drawings to detail a design project. • Create specific notes on a technical drawing to convey important information about a specific feature of a detailed object, and create general notes to convey details that pertains to information presented on the entire drawing (such as units, scale, patent details, etc.
Dimensions, specific notes (such as hole and thread notes), and general notes (such as general tolerances) are included on technical drawings according to accepted practice and an established set of standards so as to convey size and location information about detailed parts, their features, and their configuration in assemblies.	• Dimension orthographic projections and section views of simple objects or parts according to a set of dimensioning standards and accepted practices. • Identify and correctly apply chain dimensioning or datum dimensioning methods to a technical drawing. • Identify and differentiate between size dimensions and location dimensions. • Model and annotate (with a hole note) through, clearance, blind, counter bore, and countersink holes.
A degree of variation always exists between specified dimensions and	• Identify and differentiate among limit dimensions, a unilateral tolerance, and a bilateral tolerance.

the measurement of a manufactured object which is controlled by the use of tolerances on technical drawings.	
Hand sketching of multiple representations to fully and accurately detail simple objects or part of objects is a technique used to convey visual and technical information about an object.	• Hand sketch orthographic projections at a given scale and in the correct orientation to fully detail an object or part using the actual object, a detailed verbal description of the object, or a pictorial an isometric view of the object. • Generate non-technical concept sketches to represent an object or part to convey design ideas.
Computer aided drafting and design (CAD) software packages facilitate virtual modeling of parts and assemblies and the creation of technical drawings. They are used to efficiently and accurately detail parts and assemblies according to standard engineering practice.	• Create three-dimensional solid models of parts within CAD from sketches or dimensioned drawings using appropriate geometric and dimensional constraints. • Generate CAD multi-view technical drawings, including orthographic projections, sections view(s), detail view(s), auxiliary view(s) and pictorial views, as necessary, showing appropriate scale, appropriate view selection, and correct view orientation to fully describe a part according to standard engineering practice. • Create relationships among part features and dimensions using parametric formulas • Dimension and annotate (including specific and general notes) working drawings according to accepted engineering practice. Include dimensioning according to a set of dimensioning rules, proper hole and thread notes, proper tolerance annotation, and the inclusion of other notes necessary to fully describe a part according to standard engineering practice. • Create assemblies of parts in CAD and use appropriate assembly constraints to create an assembly that allows correct realistic movement among parts. Manipulate the assembly model to demonstrate the movement. • Create a CAD assembly drawing. Identify each component of the assembly with identification numbers and create a parts list to detail each component using CAD. • Create an exploded view of a given assembly. Identify each component of the assembly with identification numbers, and create a parts list to detail each component using CAD.
Styles and modes of professional correspondence are tailored to the type of audience and intended goals..	• Identify an appropriate mode of two-way communication based on the audience and intended goal of the communication. • Use an appropriate and professional tone and vernacular based on the audience of the correspondence. • Document correspondence and conversations in an accurate and organized manner. • Review and evaluate the written work of peers and make recommendations for improvement.
Technical professionals clearly and accurately document and report their work using technical writing practice in multiple forms.	• Organize and express thoughts and information in a clear and concise manner. • Adjust voice and writing style to align with audience and purpose. • Support design ideas using a variety of convincing evidence. • Utilize an engineering notebook to clearly and accurately document the design process according to accepted standards and protocols to prove the origin and chronology of a design. • Utilize journaling as a means of documentation and reflection to demonstrate original thought and reasoning. • Utilize project portfolios to present and justify design projects.

	• Document information sources using appropriate formats.
Specific oral communication techniques are used to effectively convey information and communicate with an audience.	• Deliver organized oral presentations of work tailored to the audience. • Establish objectives for the presentation that are appropriate for the audience. • Facilitate engaging and purposeful dialog with the audience.
Sketches, drawings, and images are used to record and convey specific types of information depending upon the audience and the purpose of the communication.	• Create drawings or diagrams as representations of objects, ideas, events, or systems. • Select and utilize technology (software and hardware) to create high impact visual aids. • Select and utilize videos and images from CAD software to convey information appropriate for the given audience. • Use presentation software effectively to support oral presentations.
Engineering has a global impact on society and the environment.	• Assess the development of an engineered product and discuss its impact on society and the environment.
Engineering consists of a variety of specialist sub-fields, with each contributing in different ways to the design and development of solutions to different types of problems.	• Describe the contributions of engineers from different engineering fields in the design and development of a product, system, or technology.
Engineering design and practices are governed by ethics, values, and laws.	• Identify and describe the steps of a typical product lifecycle (including raw material extraction, processing, manufacture, use and maintenance, and disposal. • Identify and explain how the basic theories of ethics relate to engineering.
Visual elements and principles of design are part of an aesthetic vocabulary that is used to describe the visual characteristics of an object, the application of which can affect the visual appeal of the object and its commercial success in the marketplace.	• Incorporate the use of the visual elements and principles of design in the design of an engineered product.
Effective design teams can improve the efficiency and effectiveness of the design process. Effective team members have good collaboration skills.	• Identify team member skill sets needed to produce an effective team. • Identify and assign team member roles. • Define the term group norms and discuss the importance of norms in creating an effective team environment. • Identify strategies to resolve team conflict.
In order to be an effective team member, one must demonstrate positive team behaviors and act according to accepted norms, contribute to group goals according to assigned roles, and use appropriate conflict resolution strategies.	• Demonstrate positive team behaviors and contribute to a positive team dynamic. • Establish common goals, equitable workloads, accountability, and create a set of team norms. • Contribute equitably to the attainment of group goals based on assigned roles. • Practice appropriate conflict resolution strategies within a team environment.
Virtual design teams include people in different locations	• Identify appropriate technology to support remote collaboration among virtual design team members (such as asynchronous

who collaborate using communication methods other than face-to-face contact.	communications, audio and video conferencing, instant messaging, synchronous file editing, and file transfer). • Participate on a virtual team using remote collaboration tools to support team collaboration and problem solving.

Unit 10 Design Challenges
Time Days: 12 days

Understandings	Knowledge and Skills
An engineering design process involves a characteristic set of practices and steps.	• Complete a design project utilizing all steps of a design process, and find a solution that meets specific design requirements.
Research derived from a variety of sources (including subject matter experts) is used to facilitate effective development and evaluation of a design problem and a successful solution to the problem.	• Utilize research tools and resources (such as the Internet; media centers; market research; professional journals; printed, electronic, and multimedia resources; etc.) to gather and interpret information to develop an effective design brief. • Utilize research tools and resources (such as the Internet; media centers; market research; professional journals; printed, electronic, and multimedia resources; etc.) to validate design decisions and justify a problem solution.
A problem and the requirements for a successful solution to the problem should be clearly communicated and justified.	• Define and justify a design problem, and express the concerns, needs, and desires of the primary stakeholders. • Present and justify design specifications, and clearly explain the criteria and constraints associated with a successful design solution. • Explain design requirements and function claims using STEM principles and practices. • Write a design brief to communicate the problem, problem constraints, and solution criteria.
Brainstorming may take many forms and is used to generate a large number of innovative, creative ideas in a short time.	• Generate and document multiple ideas or solution paths to a problem through brainstorming.
A solution path is selected and justified by evaluating and comparing competing design solutions based on jointly developed and agreed-upon design criteria and constraints.	• Jointly develop a decision matrix based on accepted outcome criteria and constraints. • Use a decision matrix to evaluate and compare multiple design solutions in order to select a solution path that satisfies the design requirements. • Clearly justify and validate a selected solution path.
Problem solutions are optimized through evaluation and reflection and should be clearly communicated.	• Describe the design process used in the solution of a particular problem and reflect on all steps of the design process. • Justify and validate a problem solution. • Identify limitations in the design process and the problem solution and recommend possible improvements or caveats.
The style of the engineering graphics and the type of drawing views used to detail an object vary depending upon the intended use of the graphic.	• Identify the proper use of each technical drawing representation including isometric, orthographic projection, oblique, perspective, auxiliary, and section views.
Technical drawings convey	• Determine the minimum number and types of views necessary to

information according to an established set of drawing practices which allow for detailed and universal interpretation of the drawing.	fully detail a part. • Choose and justify the choice for the best orthographic projection of an object to use as a front view on technical drawings. • Create a set of working drawings to detail a design project. • Create specific notes on a technical drawing to convey important information about a specific feature of a detailed object, and create general notes to convey details that pertains to information presented on the entire drawing (such as units, scale, patent details, etc.
Dimensions, specific notes (such as hole and thread notes), and general notes (such as general tolerances) are included on technical drawings according to accepted practice and an established set of standards so as to convey size and location information about detailed parts, their features, and their configuration in assemblies..	• Dimension orthographic projections and section views of simple objects or parts according to a set of dimensioning standards and accepted practices. • Identify and correctly apply chain dimensioning or datum dimensioning methods to a technical drawing. • Identify and differentiate between size dimensions and location dimensions.
A degree of variation always exists between specified dimensions and the measurement of a manufactured object which is controlled by the use of tolerances on technical drawings.	• Determine the allowance between two mating parts of an assembly based on dimensions given on a technical drawing.
Hand sketching of multiple representations to fully and accurately detail simple objects or parts of objects is a technique used to convey visual and technical information about an object..	• Hand sketch isometric views of a simple object or part at a given scale using the actual object, a detailed verbal description of the object, a pictorial view of the object, or a set of orthographic projections. • Generate non-technical concept sketches to represent an object or part to convey design ideas.
Computer aided drafting and design (CAD) software packages facilitate virtual modeling of parts and assemblies and the creation of technical drawings. They are used to efficiently and accurately detail parts and assemblies according to standard engineering practice.	• Create three-dimensional solid models of parts within CAD from sketches or dimensioned drawings using appropriate geometric and dimensional constraints. • Generate CAD multi-view technical drawings, including orthographic projections, sections view(s), detail view(s), auxiliary view(s) and pictorial views, as necessary, showing appropriate scale, appropriate view selection, and correct view orientation to fully describe a part according to standard engineering practice. • Create relationships among part features and dimensions using parametric formulas. • Dimension and annotate (including specific and general notes) working drawings according to accepted engineering practice. Include dimensioning according to a set of dimensioning rules, proper hole and thread notes, proper tolerance annotation, and the inclusion of other notes necessary to fully describe a part according to standard engineering practice. • Create sketch elements and relationships among part features in

	CAD using precise input (and an applicable coordinate system). • Explain each assembly constraint (including mate, flush, insert, and tangent), its role in an assembly model, and the degrees of freedom that it removes from the movement between parts. • Create assemblies of parts in CAD and use appropriate assembly constraints to create an assembly that allows correct realistic movement among parts. Manipulate the assembly model to demonstrate the movement. • Create a CAD assembly drawing. Identify each component of the assembly with identification numbers and create a parts list to detail each component using CAD. • Create an exploded view of a given assembly. Identify each component of the assembly with identification numbers, and create a parts list to detail each component using CAD.
Technical professionals clearly and accurately document and report their work using technical writing practice in multiple forms.	• Organize and express thoughts and information in a clear and concise manner. • Utilize an engineering notebook to clearly and accurately document the design process according to accepted standards and protocols to prove the origin and chronology of a design. • Document information sources using appropriate formats.
Visual elements and principles of design are part of an aesthetic vocabulary that is used to describe the visual characteristics of an object, the application of which can affect the visual appeal of the object and its commercial success in the marketplace.	• Incorporate the use of the visual elements and principles of design in the design of an engineered product.
Effective design teams can improve the efficiency and effectiveness of the design process. Effective team members have good collaboration skills.	• Identify and assign team member roles. • Define the term group norms and discuss the importance of norms in creating an effective team environment. • Identify strategies to resolve team conflict.
In order to be an effective team member, one must demonstrate positive team behaviors and act according to accepted norms, contribute to group goals according to assigned roles, and use appropriate conflict resolution strategies.	• Demonstrate positive team behaviors and contribute to a positive team dynamic. • Establish common goals, equitable workloads, accountability, and create a set of team norms. • Contribute equitably to the attainment of group goals based on assigned roles. • Practice appropriate conflict resolution strategies within a team environment.