SACRAMENTO CITY UNIFIED SCHOOL DISTRICT
BOARD OF EDUCATION

Agenda Item 9.1e

Meeting Date: July 16, 2015

Subject: Course of Study Approval: Introduction to Engineering and Design 1P, 2P

- ☐ Information Item Only
- ☒ Approval on Consent Agenda
- ☐ Conference (for discussion only)
- ☐ Conference/First Reading (Action Anticipated: _____)
- ☐ Conference/Action
- ☐ Action
- ☐ Public Hearing

Division: Academic Office/Curriculum & Instruction

Recommendation: Approve the Course of Study for Introduction to Engineering and Design 1P, 2P

Background/Rationale: In the course, "Introduction to Engineering and Design", students dig deep into the engineering design process, applying math, science, and engineering standards to hands-on projects. They work both individually and in teams to design solutions to a variety of problems using 3D modeling software, and use an engineering notebook to document their work.

"Introduction to Engineering and Design" is the first course for engineering students in the Project lead the Way program. It is followed by Principals of Engineering. Students who are interested in pursuing a career in Engineering should take this course. It prepares students for entry into a college Engineering program. This course uses the design process that correlates to the Common Core guidelines.

Financial Considerations: None

LCAP Goal(s): College and Career Ready Students

Documents Attached:
1. Course of Study for Introduction to Engineering and Design 1P, 2P

Estimated Time of Presentation: NA	
Submitted by:	Olivine Roberts, Chief Academic Officer and Iris Taylor, Assistant Superintendent for Curriculum & Instruction
Approved by:	José Banda, Superintendent

Sacramento City Unified School District

COURSE OF STUDY

FOR

Introduction to Engineering and Design 1P and 2P

YTS133 and YTS134

Segment	High School
Length of Course	One Year
Developed by	West Campus Engineering Committee
First Edition	Fall, 2015

SACRAMENTO CITY UNIFIED SCHOOL DISTRICT

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Introduction to Engineering and Design 1P and 2P

SECTION ONE — GENERAL INFORMATION

COURSE DESCRIPTION

Students dig deep into the engineering design process, applying math, science, and engineering standards to hands-on projects. They work both individually and in teams to design solutions to a variety of problems using 3D modeling software, and use an engineering notebook to document their work.

RATIONALE

This is the first course for engineering students. It is followed by Principals of Engineering. Students who are interested in pursuing a career in Engineering should take this course. It prepares students for entry into a college Engineering program. This course uses the design process that correlates to the Common Core guidelines.

COURSE GOALS

- Students are able to use the Design Process to solve problems and generate solutions.
    - Generate and document multiple ideas or solution paths to a problem through brainstorming
    - Describe the design process used in the solution of a particular problem and reflect on all steps of the design process.
    - 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.
    - Review and evaluate the written work of peers and make recommendations for improvement.
- Students are able to represent objects and ideas through sketches
    - Create sketches or diagrams as representations of objects, ideas, events, or systems.
    - Apply tonal shading to enhance the appearance of a pictorial sketch and create a more realistic appearance of a sketched 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 1-point and 2-point perspective pictorial views of a simple object or part given the object, a detailed verbal description of the object, a pictorial view of the object, and/or a set of orthographic projections.
    - Choose and justify the choice for the best orthographic projection of an object to use as a front view on technical drawings.
    - 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.
- Students understand and use different units of 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.
    - Use units to guide the solution to multi-step problems through dimensional analysis and choose and interpret units consistently in formulas.
    - 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.
    - Dimension orthographic projections 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.
    - 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.
    - 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).

    - Solve volume problems using volume formulas for rectangular solids, cylinders, pyramids, cones, and spheres.

- Students are able to use 3D modeling software to draw and create models
    - Develop and/or use graphical, computer, physical and mathematical models as appropriate to represent or solve problems.
    - 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 and pictorial views, as necessary, showing appropriate scale, appropriate view selection, and correct view orientation to fully describe a simple part according to standard engineering practice.
    - Create a set of working drawings to detail a design project.
    - Create three-dimensional solid models of parts within CAD from sketches or dimensioned drawings using appropriate geometric and dimensional constraints and model features. 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.
    - 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).
    - Dimension a section view of a simple object or part according to a set of dimensioning standards and accepted practices.
    - 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

- Students are able to solve, organize and present information and projects
    - Utilize project portfolios to present and justify design projects.
    - Use a spreadsheet program to graph bi-variate data and determine an appropriate mathematical model using regression analysis.
    - Solve equations for unknown quantities by determining appropriate substitutions for variables and manipulating the equations.
    - Interpret a function to solve problems in the context of the data.
    - 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.
    - Use physical properties to solve design problems (e.g., design an object or structure to satisfy physical constraints or minimize cost).
    - Explain how the visual elements and principles of design affect the aesthetics and commercial success of a product.
    - Select and utilize technology (software and hardware) to create high impact visual aids.
- Students are able to use software and 3D modeling software to clearly present parts and assemblies for production, analysis, and design
    - 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.
    - 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.
    - Analyze information gathered during reverse engineering to identify shortcoming of the design and/or opportunities for improvement or innovation.
    - 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.
- Use advanced modeling features to create three-dimensional solid models of complex parts and assemblies within CAD and with little guidance given the actual part using appropriate geometric and dimensional constraints**.**
- Using a CAD application, create relationships among part features and dimensions using parametric formulas.
- Create an exploded assembly view of a multi-part product. Identify each component of the assembly with identification numbers and create a parts list to detail each component using CAD.
- Develop and document an effective solution to a problem that meets specific design requirements.
- Document and describe the design process used in the solution of a problem and reflect on all steps of the design process.

- Students will understand shared decision-making, investigate different materials, manufacturing processes, and the short and long term impacts that their decision-making may have on society or potentially on the world.
  - Students understand the development of an engineered product and the impact of the product on society and the environment.
  - 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.
  - Deliver organized oral presentations of work tailored to the audience.
  - Demonstrate positive team behaviors and contribute to a positive team dynamic.
  - Contribute equitably to the attainment of group goals based on assigned roles.
  - Adjust voice and writing style to align with audience and purpose.
  - Deliver organized oral presentations of work tailored to the audience.

- Students are able to use the skills they've learned to complete a design process
    - To develop and document an effective solution to a problem that meets specific design requirements.
    - Document and describe the design process used in the solution of a problem and reflect on all steps of the design process.

COURSE STANDARDS

Common Core State Standards for English Language Arts
Common Core State Standards for Mathematical Practice (HS)
Standards for Technological Literacy
Next Generation Science Standards

INSTRUCTIONAL MATERIALS

Worksheets derived from PLTW materials
PowerPoints derived from PLTW materials
Answer Keys derived from PLTW materials
Engineering Work Kit that includes measuring tools and simple mechanical tools.
Engineering Workbooks or substitute for each student.
Autodesk Inventor 2015 installed on computers

SUPPLEMENTARY MATERIALS:

¾" Blocks and Button Machine
Isometric Paper – copies
3D printer

SUGGESTED AVERAGE TIME FOR COVERING MAJOR UNITS

Unit 1 Design Process

Time Days: 16 day

Unit 2 Technical Sketching and Drawing

Time Days: Approximately 11 days

Unit 3 Measurement and Statistics

Time Days: Approximate**ly** 12 days

Unit 4 Modeling Skills

Time Days: Approximately 15 days

Unit 5 Geometry of Design

Time Days: Approximately 13 days

Unit 6 Reverse Engineering

Time Days: Approximately 13 days

Unit 7 Documentation

Time Days: Approximately 24 days

Unit 8 Advanced Computer Modeling

Time Days: Approximately 11 days

Unit 9 Design Team

Time Days: Approximately 33 days

Unit 10 Design Challenges

Time Days: Approximately 10 days

TEACHER RESOURCES

- Resources provided through PLTW
- PowerPoint Presentations

RECOMMENDED STUDENT RESOURCES

- Free student copy of Inventor provided by Autodesk for personal use outside of school.
- Free Internet and Youtube Instructional videos and tutorials to learn Inventor
- Dropbox.com to provide online sharing of materials and resources

SECTION TWO — COURSE UNITS

All the units are based on the PLTW Introduction to Engineering and Design coursework.

UNIT I: Design Process

Each time that you solve a problem, a design process is used. Some processes are as simple as realizing that you are hungry for something new and then designing a new combination of foods. Process can be as complex as designing a clean water solution for a village in an emerging nation. The design process (i.e., method to solve a problem or create a new product) is a cornerstone of all engineering professions.

This lesson provides a foundation for engineering knowledge and professional practices that will be used through this and other pathway to engineering courses and throughout a student's career. Students will develop skills such as concept sketching, setting up, and maintaining an engineering notebook and portfolio.

Engineering is a professional practice that has evolved through centuries of experience. Learning concepts and practicing skills in this course will provide a foundation for a lifelong engineering career.

STANDARDS ADDRESSED

Common Core State Standards for English Language Arts

Reading

Key Ideas and Details

1. Read closely to determine what the text says explicitly and to make logical inferences from it;
Cite specific textual evidence when writing or speaking to support conclusions drawn from the text. (AS.R.1)
4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone. (AS.R.4)
7. Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words. (AS.R.7)
10. Read and comprehend complex literary and informational texts independently and proficiently. (AS.R.10)

Text Types and Purposes

2. Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content. (AS.W.2) [PREVIEW]
4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (AS.W.4) [PREVIEW]
5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach. (AS.W.5) [PREVIEW]

6. Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others. (AS.W.6) [PREVIEW]
7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation. (AS.W.7)
8. Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism. (AS.W.8)
9. Draw evidence from literary or informational texts to support analysis, reflection, and research. (AS.W.9)
10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences. (AS.W.10)

Comprehension and Collaboration
1. Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively. (AS.SL.1)
4. Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience. (AS.SL.4)
5. Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations. (AS.SL.5)
6. Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate. (AS.SL.6)

Conventions of Standard English
1. Demonstrate command of the conventions of Standard English grammar and usage when writing or speaking. (AS.L.1)
2. Demonstrate command of the conventions of Standard English capitalization, punctuation, and spelling when writing. (AS.L.2)
3. Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening. (AS.L.3)
6. Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression. (AS.L.6)

Standards for Technological Literacy

- Students will develop an understanding of the characteristics and scope of technology.
- Students will develop an understanding of the core concepts of technology.
- Students will develop an understanding of the cultural, social, economic, and political effects of technology.
- Students will develop an understanding of the effects of technology on the environment.
- Students will develop an understanding of the influence of technology on history.
- Students will develop an understanding of the attributes of design.

- Students will develop an understanding of engineering design.
- Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving
- Students will develop the abilities to apply the design process.
- Students will develop an understanding of and be able to select and use information and communication technologies.

Next Generation Science Standards

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. (MS.ETS1.1)
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. (MS.ETS1.2)
MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. (MS.ETS1.4)

INSTRUCTIONAL OBJECTIVES

Students will be able to:

- Identify the steps in an engineering design process and describe the activities involved in each step of the process. U1
- Explain the concept of proportion and how it relates to freehand sketching.
- Identify and describe a variety of brainstorming techniques and rules for brainstorming.
- Differentiate between invention and innovation.
- Identify and differentiate between the work of an engineer and the work of a scientist.
- Identify and differentiate between mechanical, electrical, civil, and chemical engineering fields.
- Generate and document multiple ideas or solution paths to a problem through brainstorming
- Describe the design process used in the solution of a particular problem and reflect on all steps of the design process.
- 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 sketches or diagrams as representations of objects, ideas, events, or systems.

- Explain the contributions of engineers from different engineering fields in the design and development of a product, system, or technology.
- Review and evaluate the written work of peers and make recommendations for improvement.

SUGGESTED ACTIVITIES

- Instant Cable Car Challenge
- Concept Sketching in Engineering Workbook
- Brainstorming Product Improvement
- Deep Dive Design Process
- Discover Engineering Disciplines
- Paper Bridge Challenge
- Design Innovation and Evolution

PowerPoint Presentations

1.3.A EngineeringNotebook.pptx
1.4.A BrainstormingSolutions.pptx
1.5.A DesignProcess.pptx
1.5.A WritingDesignBrief.pptx
1.6.A EngineeringDisciplines.pptx
1.6.A EngineeringOverview.pptx
1.8.A InstantChallengePaperBridge.pptx
1.9.A IntroResearch.pptx
1.9.A ProductDesignEvolution.pptx

SUGGESTED ASSESSMENT

Assessment throughout all units are consistent with the following:
Assessment consists of Real Time corrective assessment of work in progress for individuals and small groups.
Students are also assessed by the activities for each assignment.
Section 1 is to do the assigned task for each activity.
Section 2 is to answer questions about what was learned in the activity.
Some self-assessment and peer assessment are also included.

UNIT II: Technical Sketching and Drawing

It is often said that a picture is worth a thousand words. This proverb is very true when communicating ideas to solve problems. To properly communicate technical information about objects that must be manufactured, fluency in the universal language of technical drawing is required. One of the first steps to learning this language is developing the ability to sketch.

Visualizing, communicating, exploring, and documenting ideas occur throughout the process of design. The process begins when a client and an engineer meet for the first time to define a problem; when research requires field measurements to be taken so that a scenario can be replicated; when an idea occurs during lunch and must be quickly recorded on a napkin before it is lost; when teams of people feed off each other's ideas and brainstorm possible solutions; when an engineer works out the details of a design solution so that it can be prototyped and tested; and when a solution has been proven to work and must be documented for reproduction.

Technical sketching differs from technical drawing: technical sketches are made with a pencil, paper, and an idea, while technical drawing advances a sketch to follow specific technical drawing guidelines that employ the use of tools, such as isometric graph paper and the aid of a computer. Likewise, technical sketching differs from artistic sketching. Technical sketches follow the same standards that govern the development of technical drawings except the sketches are done freehand.

As they advance in their experiences and skills through the course, students will learn basic rules of technical sketching in this lesson and will learn the drawing standards that apply. The understanding of technical sketching is critical for designers when effectively conveying their ideas about a product. Sketching is the beginning stage of product development. Students will learn how to sketch isometric, oblique, perspective, and multi-view sketches of various objects.

Standards Addressed

Standards for Technological Literacy

Students will develop the abilities to apply the design process.
Students will develop an understanding of and be able to select and use information and communication technologies.

Common Core State Standards for Mathematical Practice (HS)

Geometry

Modeling with Geometry

-Apply Geometric Concepts in Modeling Situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).* (G.MG.1)

Instructional Objectives

Students will be able to:

- Identify line types (including construction lines, object lines, hidden 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.
- Identify and define technical drawing representations including isometric, orthographic projection, oblique, and perspective views.
- Identify the proper use of each technical drawing representation including isometric, orthographic projection, oblique, and perspective views.
- Apply tonal shading to enhance the appearance of a pictorial sketch and create a more realistic appearance of a sketched 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 1-point and 2-point perspective pictorial views of a simple object or part given the object, a detailed verbal description of the object, a pictorial view of the object, and/or a set of orthographic projections.
- Select flat patterns (nets) that fold into geometric solid forms.
- 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 and isometric view of the object.
- 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.

Suggested Activities

2.1.A IsometricSketching.docx
2.1.A IsoOlbiqueSketchHandout.pdf
2.1.A LineConventionsHandout.docx
2.2.A PerspectiveSketching.docx
2.3.A GlassBox.docx

2.4.A MultiviewSketching.docx
2.5.A SketchingPractice.doc**x**

PowerPoint Presentations

2.1.A IsometricObliquePictorials.pptx
2.1.A LineConventions.pptx
2.2.A PerspectiveSketching.pptx
2.3.A GlassBoxAssembly.pptx
2.3.A MultiviewSketching.pptx

Suggested Assessment

Assessment throughout all units are consistent with the following:
Assessment consists of Real Time corrective assessment of work in progress for individuals and small groups. Students are also assessed by the activities for each assignment. Section 1 is to do the assigned task for each activity. Section 2 is to answer questions about what was learned in the activity. Some self-assessment and peer assessment are also included.

UNIT III: Measurement and Statistics

The practice of measuring is older than recorded history. Every human civilization throughout history developed its own measuring tools and, along with them, its own measuring standards. It was through the establishment of measuring tools and standards that the Egyptians were able to build their giant pyramids and the Romans were able to build their roads and aqueducts. Shared understanding and communication established through standardization played a key role in their successful outcome. Standardization is what allows many people to work individually on parts that come together to form a finished product or system. Without measurement standards, manufactured parts would not be interchangeable and mass production could not exist. Measurement is so important that the founding fathers of the United States included it in the Constitution, giving Congress the power to set uniform standards for weights and measures. Today, the American National Standards Institute serves as the unifying force system for the measurement used in the United States. This lesson provides an introduction to measurement through the study of linear distance and angles.

Since the beginning of science, scientists have realized that laws of nature are not bound to the borders between kingdoms or countries, and that uniform standards of measure form the foundation for changing the secrets of the universe into human knowledge. In the midst of the French Revolution, scientists developed a new system of measurement that was simple, logical, and well-suited to the needs of both scientists and engineers. Since its inception 220 years ago, the metric system has spread throughout the industrialized world and is now the international standard for acquiring and communicating measurements.

In this lesson students will learn about measurement and statistics. They will apply what they have learned through

- Reading English and metric scales
- Converting measurements between U S Customary and SI units
- Performing precision measurement using dial calipers
- Applying correct dimensioning techniques to technical drawings
- Recording data with proper precision
- Performing basic statistical analysis
- Creating graphs of statistical information

Standards Addressed

Common Core State Standards for English Language Arts

Reading

Comprehension and Collaboration

1. Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively. (AS.SL.1)
2. Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally. (AS.SL.2)
4. Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience. (AS.SL.4)

Standards for Technological Literacy

- Students will develop an understanding of the core concepts of technology.
- Students will develop an understanding of the attributes of design.
- Students will develop an understanding of engineering design.
- Students will develop the abilities to apply the design process.
- Students will develop the abilities to assess the impact of products and systems.

Common Core State Standards for Mathematical Practice (HS)

Number and Quantity

Quantities
-Reason Quantitatively And Use Units To Solve Problems.

1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (N.Q .1)
2. Define appropriate quantities for the purpose of descriptive modeling. (N.Q .2)
3. Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (N.Q .3)

Algebra

Creating Equations
Create Equations That Describe Numbers or Relationships

3. Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or non-viable options in a modeling context. *For example, represent inequalities describing nutritional and cost constraints on combinations of different foods.* (A.CED.3)

Geometry

Geometric Measurement and Dimension
Explain Volume Formulas and Use Them to Solve Problems

3. Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems.* (G.GMD.3)

Modeling with Geometry
Apply Geometric Concepts in Modeling Situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).* (G.MG.1)

Statistics and Probability

Interpreting Categorical and Quantitative Data
Summarize, Represent, and Interpret Data on a Single Count or Measurement Variable

1. Represent data with plots on the real number line (dot plots, histograms, and box plots). (S.ID.1)
4. Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve. (S.ID.4)

Instructional Objectives

Students will be able to:

- Identify general rules for dimensioning on technical drawings used in standard engineering practice. U5
- Distinguish between sample statistics and population statistics and know appropriate applications of each.
- Distinguish between precision and accuracy of measurement.
- Measure linear distances (including length, inside diameter, and whole depth) with accuracy using a scale, ruler, or dial caliper and report the measurement using an appropriate level of precision. U1
- Use units to guide the solution to multi-step problems through dimensional analysis and choose and interpret units consistently in formulas. U4
- Convert quantities between units in the SI and the US Customary measurement systems. U4

- Convert between different units within the same measurement system including the SI and US Customary measurement systems. U4
- Dimension orthographic projections of simple objects or parts according to a set of dimensioning standards and accepted practices. U5
- Identify and correct errors and omissions in the dimensions applied in a technical drawing based on accepted practice and a set of dimensioning rules. U5
- Calculate statistics related to central tendency including mean, median, and mode. U6
- Calculate statistics related to variation of data including (sample and population) standard deviation and range. U6
- Represent data with plots on the real number line (e.g., dot plots, histograms, and box plots). U6
- Use statistics to quantify information, support design decisions, and justify problem solutions. U6
- Use a spreadsheet program to store and manipulate raw data. U10
- 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.

Suggested Activities with PowerPoint Presentations

3.0.KT KeyTerms.docx
3.1.a.A LinearMeasurementSI.docx
3.1.b.A LinearMeasurementUS.docx
3.1.A MeasurementSI.pptx
3.1.b.A USMeasurement.pptx
3.2.A UnitConversion.docx
3.2.A UnitConversion.pptx
3.2.h.A UnitConversionHomework.docx
3.3.A MakingLinearMeasurements.docx
3.3.A ALTERNATE.docx
3.3.A DialCalipers.pptx
3.3.A SectionViewIntro.pptx
3.4.A LinearDimensions.docx
3.4.A IntroDimensioning.pptx
3.4.A.SR DimensioningGuidelines.docx
3.5.A AppliedStatistics.docx
3.5.A IntroSummaryStatistics.pptx
3.6.A InstantChallengeFlingMachine.docx
3.6.A InferentialStatistics.pptx
3.7.A StatisticalAnalysisExcel.docx
3.7.A StatisticalAnalysisExcel.pptx
3.7.A.SR AnalysisToolPakLoadingInstructions.docx
3.8.A PrecisionAccuracyMeasurement.docx
3.8.A PrecisionAccuracyMeasurement.pptx

3.8.A TheEmpiricalRule.pptx
3.9.A StatisticsQuality.docx
3.10.A InstantChallengeOilSpill.docx

Answer Keys
3.1.a.A.AK LinearMeasurementSIAnsKey.docx
3.1.b.A.AK LinearMeasurementUSAnsKey.docx
3.2.A.AK UnitConversionAnsKey.docx
3.2.h.A.AK UnitConversionHomeworkAnsKey.docx
3.3.A.AK ALTERNATEAnsKey.docx
3.3.A.AK MakingLinearMeasurementAnsKey.docx
3.4.A.AK LinearDimensionsAnsKey.docx
3.5.A.AK AppliedStatisticsAnsKey.docx
3.7.A.AK StatisticalAnalysisExcelAnsKey.docx
3.7.A.TN StatisticalAnalysisExamplesTEACHERSONLY.xlsx
3.8.A.AK PrecisionAccuracyMeasurmentAnsKey.docx

Suggested Assessment

Assessment throughout all units are consistent with the following:
Assessment consists of Real Time corrective assessment of work in progress for individuals and small groups.
Students are also assessed by the activities for each assignment.
Section 1 is to do the assigned task for each activity.
Section 2 is to answer questions about what was learned in the activity.
Some self-assessment and peer assessment are also included.

UNIT IV: Modeling Skills

Effectively applying a design process often involves a wide variety of modeling activities. During the initial phases of the design process, defining the problem and generating concepts brainstorming is often accompanied by concept modeling. Lists and mind maps are often used to document design ideas and concepts. As research is performed, graphical modeling and/or mathematical modeling can be used to represent gathered information. Graphical modeling can involve representing information in the form of charts, graphs, maps, or geometric figures. Mathematical modeling involves representing a phenomenon or behavior with an equation or a geometric representation. For instance, an environmental engineer who is developing a solution to handle and dispose of solid waste in an area for the next 20 years may wish to represent the volume of solid waste produced over the previous 20 years with a mathematical equation. The equation will allow the engineer to predict the waste production in the future.
Design ideas and alternatives are often modeled graphically. If the design solution involves a physical object, designers typically use sketching and drawing to represent design ideas. If the problem solution involves the design of systems or processes, charts, graphs, and maps may be employed to represent the proposed designs. Early in the design process, ideas are often sketched on paper for future refinement. As ideas are formalized, greater accuracy is required. This refinement may involve converting sketches to computer models and formal technical drawings.
Today, computers and software applications are tools often used in the solution of engineering problems. Computer modeling is frequently used to represent, analyze, document, and assess a design idea. Three-dimensional computer modeling of products allows designers to virtually create, manipulate, and test products and system prior to building and testing a physical model. A physical model is often desirable because it allows hands-on manipulation and testing of a product or system in its intended operating environment. However, computer modeling is especially helpful when building a physical model is difficult or expensive. For instance, in the case of large commercial and industrial buildings, which must be designed to carry a variety of load conditions, computer modeling provides an inexpensive means through which to model and test the load carrying capacity of the building structure. Or, if a chemical process is part of the design solution, a computer program can simulate the proposed process and efficiently allow adjustment of design factors (such as concentrations, temperature, and pressure) to hone in on a precise solution before large-scale physical testing is performed.
If the design process is applied to the design of a consumer product, it is almost always necessary to build a physical model for a variety of reasons. A physical model provides a representation of the design to which people can relate. They can see the design intent. And, when the physical model is built to the design specifications, the product can be used for the intended purpose and tested. In addition, physical models help potential consumers and investors understand the product and can improve the chances of gaining financial support and customers.

The testing phase of the design process can also involve a variety of modeling techniques. Before testing can be performed, the test(s) itself must be designed, which can require the use of concept, graphical, mathematical, computer and/or physical models. Physical models of the design are often used to allow testing of the actual product. Computer modeling is used to represent the product and test a design when physical testing is not feasible or is prohibitively expensive. The data gathered during the testing phase of the design process is often represented with graphical and/or mathematical modeling.
In this lesson students will learn how to create a product from conception to reality and will employ a variety of modeling techniques. They will do this by applying the design process steps first-hand in the creation of their product. Students will live the life of a product designer and create a solution to a problem that exists for a company.

Standards Addressed

Common Core State Standards for English Language Arts

Reading

Text Types and Purposes

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

Comprehension and Collaboration

2. Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally. (AS.SL.2)
4. Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience. (AS.SL.4)
5. Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations. (AS.SL.5)
6. Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate. (AS.SL.6)

Conventions of Standard English

1. Demonstrate command of the conventions of Standard English grammar and usage when writing or speaking. (AS.L.1)
3. Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening. (AS.L.3)
6. Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression. (AS.L.6)

Standards for Technological Literacy

Students will develop an understanding of the core concepts of technology.
Students will develop an understanding of the attributes of design.
Students will develop an understanding of engineering design.
Students will develop the abilities to apply the design process.
Students will develop the abilities to use and maintain technological products and systems.
Students will develop an understanding of and be able to select and use information and communication technologies.

Common Core State Standards for Mathematical Practice (HS)

Number and Quantity

Quantities
Reason Quantitatively And Use Units To Solve Problems.

1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (N.Q .1)
2. Define appropriate quantities for the purpose of descriptive modeling. (N.Q .2)

Algebra
Creating Equations
Create Equations That Describe Numbers or Relationships

2. Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (A.CED.2)

4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *For example, rearrange Ohm's law V = IR to highlight resistance R.* (A.CED.4)

Reasoning With Equations and Inequalities

Solve Equations and Inequalities in One Variable

3. Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. (A.REI.3)

-Represent and Solve Equations and Inequalities Graphically

10. Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line). (A.REI.10)

Functions

Interpreting Functions

Understand the Concept of a Function and Use Function Notation

1. Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If f is a function and x is an element of its domain, then f(x) denotes the output of f corresponding to the input x. The graph off is the graph of the equation y = f(x). (F.IF.1)

2. Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context. (F.IF.2)

-Interpret Functions That Arise In Applications In Terms Of the Context

5. Relate the domain of a function to its graph and, where applicable, to the quantitative

Relationship it describes. *For example, if the function h(n) gives the number of person-hours it takes to assemble n engines in a factory, then the positive integers would be an appropriate domain for the function.** (F.IF.5)

6. Calculate and interpret the average rate of change of a function (presented symbolically or as a table) over a specified interval. Estimate the rate of change from a graph.* (F.IF.6

Building Functions

Build a Function That Models a Relationship between Two Quantities

1. A. Determine an explicit expression, a recursive process, or steps for calculation from a context. (F.BF.1.a)

Linear, Quadratic, and Exponential Models
Interpret Expressions for Functions In Terms Of the Situation They Model

5. Interpret the parameters in a linear or exponential function in terms of a context. (F.LE.5)

Geometry

Modeling with Geometry
Apply Geometric Concepts in Modeling Situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).* (G.MG.1)

Statistics and Probability

Interpreting Categorical and Quantitative Data
Summarize, Represent, and Interpret Data on Two Categorical and Quantitative Variables

6. A. Fit a function to the data; use functions fitted to data to solve problems in the context of the data. *Use given functions or choose a function suggested by the context. Emphasize linear, quadratic, and exponential models.* (S.ID.6.a
6. c. fit a linear function for a scatter plot that suggests a linear association. (S.ID.6.c) -Interpret Linear Models

7. Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data. (S.ID.7)

Next Generation Science Standards

Engineering Design

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. (HS.ETS1.2)
HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of

constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. (HS.ETS1.3)
HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. (HS.ETS1.4)

Instructional Objectives

Students will be able to:

- 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.
- Be familiar with the terminology related to and the use of a 3D solid modeling program in the creation of solid models and technical drawings.
- Differentiate between additive and subtractive 3d solid modeling methods
- Develop and/or use graphical, computer, physical and mathematical models as appropriate to represent or solve problems.
- Fabricate a simple object from technical drawings that may include an isometric view and orthographic projections. U1, U5
- Create three-dimensional solid models of parts within CAD from sketches or dimensioned drawings using appropriate geometric and dimensional constraints. U1, U2
- Generate CAD multi-view technical drawings, including orthographic projections and pictorial views, as necessary, showing appropriate scale, appropriate view selection, and correct view orientation to fully describe a simple part according to standard engineering practice. U1, U2
- Construct a testable prototype of a problem solution. U1, U3
- Analyze the performance of a design during testing and judge the solution as viable or non-viable with respect to meeting the design requirements. U3
- Create a set of working drawings to detail a design project. U1, U2
- Organize and express thoughts and information in a clear and concise manner. U4
- Utilize project portfolios to present and justify design projects. U4
- Use a spreadsheet program to graph bi-variety data and determine an appropriate mathematical model using regression analysis. U1, U7
- Construct a scatter plot to display bi-variety data, investigate patterns of association, and represent the association with a mathematical model (linear equation) when appropriate. U1, U5
- Solve equations for unknown quantities by determining appropriate substitutions for variables and manipulating the equations. U6
- Use function notation to evaluate a function for inputs in its domain and interpret statements that use function notation in terms of a context. U7
- Build a function that describes a relationship between two quantities given a graph, a description of a relationship, or two input-output pairs. U1, U7

- Interpret a function to solve problems in the context of the data. U6, U7
- Interpret the slope (rate of change) and the intercept (constant term) of a linear function in the context of data. U1, U5
- Compare the efficiency of the modeling method of an object using different combinations of additive and subtractive methods. U2

Suggested Activities with PowerPoint Presentations

4.1.P PuzzleDesignChallenge.docx
4.1.P.RU PuzzleDesignChallengeRubric.docx
4.1.a.A PuzzlePartCombinations.docx
4.1.a.A PuzzlePartCombinationsExamples.docx
4.1.a.A Modeling.pptx
4.1.a.A PuzzlePartCombinationsExamples.docx
4.1.b.A GraphicalModeling.docx
4.1.c.A MathematicalModeling.docx
4.1.c.A MathematicalModeling.pptx
4.1.d.A SoftwareModelingIntroductionADDSTEAM.docx
4.1.e.A SoftwareModelingIntroductionVideo.docx
4.1.f.A SoftwareModelingIntroductionReference.docx
4.1.g.A ModelCreation.docx
4.1.g.A AdditiveSubtractiveModeling.pptx
4.1.h.A AssemblyConstraints.pptx
4.1.i.A CreatingDrawingsCAD.pptx
4.1.j.A Portfolios.pptx
4.2.A PuzzleCubePackageOptional.docx
4.2.A.RU PuzzleCubePackage.Rubric.docx

Answer Keys
4.1.a.A.AK PuzzlePartCombinationsAnswerKey.OLD.docx
4.1.c.A.AK MathematicalModelingAnsKey.docx
4.1.d.A.AK SoftwareModelingIntroductionADDSTEAMAnswerKey.docx
4.1.e.A.AK SoftwareModelingIntroductionVideoAnswerKey.docx
4.1.g.A.AK ModelCreationAnswerKey.docx

Suggested Assessment

Assessment throughout all units are consistent with the following:
Assessment consists of Real Time corrective assessment of work in progress for individuals and small groups.
Students are also assessed by the activities for each assignment.
Section 1 is to do the assigned task for each activity.
Section 2 is to answer questions about what was learned in the activity.
Some self-assessment and peer assessment are also included.

UNIT V: Geometry of Design

Geometric shapes are found everywhere. Take a moment to analyze products or objects you use every day. Geometric shapes and solids are the basis of these products. Engineers who have a strong understanding of these shapes, solids, and other geometric relationships can help designers develop and create solutions to a variety of problems. As designers progress through the design process and these design solutions are formalized, the level of accuracy and precision in the design specifications must increase. Conceptual sketches are converted to computer models and formal drawings, which include annotations describing the size and characteristics of the design features. A strong understanding of shapes and other geometric relationships is necessary to effectively and efficiently develop these computer and graphic representations. Designers have used Computer Aided Design (CAD) programs for decades to refine ideas and generate images that manufacturers and other professionals can use to make profitable solutions to problems. The development of three-dimensional CAD solid modeling programs has resulted in significant increases in the quality of complex designs while drastically reducing the amount of time needed to produce those designs. Some engineers feel that the development of three-dimensional CAD solid modeling programs has made engineering more engaging and fun not to mention more accurate and precise.

Today's software that employs parametric design functionality requires an understanding of geometric relationships, such as perpendicular, parallel, and tangent. Students will transfer their knowledge of geometric relationships to parametric modeling.

In this lesson students will apply the skills learned in prior units. They will learn how to calculate the area of two-dimensional shapes. Students will also learn how to calculate the surface area, volume, and weight of three-dimensional solids and the interaction of volume and weight to determine material density. Students will also improve their skill in the use of CAD modeling software to enhance their understanding of plane and solid geometry.

Standards Addressed

Common Core State Standards for English Language Arts

Reading
Comprehension and Collaboration

1. Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively. (AS.SL.1)
2. Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally. (AS.SL.2)

4. Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience. (AS.SL.4)
6. Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate. (AS.SL.6)

Conventions of Standard English

1. Demonstrate command of the conventions of Standard English grammar and usage when writing or speaking. (AS.L.1)
6. Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression. (AS.L.6)

Common Core State Standards for Mathematical Practice (HS)

Algebra

Creating Equations
-Create Equations That Describe Numbers or Relationships

1. Create equations and inequalities in one variable and use them to solve problems. *Include equations arising from linear and quadratic functions, and simple rational and exponential functions.* (A.CED.1)
4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *For example, rearrange Ohm's law V = IR to highlight resistance R.* (A.CED.4)

Reasoning With Equations and Inequalities
-Solve Equations and Inequalities in One Variable

3. Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. (A.REI.3)
4.b. Solve quadratic equations by inspection (e.g., for $x^2 = 49$), taking square roots, completing the square, the quadratic formula and factoring, as appropriate to the initial form of the equation. Recognize when the quadratic formula gives complex solutions and write them as $a \pm bi$ for real numbers a and b. (A.REI.4.b)

Geometry

Geometric Measurement and Dimension
-Visualize Relationships Between Two-Dimensional and Three-Dimensional Objects

4. Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects. (G.GMD.4)

Modeling with Geometry
-Apply Geometric Concepts in Modeling Situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).* (G.MG.1)
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).* (G.MG.2)
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).* (G.MG.3)

Standards for Technological Literacy

Students will develop an understanding of the attributes of design.
Students will develop the abilities to use and maintain technological products and systems.
Students will develop an understanding of and be able to select and use information and communication technologies.

Instructional Objectives

Students will be able to:

- Identify types of polygons including a square, rectangle, pentagon, hexagon, and octagon.
- Differentiate between inscribed and circumscribed shapes.
- Identify and differentiate geometric constructions and constraints (such as horizontal lines, vertical lines, parallel lines, perpendicular lines, collinear points, tangent lines, tangent circles, and concentric circles) and the results when applied to sketch features within a 3D solid modeling environment.
- Distinguish between the meanings of the terms weight and mass.
- Define the term “physical property” and identify the properties of length, volume, mass, weight, density, and surface area as physical properties.

- Identify three-dimensional objects generated by rotations of two-dimensional shapes and vice-versa.
- 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. U1, U2
- Create three-dimensional solid models of parts within CAD from sketches or dimensioned drawings using appropriate geometric and dimensional constraints and model features. U1, U3
- Measure mass with accuracy using a scale and report the measurement using an appropriate level of precision. U2
- Measure volume with accuracy and report the measurement with an appropriate level of precision. U2
- 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). U2
- Solve volume problems using volume formulas for rectangular solids, cylinders, pyramids, cones, and spheres. U2
- Use physical properties to solve design problems (e.g., design an object or structure to satisfy physical constraints or minimize cost). U2
- 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.

Suggested Activities with PowerPoint Presentations and PDF's

5.0.KT KeyTerms.docx
5.1.A CalculatingPropertiesShapes.docx
5.1.A GeometricShapesArea.pptx
5.2.a.A Geometric Constraints.docx
5.2.a.A.SR GeometricConstraints.idw
5.2.b.A IntroductionToCADModelingSkills.docx
5.2.A WorkPointsAxesPlanes.pptx
5.2.b.A.SR AutomobloxT9DimDwgs.docx
5.3.A DeterminingDensity.docx
5.3.A.SR DensityUseCommonMaterialsChart.docx
5.3.A.SR DeterminingDensityDelrinBallMcMasterCarr0.pdf
5.3.A.SR DeterminingDensitySteelBallMcMasterCarr02.pdf

5.3.A.SR DeterminingDensityTitaniumMcMasterCarr01.pdf
5.3.A.SR DeterminingDensityWoodDensities.pdf
5.4.A CalculatingPropertiesSolids.docx
5.4.A PropertiesGeometricSolids.pptx
5.5.a.A CADModelFeatures.docx
5.5.A.b CADModelFeatures.docx
5.6.A .PhysicalPropertyAnalysis.docx
5.6.A PhysicalPropertyAnalysis.pptx
5.7.A InstantChallengeChoremaster.docx

Answer Keys
5.1.A.AK CalculatingPropertiesShapesAnsKey.docx
5.3.A.AK DeterminingDensityAnsKey.docx
5.4.A.AK CalculatingPropertiesSolidsAnsKey.docx
5.6.A.AK PhysicalPropertyAnalysisAnsKey.docx

Suggested Assessment
Assessment throughout all units are consistent with the following:
Assessment consists of Real Time corrective assessment of work in progress for individuals and small groups.
Students are also assessed by the activities for each assignment.
Section 1 is to do the assigned task for each activity.
Section 2 is to answer questions about what was learned in the activity.
Some self-assessment and peer assessment are also included.

UNIT VI: Reverse Engineering

Reverse Engineering is an important process in the documentation and redesign of products. Through reverse engineering all aspects of a product can be analyzed. There are many reasons to reverse engineer a product. The information gathered during this process can provide information on products for which documentation has been lost. Reverse engineering can help the designer or team determine what they can do to make the product better and optimize manufacturing potential to increase company profits. Often, reverse engineering is necessary in order to provide details necessary to provide interoperability between existing and new products or to provide information on competitor products.

The process of Reverse Engineering involves analyzing the product's function, structure, and visual elements. In this unit, students will get an opportunity to assess all three aspects of a product.

Visual design principles and elements constitute a language that can be used to describe any object without reference to its function or formal title. It is important for engineers, as well as other design professionals, to have an understanding of visual design principles and elements in order to control the visual impact of the products and spaces that they create. Students will learn the basic terminology essential to the understanding of the visual language of design in order to communicate what they see and design visually impactful products.

Students will perform a functional analysis through non-destructive methods of observation – the product under investigation will remain intact. As part of the functional analysis students will then generate hypotheses of the sequential operations of their products, and identify the inputs and outputs that are indicative of those systems.

As a final step in the reverse engineering process, students will physically disassemble a product and document the constituent parts, their properties, and their operation with the intent of providing students with a better understanding of the product's strengths, weaknesses and the manufacturing processes used in manufacturing.

Standards Addressed

Common Core State Standards for English Language Arts

Reading

Text Types and Purposes

1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence. (AS.W.1)

2. Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content. (AS.W.2)
4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (AS.W.4)
10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences. (AS.W.10)

Comprehension and Collaboration

1. Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively. (AS.SL.1)
2. Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally. (AS.SL.2)
4. Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience. (AS.SL.4)
5. Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations. (AS.SL.5)

Conventions of Standard English

6. Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression. (AS.L.6)

Standards for Technological Literacy

Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.
Students will develop the abilities to use and maintain technological products and systems.

Instructional Objectives

Students will be able to:

- Identify and describe the visual principles and elements of design apparent in a natural or man-made object.
- Describe the process of reverse engineering.

- Explain the various reasons to perform reverse engineering including discovery, documentation, investigation, and product improvement.
- Explain how the visual elements and principles of design affect the aesthetics and commercial success of a product.
- 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).
- Select and utilize technology (software and hardware) to create high impact visual aids.

Suggested Activities

6.0.KT KeyTerms.docx
6.1.A VisualPrinciplesElementsID.docx
6.1a.A VisualPrinciplesElementsMatrixTemplate.docx
6.1.A ElementsPrinciplesofDesign.pptx
6.1a.A.SR VisualPrinciplesElementsMatrixExample.docx
6.2.A VisualAnalysisAutomoblox.docx
6.2.A VisualAnalysisALTERNATE.docx
6.3.A FunctionalAnalysisAutomoblox.docx
6.3.A FunctionalAnalysisALTERNATE.docx
6.3.A ReverseEngineering.pptx
6.3.A SimpleMachinesOPTIONAL.pptx
6.3.A.SR ProductObservationExample.docx
6.4.A StructuralAnalysisAutomoblox.docx
6.4.A.SR ProductDisassemblyChart.docx
6.4.A.SR ProductDisassemblyMaterialUsageChart.docx
6.5.P ProductReverseEngneeringPresentation.docx
6.5.P.RU ProductReverseEngineeringPresentationRubr.docx

Suggested Assessment

Assessment throughout all units are consistent with the following:
Assessment consists of Real Time corrective assessment of work in progress for individuals and small groups.
Students are also assessed by the activities for each assignment.
Section 1 is to do the assigned task for each activity.
Section 2 is to answer questions about what was learned in the activity.
Some self-assessment and peer assessment are also included.

UNIT VII: Documentation

Effective communication of ideas and information has been a goal of humans since the beginning of time. There is evidence that even cavemen used symbols and drawings to convey and preserve information or ideas. These cave drawings have survived for centuries, but the message and intent of the drawings are unclear when people try to interpret them today. Varied interpretations of the same drawing have been made, ranging from an artistic attempt to a record of everyday life.

During the Industrial Revolution, early documentation of manufactured parts consisted of varying pictorial drawings with only a few dimensions. This method was adequate when a small group or an individual made all of the parts for the entire product. Verbal communication or personal knowledge was used to fill in the blanks. Manufacturing began to expand as companies started to specialize in different areas. Now, parts of machines are being created by different people in different companies, in different states, and eventually in different areas of the world. These individuals working in isolation do not understand how the parts that were being used will function in the overall project. The result is that many of the finished parts do not function properly. The solution was the development of standards that govern how the design of parts are dimensioned and tolerance in order to communicate effectively. These standards were developed from common, acceptable practices and continue to evolve to this day.

The drafting, dimensioning, and tolerance standards are a design language that allow designers too clearly and accurately communicate their ideas about form and function to people all over the world, regardless of what language they speak. It is important that everyone involved with the design process understands the proper documentation of technical drawings to insure that the design will achieve its full potential. Mistakes to technical drawings could be costly for a company and result in a loss of profit which could cost people jobs. Drafting standards are a language all their own. It is a language that every designer must understand and become fluent in using.

Standards Addressed

Common Core State Standards for English Language Arts

Reading

Text Types and Purposes

2. Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content. (AS.W.2)
6. Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others. (AS.W.6)
10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences. (AS.W.10)

Comprehension and Collaboration

1. Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively. (AS.SL.1)
2. Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally. (AS.SL.2)
4. Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience. (AS.SL.4)
5. Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations. (AS.SL.5)
6. Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate. (AS.SL.6)

Conventions of Standard English

1. Demonstrate command of the conventions of Standard English grammar and usage when writing or speaking. (AS.L.1)
2. Demonstrate command of the conventions of Standard English capitalization, punctuation, and spelling when writing. (AS.L.2)
3. Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening. (AS.L.3)
6. Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression. (AS.L.6)

Common Core State Standards for Mathematical Practice (HS)

Number and Quantity

Quantities
-Reason Quantitatively And Use Units To Solve Problems.

3. Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (N.Q .3)

Geometry

Geometric Measurement and Dimension
-Visualize Relationships Between Two-Dimensional and Three-Dimensional Objects

4. Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects. (G.GMD.4)

Modeling with Geometry
-Apply Geometric Concepts in Modeling Situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).* (G.MG.1)
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).* (G.MG.3)

Standards for Technological Literacy

Students will develop an understanding of the core concepts of technology.
Students will develop an understanding of the attributes of design.
Students will develop the abilities to apply the design process.
Students will develop the abilities to use and maintain technological products and systems.
Students will develop an understanding of and be able to select and use information and communication technologies.

Next Generation Science Standards

Engineering Design

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. (HS.ETS1.2)
HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. (HS.ETS1.3)
HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. (HS.ETS1.4)

Instructional Objectives

Students will be able to:

- 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.
- Generate section views using CAD according to standard engineering practice.
- Dimension a section view of a simple object or part according to a set of dimensioning standards and accepted practices.
- 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 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 pertain to information presented on the entire drawing (such as units, scale, patent details, etc.).
- Model and annotate (with a hole note) through, clearance, blind, counter bore, and countersink holes.
- Compare the effect of chain dimensioning and datum dimensioning on the tolerance of a particular specified dimension.
- 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.
- Identify the type of fit given a drawing, a description, or a physical example of two mating 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.
- Analyze information gathered during reverse engineering to identify shortcoming of the design and/or opportunities for improvement or innovation.
- 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.
- Support design ideas using a variety of convincing evidence.
- Jointly develop a decision matrix based on accepted outcome criteria and constraints.
- Clearly justify and validate a selected solution path.
- Create a set of working drawings to detail a design project.

Suggested Activities

7.0 KeyTerms.docx
7.1.A MoreDimensioning.docx
7.1.A DimensioningStandards.pptx
7.2.A SectionViews.docx
7.2.A AlternateViews.pptx
7.2.A HolesHoleNotes.pptx
7.3.A Tolerances.docx
7.3.A Tolerances.pptx
7.4.A AssemblyModels.docx
7.4.A AssemblyConstraintsLINKTOUNIT4FILE.pptx
7.4.A Documentation.pptx
7.5.P EngineeringDocumentationAutomoblox.docx
7.5.P EngineeringDocumentationALTERNATE.docx
7.6.A DesignBriefApollo13.docx
7.6.A WritingDesignBrief.pptx
7.6.A2 WritingProblemStatement.pptx
7.6.A1 CriteriaConstriaints.pptx
7.6.a.A.SR DesignBriefExample.docx
7.7.B AutomobloxProductEnhancement.docx
7.7.B.SR DesignBriefTemplate.docx
7.7.P.SR DecisionMatrixTemplateExcel.xlsx
7.7.B.SR DecisionMatrixTemplateWord.docx
7.7.a.B ProductImprovementALTERNATE.docx
7.7.B DecisionMatrix.pptx

7.7.B TechnicalWritingOPTIONAL.pptx

Answer Keys
7.1.A.AK MoreDimensioningAnsKey.docx
7.2.A.AK SectionViewsAnsKey.docx
7.3.A.AK TolerancesAnsKey.docx
7 6 A AK DesignBriefApollo13EXAMPLE.docx

Suggested Assessment

Assessment throughout all units are consistent with the following:
Assessment consists of Real Time corrective assessment of work in progress for individuals and small groups.
Students are also assessed by the activities for each assignment.
Section 1 is to do the assigned task for each activity.
Section 2 is to answer questions about what was learned in the activity.
Some self-assessment and peer assessment are also included.

UNIT VIII: Advanced Computer Modeling

Parameters-based computer modeling programs utilize the powerful mathematical capabilities of computers to store, maintain, modify, and update vast quantities of information. CAD solid modeling software bridge design intent and the resulting geometry by giving an engineer an opportunity to establish design parameters. Parameters establish the relationships between the geometric elements of a design and allow the computer to make significant modifications to multiple areas of a design simultaneously. This is what separates a solid modeling program from simpler CAD programs. Coupled with the ability to share design information through the internet with teammates and customers across the world, parameter-based computer modeling has proven itself to be a significant design tool.

Most devices are comprised of several components that work together. CAD solid modeling programs allow designers to simulate the interactions between the components of a design to forecast how the design will behave when it is actually manufactured. Students will use the computer to determine if interferences exist between assembled components. Once students have experienced assembling models, they may animate the models by driving their assembly constraints to verify the models' functional characteristics. Students may also learn how to use algebraic equations to drive multiple constraints simultaneously.

It is important that the parallels between CAD operations and manufacturing operations be identified as students learn how objects are created in a virtual environment. After all, designing a virtual object that cannot be built is a major problem.

This unit presents many of the 3D functions used to develop individual and assembly CAD solid models. Students will use these modeling skills to develop their design solutions to various projects and problems throughout the rest of the course. The goal of this lesson is to provide an opportunity for students to acquire the knowledge and experience to effectively utilize CAD as a design tool in an engineering design process.

Standards Addressed

Common Core State Standards for English Language Arts

Reading

Conventions of Standard English

6. Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression. (AS.L.6)

Standards for Technological Literacy

Students will develop an understanding of the attributes of design.
Students will develop an understanding of engineering design.
Students will develop the abilities to apply the design process.
Students will develop the abilities to use and maintain technological products and systems.
Students will develop an understanding of and be able to select and use information and communication technologies.

Common Core State Standards for Mathematical Practice (HS)

Algebra

Creating Equations
-Create Equations That Describe Numbers or Relationships

1. Create equations and inequalities in one variable and use them to solve problems. *Include equations arising from linear and quadratic functions, and simple rational and exponential functions.* (A.CED.1)
2. Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (A.CED.2)

Reasoning With Equations and Inequalities
-Solve Equations and Inequalities in One Variable

3. Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. (A.REI.3)

Functions

Linear, Quadratic, and Exponential Models
-Interpret Expressions for Functions In Terms Of the Situation They Model

5. Interpret the parameters in a linear or exponential function in terms of a context. (F.LE.5)

-Apply Geometric Concepts in Modeling Situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).* (G.MG.1)

Instructional Objectives

Students will be able to:

- Identify, define, and explain the proper use of an auxiliary view in technical drawing.
- Use advanced modeling features to create three-dimensional solid models of complex parts and assemblies within CAD and with little guidance given the actual part using appropriate geometric and dimensional constraints.
- Formulate equations and inequalities to represent relationships between quantities.
- Using a CAD application, create relationships among part features and dimensions using parametric formulas.
- Create an exploded assembly view of a multiple-part product. Identify each component of the assembly with identification numbers and create a parts list to detail each component using CAD.
- Perform a peer review of technical drawings and offer constructive feedback based on standard engineering practices.

Suggested Activities

8.0.KT KeyTerms.docx
8.1.P ModelButtonMaker.docx
8.1a.A MiniatureTrainOPTIONAL.docx
8.1b.A MiniatureTrainChangeOrdersOPTIONAL.docx
8.2.A ParametricConstraints.docx
8.2a.A ParametricConstraintsPractice.docx
8.2.A ParametricModeling.pptx
8.3.A AuxiliaryViews.docx(OPTIONAL)
8.3.A AuxiliaryViews.pptx
8.4.A WorkingDrawingsButtonMaker.docx
8.4a.A WorkingDrawingsMiniatureTrain.docx
8.4.A ExplodedCADAssemblyModels.pptx
8.6.A AnimatingAssemblyModelsExportingVideo.pptx

Answer Keys

8.2. A.AK ParametricConstraintsAnswerKey.docx
8.2a.A.AK ParametricConstraintsPracticeAnsKey.docx
8.3.A.AK AuxiliaryViewsAnsKey.docx

Suggested Assessment

Assessment throughout all units are consistent with the following:

Assessment consists of Real Time corrective assessment of work in progress for individuals and small groups.
Students are also assessed by the activities for each assignment.
Section 1 is to do the assigned task for each activity.
Section 2 is to answer questions about what was learned in the activity.
Some self-assessment and peer assessment are also included.

UNIT IX: Design Team

Design teams are increasingly separated by distance. This is driven by many reasons, including remaining competitive in an increasingly globalized economy and reducing expense and lost time due to travel. This separation requires a different approach than a design team who can meet face to face. In this unit you will learn and practice processes to solve a design problem with a geographically separate team.

The next time that you walk into a building, understand that the roof remains safely over your head because an engineer designed it and the final product was inspected to confirm that the construction met the design requirements. The same is true when you drive in a car, fly in an airplane, or consume food. Engineers create products that affect public safety and well-being. Because of this engineers have a high level of responsibility to society and require adherence to high ethical standards. In this unit students will experience shared decision-making as they investigate different materials, manufacturing processes, and the short and long term impacts that their decision-making may have on society or potentially on the world.

Standards Addressed

Common Core State Standards for English Language Arts

Reading

Key Ideas and Details

1. Read closely to determine what the text says explicitly and to make logical inferences from it;
Cite specific textual evidence when writing or speaking to support conclusions drawn from the text. (AS.R.1)
2. Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas. (AS.R.2)
3. Analyze how and why individuals, events, and ideas develop and interact over the course of a text. (AS.R.3)
4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone. (AS.R.4)
8. Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence. (AS.R.8)
10. Read and comprehend complex literary and informational texts independently and proficiently. (AS.R.10)

Text Types and Purposes

1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence. (AS.W.1)
2. Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content. (AS.W.2)
4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (AS.W.4)
6. Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others. (AS.W.6)
7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation. (AS.W.7)
8. Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism. (AS.W.8)
9. Draw evidence from literary or informational texts to support analysis, reflection, and research. (AS.W.9)
10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences. (AS.W.10)

Comprehension and Collaboration

1. Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively. (AS.SL.1)
2. Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally. (AS.SL.2)
4. Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience. (AS.SL.4)
5. Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations. (AS.SL.5)
6. Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate. (AS.SL.6)

Conventions of Standard English

1. Demonstrate command of the conventions of Standard English grammar and usage when writing or speaking. (AS.L.1)
2. Demonstrate command of the conventions of Standard English capitalization, punctuation, and spelling when writing. (AS.L.2)
3. Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening. (AS.L.3)
6. Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression. (AS.L.6)

Common Core State Standards for Mathematical Practice (HS)

Apply Geometric Concepts in Modeling Situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).* (G.MG.1)
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).* (G.MG.3)

Standards for Technological Literacy

Students will develop an understanding of the core concepts of technology.
Students will develop an understanding of the cultural, social, economic, and political
Students will develop an understanding of the effects of technology on the environment.
Students will develop an understanding of the attributes of design.
Students will develop an understanding of engineering design.
Students will develop the abilities to apply the design process.
Students will develop the abilities to use and maintain technological products and systems.
Students will develop an understanding of and be able to select and use information and communication technologies.

Next Generation Science Standards

<u>Engineering Design</u>

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. (HS.ETS1.2)
HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. (HS.ETS1.3)
HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. (HS.ETS1.4)

Instructional Objectives

Students will be able to:

- 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.
- Identify team member skill sets needed to produce an effective team.
- Define the term group norms and discuss the importance of norms in creating an effective team environment.
- Identify the advantages and disadvantages of virtual design teams compared to traditional design teams.
- Assess the development of an engineered product and the impact of the product on society and the environment.
- 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.
- Deliver organized oral presentations of work tailored to the audience.
- Organize and express thoughts and information in a clear and concise manner.
- Participate on a virtual team using remote collaboration tools to support team collaboration and problem solving.
- Identify appropriate technology to support remote collaboration among virtual design team members (such as asynchronous communications, audio and video conferencing, instant messaging, synchronous file editing, and file transfer).
- Demonstrate positive team behaviors and contribute to a positive team dynamic.

- Contribute equitably to the attainment of group goals based on assigned roles.
- Practice appropriate conflict resolution strategies within a team environment.
- 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. U8
- Create and utilize a Gantt chart to plan, monitor, and control task completion during a design project.
- Adjust voice and writing style to align with audience and purpose.
- Deliver organized oral presentations of work tailored to the audience.

Suggested Activities

9.0.KT KeyTerms.docx
9.1.A ProductLifecycleRecycle.docx
9.1.A GlobalHumanEthicalImpacts.pptx
9.1.A.RU ProductLifecycleRecycleRubric.docx
9.2.B DesignEthicsDesignBrief.docx
9.2a.B.SR DesignEthicsDesignBriefSample.docx
9.3.P VirtualDesignChallenge.docx
9.3.P GanttChart.pptx
9.3.P Teamwork.pptx
9.3.a.A.i VirtualDesignBrief.CoffeeShop.docx
9.3.a.A.ii VirtualDesignBrief.SpeakerSupport.docx
9.3.a.A.iii VirtualDesignBrief.AntiqueGoblet.docx
9.3.a.A.iv VirtualDesignBriefHappyMealToy.docx
9.3.a.A.v VirtualDesignBriefWoodenMechanical.docx
9.3.a.A.vi VirtualDesignBriefLockerOrganizer.docx
9.2b.B.SR DesignEthicsDesignBriefTemplate.docx
9.3.b.A.RU VirtualTeamingRubric.docx
9.3.c.A DesignProjectTallySheet.docx
9.3.d.A PeriodicTeammateTenPointEvaluation.docx
9.3.e.A PeriodicSelfEvaluation.docx
9.3.f.A.RU EngineeringNotebookRubric.docx
9.3.g.A EngineeringNotebookEvaluationItemized.docx
9.3.h.A EngineeringNotebookEvaluationBlank.docx
9.3.i.A SummaryPresentationEvaluation.docx
9.3.j.A TeammatePerformanceSummary.docx
9.3.k.A.RU DetailDrawingRubric.docx
9.3.l.A DecisionMatrixTemplateWord.docx
9.3.m.A DecisionMatrixTemplateExcel.xlsx
9.4.A TeamNorms.docx

9.5.A ProductResearch.docx
9.5.a.A ProductResearchSample.docx

Suggested Assessment
Assessment throughout all units are consistent with the following:
Assessment consists of Real Time corrective assessment of work in progress for individuals and small groups.
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Section 1 is to do the assigned task for each activity.
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Some self-assessment and peer assessment are also included.

UNIT X: Design Challenge

As time and technology have advanced, the process of designing products has become quicker, more precise, and more efficient, which enables changes to be made when needed. The process for getting a concept to a marketable solution is also being completed with higher quality and in far less time.

The design of solutions to problems is sometimes completed in teams. These teams work together, constantly communicating with each other, to create the desired product. The team may receive a problem and then must create a solution with very few constraints. This allows teams to think outside the box and use their imagination. The process of deriving solutions to these problems will vary from team to team. Designs are usually presented to supervisors or board members, and a single solution is then chosen.

In this unit students will work in teams of two. They will choose a problem from a list of design briefs and create a solution to the problem. Each team will apply the design process steps in the development of their solution. Students will work together as a product design team to create a solution to their chosen problem. The design challenges are written up in such a way that teams will experience a design work environment. Design challenges include redesigning a fluid power system, designing an executive desk set, as well as others. Students will then make plans to market their solution to the company.

Standards Addressed

Common Core State Standards for English Language Arts

Reading

Text Types and Purposes

6. Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others. (AS.W.6)
8. Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism. (AS.W.8)
9. Draw evidence from literary or informational texts to support analysis, reflection, and research. (AS.W.9)
10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences. (AS.W.10)

Comprehension and Collaboration

1. Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively. (AS.SL.1)
4. Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience. (AS.SL.4)
5. Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations. (AS.SL.5)
6. Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate. (AS.SL.6)

Conventions of Standard English

1. Demonstrate command of the conventions of Standard English grammar and usage when writing or speaking. (AS.L.1)
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Common Core State Standards for Mathematical Practice (HS)

Apply Geometric Concepts in Modeling Situations

1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).* (G.MG.1)
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).* (G.MG.3)

Standards for Technological Literacy

Students will develop an understanding of the core concepts of technology.
Students will develop an understanding of the attributes of design.
Students will develop an understanding of engineering design.
Students will develop the abilities to apply the design process.

Student will develop the abilities to use and maintain technological products and systems.
Students will develop an understanding of and be able to select and use information and communication technologies.

Next Generation Science Standards

Engineering Design

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. (HS.ETS1.2)
HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. (HS.ETS1.3)
HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. (HS.ETS1.4)

Instructional Objectives

Students will be able to:

Identify the steps in an engineering design process and describe the activities involved in each step of the process.
Develop and document an effective solution to a problem that meets specific design requirements. U1
Document and describe the design process used in the solution of a problem and reflect on all steps of the design process.

Suggested Activities

10.1.P DesignChallenges.docx
10.1.P.RU DesignChallengesRubric.docx
10.1. P.SR DecisionMatrixTemplateExcel.xlsx
10.1.P.SR DecisionMatrixTemplateWord.docx

Suggested Assessment

Assessment throughout all units are consistent with the following:
Assessment consists of Real Time corrective assessment of work in progress for individuals and small groups.
Students are also assessed by the activities for each assignment.

Section 1 is to do the assigned task for each activity.
Section 2 is to answer questions about what was learned in the activity.
Some self-assessment and peer assessment are also included.