Curriculum: Introduction to Engineering Design (PLTW)

Curricular Unit: Design Process

Instructional Unit: A. Develop an understanding of the broad field of engineering and a design process that engineers use to develop innovative solutions to real problems
- Apply the engineering design process to design a system, component, or process to meet desired needs within realistic constraints
- Understand the role and impact of engineering and engineering solutions within a global, economic, environmental, and societal context

**Standard Alignments (Section 2)**

| MGGLE: CD.8.A; PS.2.A,C; PS.3.A (9th Gr.) |
| Knowledge: (CA) 1,3,4,6 |
| NETS: 3a; 5b; 6 |
| Performance: 1.2, 1.4, 2.1, 2.3, 2.5-2.7, 3.2, 3.4-3.7, 4.4-4.8 |

**Unit (Section 3)**

**Learning Targets:**

- **Knowledge:**
  - Identify the steps in an engineering design process and describe the activities involved in each step of the process
  - 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

- **Skills:**
  - 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

Instructional Strategies:

• The teacher will:
  • facilitate:
    • collaboration
    • discussions about the Cable Car and Aerodynamic Distance challenge
      – Students will utilize the collaboration and discussions to practice brainstorming
  • model and guide students through the design process
    – Given teacher created scenarios, students will identify various steps in the design process
  • model the use of an engineering notebook
    – Students will practice those skills and industry standards while working in their engineering notebooks
  • Through research, students will identify the role and impact of engineering

Assessments/Evaluations:

• Formative:
  • Instant Challenge: Cable Car activity – Conclusion questions
  • Small group/class discussions: After presenting the essential question, “How might we create the best possible solution to a problem?” the teacher will consider student responses and preconceptions in order to inform effective teaching
  • Instant Challenge Aerodynamic Distance activity: Conclusion questions #1-3
  • Concept Sketching activity: Realistic and proportional representations in sketches
  • Product Improvement activity: Quantity and variety in brainstorming ideas
  • The Deep Dive activity:
    • Appropriate classification of the tasks involved in a design process
    • Conclusion questions #1, 4-6
  • Discover Engineering activity:
    • Understanding of appropriate descriptions of the roles and responsibilities of civil, chemical, mechanical and electrical engineers
    • Conclusion questions #2,4
  • What Is It activity:
    • Thorough peer review of essay using a scoring guide
    • Incorporation of suggested changes by the author
  • Instant Challenge – Paper Bridge activity: Conclusion question #3
  • Design Innovation activity:
    • Appropriate classification of chosen design as invention or innovation
    • Appropriate research and documentation
    • Conclusion questions #2-4
• Unit assessment items: All items

• Summative:
  • Concept Sketching activity:
    • Realistic and proportional representations in sketches
    • Conclusion questions #1-4
  • Product Improvement activity:
    • Realistic and proportional representations in sketches
    • Conclusion questions #1-3
  • The Deep Dive activity: Conclusion questions #2,3
  • Discover Engineering activity: Conclusion questions #1,3
  • What Is It activity – assessed using a scoring guide
  • Instant Challenge – Paper Bridge activity:
    • Effective use and documentation of the design process (engineering notebook)
    • Design meets constraints and criteria of problem
    • Conclusion questions # 1,2
  • Design Innovation activity: Conclusion question #1
  • Unit assessment items: All items
  • EoC: All items

Sample Assessment Questions:

• When solving an engineering problem, how can we be reasonably sure that we have created the BEST solution possible? What is the evidence?
• What is the most effective way to generate potential solutions to a problem? How many alternate solutions are necessary to ensure a good final solution?
• What engineering accomplishment of the 20th century has had the greatest impact on society? Justify your answer.
• What will be the biggest impact that engineering will have on society and your life in the 21st century? Justify your answer.
• Engineering tends to be a male-dominated profession. Why is that?

Instructional Resources/Tools:

• A1.1 Instant Challenge: Cable Car
• A1.2 Instant Challenge: Aerodynamic Distance
• A1.3 Concept Sketching
• A1.4 Product Improvement
• A1.5 Deep Dive
• A1.6 Discover Engineering
• A1.6b Engineering and Related STEM Careers (Optional)
• A1.7 What Is It?
• A1.8 Instant Challenge: Paper Bridge
• A1.9 Design Innovation

Cross Curricular Connections:

• ELA:
  • Reading
- Writing
- Speaking and listening

**Depth of Knowledge (Section 5)**

DOK: 4
Curriculum: Introduction to Engineering Design (PLTW)

Curricular Unit: Technical Sketching and Drawing

Instructional Unit: B. Develop an understanding of the purpose and practice of visual representations and communication within engineering

- Use the accepted practices and techniques of engineering graphics and technical drawings to clearly convey information and ideas
- Proficiently apply spatial skills to conceptualize and understand objects in 3D space and visualize and understand mental rotation of objects and how they appear in different positions

Standard Alignments (Section 2)

| VAGLE: PP.1.A (HS Level 1); EP.1.A,F,G (HS level 4); EP.2.C,F (HS level 4) |
| Knowledge: (CA) 1,3,4,6 (MA) 2,4 |
| CCSS: 9-10.SL.1; 9-10.SL.6; 9-10.RST.4; G-MG.1 |
| NETS: 5b; 6 |
| Performance: 1.5, 2.5-2.7, 3.4, 4.4, 4.5, 4.8 |

Unit (Section 3)

Learning Targets:

- Knowledge:
  - 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

- Skills:
  - 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
Choose and justify the choice for the best orthographic projection of an object to use as a front view on technical drawings

Instructional Strategies:

- The teacher will:
  - model different line types
  - create instructional videos to demonstrate 2- and 3-dimensional sketching skills.
  - Students will utilize:
    - direct instruction
    - instructional videos
to create a variety of technical drawings

Assessments/Evaluations:

- Formative:
  - Isometric Sketching activity: Peer/teacher assessment of sketching tasks 4-8
  - Small group/class discussion (essential question 1): The teacher will consider student responses and preconceptions in order to inform effective teaching
  - Perspective Sketching activity:
    - Peer/teacher assessment of sketching tasks 3-5
    - Conclusion questions 1-2
  - Class discussion (essential question 2): The teacher will consider student responses and preconceptions in order to inform effective teaching
  - Glass Box activity: Conclusion questions
  - Multi-View Sketching activity:
    - Peer/teacher assessment of sketching tasks 3-5
    - Conclusion questions 1-2
  - Sketching Practice activity: Conclusion questions
  - Small group/class discussion (essential questions 3,4): The teacher will consider student responses and preconceptions in order to inform effective teaching
  - Interim/common assessment: All items

- Summative:
  - Isometric Sketching activity:
    - Essential question 1
    - Additional sketches from #6,8
    - Conclusion questions
  - Perspective Sketching activity:
    - Additional sketches of puzzle pieces or from #5
    - Conclusion question 3
  - Multi-View Sketching:
    - Conclusion question 3-5
    - Additional sketches from Extending Your Learning
  - Sketching activity: All tasks and conclusion questions
  - Interim/common assessment: All items
  - Summative – EoC: All items
Sample Assessment Questions:

- How is technical drawing similar to and different from artistic drawing?
- What can cause a technical drawing to be misinterpreted or to be inadequate when conveying the intent of a design to someone unfamiliar with the original problem or solution?
- In what ways can technical drawings help or hinder the communication of problem solution in a global community?
- Strong spatial-visualization skills have been linked to success in engineering. Why are spatial-visualization skills so important to engineering success?

Instructional Resources/Tools:

- A2.1 Isometric Sketching
- A2.2 Perspective Sketching
- A2.3 Glass Box
- A2.4 Multi-View Sketching
- A2.5 Sketching Practice

Cross Curricular Connections:

- ELA:
  - Reading
  - Writing
  - Speaking and listening
- Math:  Modeling with geometry

**Depth of Knowledge (Section 5)**

DOK: 4
Curriculum: Introduction to Engineering Design (PLTW)

Curricular Unit: Measurement and Statistics

Instructional Unit: C. Apply appropriate practice and applications of measurement and statistics within the discipline of engineering

- Analyze and interpret data in order to make valid and reliable claims or determine optimal design solutions
- Apply mathematics and computational thinking (specifically ratios, rates, percentages, and unit conversions) to solve problems involving quantities and units

**Standard Alignments (Section 2)**

<table>
<thead>
<tr>
<th>MGGL:</th>
<th>PS.2.A,C; PS.3.A</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCCLE:</td>
<td>SC7.1.B,C</td>
</tr>
<tr>
<td>VAGLE:</td>
<td>PP.1.C (HS level 4)</td>
</tr>
<tr>
<td>Knowledge:</td>
<td>(CA) 1,3,4,6 (MA) 1-5</td>
</tr>
<tr>
<td>CCSS:</td>
<td>9-10.W.10; 9-10.SL.1; 9-10.L.6; 9-10.RST.4; 9-10.RST.7; 9-10.WHST.10; N-Q.1; N-Q.2; N-Q.3 A-CED.3; G-MG.1; S-ID.1; S-ID.4</td>
</tr>
<tr>
<td>NETS:</td>
<td>1a-c; 2b,d; 4a,b; 5; 6</td>
</tr>
<tr>
<td>Performance:</td>
<td>1.4, 1.6, 1.8, 2.7, 3.4, 3.5, 4.1, 4.4-4.6, 4.8</td>
</tr>
</tbody>
</table>

**Unit (Section 3)**

Learning Targets:

- Knowledge:
  - Identify general rules for dimensioning on technical drawings used in standard engineering practice
  - Distinguish between sample statistics and population statistics and know appropriate applications of each
  - Distinguish between precision and accuracy of measurement

- Skills:
  - 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
• Calculate statistics related to variation of data including (sample and population)
standard deviation and range
• 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
• Use a spreadsheet program to:
  • store and manipulate raw data
  • perform calculations using formulas
  • create and display a histogram to represent a set of data
• Use function tools within a spreadsheet program to calculate statistics for a set of
data including mean, median, mode, range, and standard deviation
• Use the Empirical Rule to interpret data and identify ranges of data that include
68 percent of the data, 95 percent of the data, and 99.7 percent of the data given
the appropriate descriptive statistics
• Choose a level of precision and accuracy appropriate to limitations on
measurement when reporting quantities
• Evaluate and compare the accuracy and precision of different measuring devices

Instructional Strategies:

• The teacher will:
  • model different measuring devices. Students will precisely measure a variety of
objects
  • Create instructional videos to demonstrate dimensioning 2-dimensional multi-
view drawings. Students will utilize:
    • direct instruction
    • instruction videos
    • collaboration
to dimension various multi-view drawings

Assessments/Evaluations:

• Formative:
  • Linear Measurement with Metric Units activity:
    • Tasks #9 and #10
    • Conclusion questions
  • Linear Measurement with US Customary Units activity:
    • Peer/teacher assessment of Tasks #10 and #11
    • Conclusion questions
  • Journal Entry (essential question 2): The teacher will consider student responses
and preconceptions in order to inform effective teaching
  • Unit Conversion activity: Conclusion questions
  • Journal entry (essential question 4): The teacher will consider student responses
and preconceptions in order to inform effective teaching

- Making Linear Measurements activity:
  - Optional task from #5
  - Conclusion questions
- Making Linear Measurements ALTERNATE activity: Conclusion questions
- Linear Dimensions activity:
  - Peer/teacher assessment of task #10
  - Conclusion questions
- Class discussion (essential question 5): The teacher will consider student responses and preconceptions in order to inform effective teaching
- Applied Statistics activity: Conclusion questions
- Statistical Analysis with Excel (Statistical Analysis Examples) activity:
  - Peers compare results of parts 2 and 3
  - Conclusion questions
- Small group/class discussion or journal entry (essential questions 3,6): The teacher will consider student responses and preconceptions in order to inform effective teaching
- Small group/class discussion (essential questions 1): The teacher will consider student responses and preconceptions in order to inform effective teaching
- Instant Challenge: Oil Spill (optional): Conclusion questions
- Unit Assessment Items: All items

- Summative:
  - Linear Measurement with Metric Units activity: Tasks similar to #9,10
  - Linear Measurement with US Customary Units activity: Tasks similar to #10,11
  - Unit Conversion homework activity: Peer/teacher evaluation of all tasks
  - Making Linear Measurements activity: Optional task from #5
  - Making Linear Measurements ALTERNATE activity: Optional task from A 3.3 #5
  - Linear Dimensions activity:
    - Extend Your Learning #11-13
    - Follow instructions for #8 with another puzzle cube piece
  - Applied Statistics activity: Follow instructions for #2 with alternate Automoblox data
  - Instant Challenge: Fling Machine activity: Conclusion questions
  - Statistical Analysis with Excel (Statistical Analysis Examples) activity:
    - Conclusion question 1
  - Statistics and quality activity: Peer/teacher assessment of all tasks
  - Units Assessment items: All items
  - Summative – EoC: All items

Sample Assessment Questions:

- Can statistics be interpreted to justify conflicting viewpoints? Can this affect how we use statistics to inform, justify and validate a problem solution?
- Why is error unavoidable when making a measurement?
- When recording measurement data, why is the use of significant figures important?
- What strategy would you use to teach another student how to use units and quantitative reasoning to solve a problem involving quantities?
- What would happen if engineers did not follow accepted dimensioning standards and guidelines but, instead, used their own individual dimensioning methods?
- When measuring the length of a part, would an inaccurate (but precise) measuring instrument be more or less likely to indicate the actual measurement than an imprecise (but accurate) measuring instrument? Justify your answer

**Instructional Resources/Tools:**

- A3.1a Linear Measurement with Metric Units
- A3.1b Linear Measurement with US Customary Units
- A3.2 Unit Conversion
- A3.2h Unit Conversion Homework
- A3.3 Making Linear Measurements
- A3.3 Making Linear Measurements ALTERNATE
- A3.4 Linear Dimensions
- A3.5 Applied Statistics
- A3.6 Instant Challenge: Fling Machine
- A3.7:
  - Statistical Analysis with Excel
  - Statistical Analysis Examples
- A3.8 Precision and Accuracy of Measurement
- A3.9 Statistics and Quality
- A3.10 Instant Challenge: Oil Spill (optional)

**Cross Curricular Connections:**

- **ELA:**
  - Reading
  - Writing
  - Speaking and listening
- **Math:**
  - Quantities
  - Creating equations
  - Modeling with geometry
  - Interpreting categorical and quantitative data

**Depth of Knowledge (Section 5)**

DOK: 4
Curriculum: Introduction to Engineering Design (PLTW)

Curricular Unit: Modeling Skills

Instructional Unit: D. Apply modeling methods and formats used to represent systems, components, processes and other designs

- Use the engineering design process to design a system, component, or process to meet desired needs within realistic constraints
- Create and use mathematical/computational models or simulations to represent design solutions or support explanations
- Develop and use multiple types of models to analyze systems, components or processes and/or to solve problems
- Use current engineering tools (e.g., spreadsheet software, CADD software) in problem solving and engineering design

**Standard Alignments (Section 2)**

<table>
<thead>
<tr>
<th>MGGLE: PS.3.A</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAGLE: PP.1.A (HS level 1); PP.1.C (HS level 4); EP.1.A,F,G (HS level 4); EP.2.A-F (HS level 4)</td>
</tr>
<tr>
<td>Knowledge: (CA) 1,3,4,6 (MA) 1-5</td>
</tr>
<tr>
<td>CCSS: 9-10.W.2a,b,d-f; 9-10.W.4; 9-10.W.10; 9-10.SL.5; 9-10.L.1; 9-10.L.2c; 9-10.L.6; 9-10.RST.4; 9-10.RST.7; 9-10.WHST.2a,b,d-f; 9-10.WHST.4; 9-10.WHST.10; N-Q.1; N-Q.2; N-Q.3; A-SSE.1a; A-CED.1; A-CED.2; A-CED.4; A-REI.3; A-REI.10; F-IF.1; F-IF.2; F-IF.5; F-IF.6; F-IF.7a; F-BF.1; F-LE.5; G-MG.1; G-MG.3; S-ID.6.a,c; S-ID.7; S-ID.8; S-IC.1</td>
</tr>
<tr>
<td>NETS: 1a-c; 2b,d; 4a,b; 5; 6</td>
</tr>
<tr>
<td>Performance: 1.4, 1.6-1.8, 2.1, 2.3, 2.6, 2.7, 3.2, 3.5-3.7, 4.1, 4.4-4.6, 4.8</td>
</tr>
</tbody>
</table>

**Unit (Section 3)**

Learning Targets:

- Knowledge:
  - 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

- Skills:
  - 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 orthogonal projections
  - 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
- Construct a testable prototype of a problem solution
- Analyze the performance of a design during testing and judge the solution as viable or non-viable with respect to meeting the design requirements
- Create a set of working drawings to detail a design project
- Organize and express thoughts and information in a clear and concise manner
- Utilize project portfolios to present and justify design projects
- Use a spreadsheet program to graph bivariate data and determine an appropriate mathematical model using regression analysis
- Construct a scatter plot to display bivariate data, investigate patterns of association, and represent the association with a mathematical model (linear equation) when appropriate
- Solve equations for unknown quantities by determining appropriate substitutions for variables and manipulating the equations
- Use function notation to evaluate a function for inputs in its domain and interpret statements that use function notation in terms of a context
- Build a function that describes a relationship between two quantities given a graph, a description of a relationship, or two input-output pairs
- Interpret a function to solve problems in the context of the data
- Interpret the slope (rate of change) and the intercept (constant term) of a linear function in the context of data
- Compare the efficiency of the modeling method of an object using different combinations of additive and subtractive methods

Instructional Strategies:

- The teacher will model different:
  - tools for manipulating and analyzing data
  - methods for CAD software modeling
- Students will utilize direct instruction with:
  - instructional videos
  - peer collaboration
to design and create a puzzle cube

Assessments/Evaluations:

- Formative:
  - Class discussion (essential question 1): The teacher will consider student responses and preconceptions in order to inform effective teaching
  - Puzzle Part Combinations activity:
    - Puzzle piece sketches
    - Conclusion questions
  - Graphical Modeling activity: Peer review of sketches per Task #6
- Mathematical Modeling activity: Peers will compare/correct answers to Parts 2,3
- Small group/class discussion (essential question 3): The teacher will consider student responses and preconceptions in order to inform effective teaching
- Software Modeling Introduction (Digital STEAM) activity: Conclusion questions
- Software Modeling Introduction (video download) activity: Conclusion questions
- Model Creation activity:
  - Peers will compare physical properties of 3D models in “Inventor” and identify mistakes
  - Conclusion questions
- Puzzle Cube Package (optional) activity: Conclusion questions
- Unit Assessment Items: All items

**Summative:**
- Puzzle Design Challenge project – assessed using:
  - a scoring guide
  - conclusion questions
- Mathematical Modeling activity: Conclusion questions
- Model Creation activity: Student modeling of a simple solid object similar to those included in activity from a dimensioned isometric view
- Journal entry (essential question 3): The teacher will assess student responses
- Puzzle Cube Package (optional) activity: Scoring guide
- Unit Assessment Items: All items
- Summative – EoC: All items

**Sample Assessment Questions:**

- How should one decide what information and/or artifacts to include in a portfolio? Should a portfolio always include documentation on the complete design process?
- Did you use every possible type of model during the design and construction of your puzzle cube? Describe each model that you used?
- How reliable is a mathematical model?

**Instructional Resources/Tools:**

- P4.1 Puzzle Design Challenge
- A4.1a Puzzle Part Combinations
- A4.1b Graphical Modeling
- A4.1c Mathematical Modeling
- A4.1d Software Modeling Introduction (Digital STEAM)
- A4.1e Software Modeling Introduction (video download)
- A4.1f Software Modeling Introduction Reference
- A4.1g Model Creation
- A4.2 Puzzle Cube Package (optional)

**Cross Curricular Connections:**

- ELA:
  - Reading
  - Writing
  - Speaking and listening
• Math:
  • Quantities
  • Seeing structure in expressions
  • Creating equations
  • Reasoning with equations and inequalities
  • Interpreting functions
  • Building functions
  • Linear, quadratic and exponential models
  • Modeling with geometry
  • Interpreting categorical and quantitative data

**Depth of Knowledge (Section 5)**

DOK: 4
Curriculum: Introduction to Engineering Design (PLTW)

Curricular Unit: Geometry Design

Instructional Unit: E. Apply two- and three-dimensional geometric concepts and knowledge to problem solving and engineering design

- Use current engineering tools (e.g., spreadsheet software, CADD software) to create models, solve problems and perform engineering design
- Apply geometric concepts and methods to describe and model objects and solve problems

**Standard Alignments (Section 2)**

<table>
<thead>
<tr>
<th>MGGLE: PS.2.A,C; PS.3.A</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAGLE: PP.1.C (HS level 4)</td>
</tr>
<tr>
<td>Knowledge: (CA) 1,3,4,6 (MA) 1-5</td>
</tr>
<tr>
<td>CCSS: 9-10.SL.1; 9-10.SL.6; 9-10.L.6; 9-10.RST.3; 9-10.RST.4; N-Q.2; N-Q.3; A-CED.4; A-REI.3; A-REI.4b; G-GMD.3; G-GMD.4; G-MG.1; G-MG.2; G-MG.3</td>
</tr>
<tr>
<td>NETS: 1a-c; 2b,d; 4a,b; 5; 6</td>
</tr>
<tr>
<td>Performance: 1.4, 1.8, 2.5, 2.7, 3.1, 3.4-3.6, 4.4-4.6, 4.8</td>
</tr>
</tbody>
</table>

**Unit (Section 3)**

**Learning Targets:**

**Knowledge:**
- 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

**Skills:**
- 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
- Create three-dimensional solid models of parts within CAD from sketches or dimensioned drawings using appropriate geometric and dimensional constraints
and model features

• Measure mass with accuracy using a scale and report the measurement using an appropriate level of precision
• Measure volume with accuracy and report the measurement with an appropriate level of precision
• 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
• Use physical properties to solve design problems (e.g., design an object or structure to satisfy physical constraints or minimize cost)
• 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

Instructional Strategies:

• The teacher will:
  • model mathematical problems. Students will solve problems involving area, surface area and volume
  • model different methods for CAD software modeling. Students will utilize:
    • direct instruction
    • instructional videos
to build a 3-dimensional model of the automoblox truck using Inventor software

Assessments/Evaluations:

• Formative:
  • Journal entry (essential question 2): The teacher considers student responses and preconceptions in order to inform effective teaching
  • Calculating Properties of Shapes activity: Peers will compare answers for task #10
  • Introduction to CAD Modeling Skills activity: Conclusion questions
  • Determining Density project: Peers will compare answers and make corrections to extend your learning task responses
  • Calculating Properties of Solids activity: Peers compare answers and make corrections to all tasks
  • CAD Model Features Parts 1 and 2 activities: Peer review and comparison of 3D model(s) including physical properties
  • Physical Property Analysis activities: Peers compare answers, identify errors and correct mistakes
  • Small group/class discussion (essential questions 2 and 3): The teacher will consider student responses and preconceptions in order to inform effective teaching
- Instant Challenge – Choremaster activity: Conclusion questions
- Unit Assessment Items: All items

**Summative:**
- Calculating Properties of Solids activity: Conclusion questions
- Geometric Constraints activity: Conclusion questions
- Determining Density project:
  - Conclusion questions
  - Students will determine the density of a teacher-supplied object made of unknown material and make a prediction of that material
- Calculating Properties of Solids activity: Conclusion questions
- CAD Model Features Parts 1 and 2 activities: Conclusion questions
- Physical Property Analysis activities:
  - Construct a teacher-created 3D model and answer questions similar to those for examples 1-3
  - Conclusion questions
- Unit Assessment Items: All items
- Summative – EoC: All items

**Sample Assessment Questions:**

- What advantage(s) do Computer Aided Design (CAD) and Drafting provide over traditional paper and pencil design? What advantages does paper and pencil design provide over CAD?
- Which high school math topic/course, Algebra or Geometry, is more closely related to engineering? Justify your answer.
- How does the material chosen for a product impact the design of the product?

**Instructional Resources/Tools:**

- A5.1 Calculating Properties of Shapes
- A5.2a Geometric Constraints
- A5.2b Introduction to CAD Modeling Skills
- P5.3 Determining Density
- A5.4 Calculating Properties of Solids
- A5.5a CAD Model Features Parts 1 and 2
- A5.6 Physical Property Analysis
- A5.7 Instant Challenge: Choremaster

**Cross Curricular Connections:**

- **ELA:**
  - Reading
  - Writing
  - Speaking and listening
- **Math:**
  - Quantities
  - Creating equations
  - Reasoning with equations and inequalities
  - Geometric measurement and dimension
  - Modeling with geometry
<table>
<thead>
<tr>
<th>Depth of Knowledge (Section 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOK: 4</td>
</tr>
</tbody>
</table>
Curriculum: Introduction to Engineering Design (PLTW)

Curricular Unit: Reverse Engineering

Instructional Unit: F. Apply engineering principles and practices to reverse engineer a consumer product
- Communicate technical information or ideas in multiple formats including orally, graphically, textually and mathematically, as appropriate
- Plan and conduct an investigation or test a design to gather data to document a design, build and revise models, and/or solve a problem

**Standard Alignments (Section 2)**

<table>
<thead>
<tr>
<th>MGGLE: PS.2.A,C; PS.3.A</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAGLE: PP.1.A (HS level 1); PP.1.C (HS level 4); EP.1.A,F,G (HS level 4); EP.2.A-F (HS level 4)</td>
</tr>
<tr>
<td>Knowledge: (CA) 1,3,4,6</td>
</tr>
<tr>
<td>CCSS: 9-10.W.2d,e; 9-10.W.4; 9-10.SL.1; 9-10.SL.4; 9-10.SL.5; 9-10.L.1; 9-10.L.2c; 9-10.L.6; 9-10.RST.4; 9-10.WHST.2a,b,d,e; 9-10.WHST.4; 9-10.WHST.10</td>
</tr>
<tr>
<td>NETS: 1a-c; 2b,d; 4a,b; 5; 6</td>
</tr>
<tr>
<td>Performance: 1.2, 1.4, 2.1, 2.3, 2.5, 2.7, 3.1-3.3, 3.5, 3.6, 3.8, 4.1, 4.4-4.6, 4.8</td>
</tr>
</tbody>
</table>

**Unit (Section 3)**

- **Knowledge:**
  - 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

- **Skills:**
  - 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
### Instructional Strategies:

- The teacher will facilitate:
  - collaboration
  - discussions about Reverse Engineering
- Students will utilize the collaboration and discussions to disassemble and analyze a product to understand the visual, functional and structural aspects of its design

### Assessments/Evaluations:

- **Formative:**
  - Elements and Principles of Design Identification: Peer assessment of visual analysis
  - Functional Analysis Automoblox: Peers will compare black box model
  - Functional Analysis ALTERNATE: Peers will compare black box model
  - Small group/class discussion (essential question 2): The teacher will consider student responses and preconceptions in order to inform effective teaching
  - Structural Analysis Automoblox: Peers will compare answers to #4 and #5
  - Product Disassembly ALTERNATE: Peers will compare answers responses
  - Unit Assessment Items: All items

- **Summative:**
  - Elements and Principles of Design Identification: Conclusion questions
  - Visual Analysis Automoblox:
    - Assessment of visual analysis
    - Conclusion questions
  - Visual Analysis ALTERNATE:
    - Assessment of visual analysis
    - Conclusion questions
  - Functional Analysis Automoblox: Conclusion questions
  - Functional Analysis ALTERNATE: Conclusion questions
  - Structural Analysis Automoblox: Conclusion questions
  - Product Disassembly ALTERNATE: Conclusion questions
  - Journal entry (essential question 1): Teacher assesses student responses
  - Product Reverse Engineering Presentation:
    - Scoring guide
    - Conclusion questions
  - Unit Assessment Items: All items
  - Summative – EoC: All items

### Sample Assessment Questions:

- Why are many consumer product designs not commercially successful?
- When, if ever, is it acceptable for a company to reverse engineer and reproduce a successful consumer product designed by another person/company?
Instructional Resources/Tools:

- A6.1 Elements and Principles of Design Identification
- A6.2 Visual Analysis Automoblox
- A6.2a Visual Analysis ALTERNATE
- P6.3 Functional Analysis Automoblox
- P6.3a Functional Analysis ALTERNATE
- A6.4 Structural Analysis Automoblox
- A6.4a Product Disassembly ALTERNATE
- A6.5 Product Reverse Engineering Presentation

Cross Curricular Connections:

- ELA:
  - Reading
  - Writing
  - Speaking and listening

**Depth of Knowledge (Section 5)**

DOK: 4
Curriculum: Introduction to Engineering Design (PLTW)

Curricular Unit: Documentation

Instructional Unit: G. Expand basic knowledge of technical drawing representations to include the creation of alternate views and appropriate dimensioning and annotation

- Define a design problem that involves criteria and constraints that may include social, technical and/or environmental considerations
- Use the engineering design process to design a system, component, or process to meet desired needs within realistic constraints
- Communicate technical information or ideas in multiple formats including orally, graphically, textually and mathematically, as appropriate

**Standard Alignments (Section 2)**

<table>
<thead>
<tr>
<th>MGGLE</th>
<th>VAGLE: PP.1.A (HS level 1); PP.1.C (HS level 4); EP.1.A,F,G (HS level 4); EP.2.A-F (HS level 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Knowledge: (CA) 1,3,4,6 (MA) 2,4,5</td>
</tr>
<tr>
<td></td>
<td>CCSS: 9-10.W.2a,b,d,e; 9-10.W.4; 9-10.W.10; 9-10.SL.1; 9-10.L.1; 9-10.L.2c; 9-10.L.6; 9-10.RST.4; 9-10.RST.7; 9-10.WHST.2a,b,d,e; 9-10.WHST.4; 9-10.WHST.10; N-Q.3; G-GMD.4; G-MG.1; G-MG.3</td>
</tr>
<tr>
<td></td>
<td>NETS: 1a-c; 2b,d; 4a,b; 5; 6</td>
</tr>
<tr>
<td></td>
<td>Performance: 1.2, 1.4, 2.1, 2.3, 2.5, 2.7, 3.1-3.3, 3.5, 3.6, 3.8, 4.1, 4.4-4.6, 4.8</td>
</tr>
</tbody>
</table>

**Unit (Section 3)**

Learning Targets:

- Knowledge:
  - Identify and differentiate between size dimensions and location dimensions
  - Identify and correctly apply chain dimensioning or datum dimensioning methods to a technical drawing
  - Identify dimensioning standards commonly used in technical drawing
  - Identify the shapes of two-dimensional cross sections of three dimensional objects
  - Identify, define and explain the proper use of a section view in technical drawing
  - Read and interpret a hole note to identify the size and type of hole including through, clearance, blind, counter bore, and countersink holes
  - Identify and differentiate among limit dimensions, a unilateral tolerance, and a bilateral tolerance
  - Differentiate between clearance and interference fit
  - Explain each assembly constraint (including mate, flush, insert, and tangent), its role in an assembly model, and the degrees of freedom that it removes from the movement between parts
Skills:

- 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
- 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
### Instructional Strategies:

- The teacher will:
  - model alternate technical drawing views
  - create instructional videos to demonstrate advanced dimensioning and annotation to technical drawings. Students will utilize:
    - direct instruction
    - instructional videos
  
- Students will utilize:
  - direct instruction
  - instructional videos
  
  to create a variety of technical drawings that document measurements collected during the reverse engineering process.

### Assessments/Evaluations:

- **Formative:**
  - More Dimensioning activity: Peer assessment of dimensioning per #6
  - Sectional Views activity: Peer review of #6 prior to completing #7
  - Tolerances activity:
    - Self-assessment based on correct answers provided by the teacher
    - Correction of responses and self-reflection/journal entry as to why responses were incorrect
  - Assembly Model project: Peer/teacher assessment of assembly models
  - Engineering Documentation Automoblox project: Self/peer assessment using P 7.5 scoring guide
  - Engineering Documentation ALTERNATE project: Self/peer assessment using P 7.5 scoring guide
  - Design Brief (Apollo 13) project: Conclusion questions
  - Small group/class discussion (essential questions 1,2,4): The teacher will consider student responses and preconceptions in order to inform effective teaching
  - Automoblox Product Enhancement problem: Conclusion questions
  - Small group/class discussion (essential question 3): The teacher will consider student responses and preconceptions in order to inform effective teaching
  - Unit Assessment Items: All items

- **Summative:**
  - More Dimensioning activity:
    - Conclusion questions
    - Students will create dimensioned drawings of teacher-provided parts similar to those included in the activity
  - Sectional Views activity:
    - Conclusion questions
    - Sketch section view of teacher provided part (e.g., tape dispenser)
  - Tolerances activity: Conclusion questions
  - Journal entry (essential question 5): The teacher assesses student responses
  - Assembly Model project: Conclusion questions
  - Engineering Documentation Automoblox project:
    - Conclusion questions
    - P 7.5 scoring guide
Sample Assessment Questions:

- What are the consequences to the final solution if the design problem is poorly communicated?
- How does one know that a given design solution is the best possible solution?
- Engineering is described as the application of math, science and technology to solve problems. Does this description imply that designing an enhancement to an Automoblox vehicle is the work of an engineer? Justify your answer.
- What quality makes a set of drawings sufficient to adequately represent the design intent?
- Is it always necessary to indicate a tolerance for every dimension on a technical drawing? Justify your answer.
- Stephen Covey includes “Begin with the End in Mind” as one of the seven habits listed in his book *The 7 Habits of Highly Effective People*. How can this habit make an engineer more effective?
- In your opinion, which step of the design process is most important to successfully innovate or invent a new product? Justify your answer.

Instructional Resources/Tools:

- A 7.1 More Dimensioning
- A 7.2 Sectional Views
- A 7.3 Tolerances
- P 7.4 Assembly Model
- P 7.5 Engineering Documentation Automoblox
- P 7.5a Engineering Documentation ALTERNATE
- P 7.6 Design Brief (Apollo 13)
- B 7.7 Automoblox Product Enhancement

Cross Curricular Connections:

- ELA:
  - Reading
  - Writing
  - Speaking and listening
- Math:
  - Quantities
  - Geometric measurement and dimension
  - Modeling with geometry
Depth of Knowledge (Section 5)

DOK: 4
Curriculum: Introduction to Engineering Design (PLTW)

Curricular Unit: Advanced Computer Modeling

Instructional Unit: H. Expand 3-dimensional computer modeling skills

- Use mathematical and computational thinking to represent phenomenon and solve engineering problems
- Use current engineering tools (e.g., spreadsheet software, CADD software) to create models, solve problems and perform engineering design
- Communicate technical information or ideas in multiple formats including orally, graphically, textually and mathematically, as appropriate

**Standard Alignments (Section 2)**

<table>
<thead>
<tr>
<th>MGGLE</th>
<th>PS.2.A,C; PS.3.A</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAGLE</td>
<td>PP.1.A (HS level 1); PP.1.C (HS level 4); EP.1.A,F,G (HS level 4); EP.2.A-F (HS level 4)</td>
</tr>
<tr>
<td>Knowledge</td>
<td>(CA) 1,3,4,6 (MA) 1,2,4,5</td>
</tr>
<tr>
<td>CCSS</td>
<td>9-10.SL.1; 9-10.L.6; 9-10.RST.4; A-SSE.1; A-CED.1; A-CED.2; A-CED.3; A-REI.3; F-LE.5; G-MG.1</td>
</tr>
<tr>
<td>NETS</td>
<td>1a,b; 2; 3a,b; 4; 5; 6</td>
</tr>
<tr>
<td>Performance</td>
<td>1.4, 1.8, 2.5, 2.7, 3.1, 3.4-3.6, 4.4-4.6, 4.8</td>
</tr>
</tbody>
</table>

**Unit (Section 3)**

**Learning Targets:**

- **Knowledge:**
  - Identify, define, and explain the proper use of an auxiliary view in technical drawing

- **Skills:**
  - 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 multi-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
  - (Optional) – Hand sketch an auxiliary 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
(Optional) – Generate an auxiliary view using CAD according to standard engineering practice

**Instructional Strategies:**

- The teacher will model different advanced methods for CAD software modeling. Students will utilize:
  - direct instruction
  - instructional videos
to reverse engineer and model a consumer product to create a 3-dimensional model using Inventor software

**Assessments/Evaluations:**

- **Formative:**
  - Model Button Maker project:
    - Conclusion questions
    - Peer comparison of physical properties of parts
  - Model Miniature Train (optional) project:
    - Conclusion questions
    - Peer comparison of physical properties of parts
  - Parametric Constraints activity: Conclusion questions
  - Auxiliary Views (optional) activity: Peer assessment and then revision of activity tasks
  - Small group/class discussion (essential question 1): The teacher will consider student responses and preconceptions in order to inform effective teaching
  - Working Drawings (Button Maker) activity: Self-evaluation and/or peer evaluation using A8.4 scoring guide
  - Working Drawings Miniature Train (optional) activity: Self-evaluation and/or peer evaluation of activity tasks
  - Unit Assessment Items: All items

- **Summative:**
  - Parametric Constraints activity: Completion of #3 (optional task)
  - Parametric Constraints Practice (optional) activity: Ask students to justify their work in verbal or written form
  - Auxiliary Views (optional) activity:
    - Assessment of Task #3
    - Conclusion questions
  - Working Drawings (Button Maker) activity:
    - Scoring guide
    - Conclusion questions
  - Working Drawings Miniature Train (optional) activity: Conclusion questions
  - Journal entry (essential question 2): The teacher assesses student responses
  - Instant Challenge: Air Vehicle activity: Conclusion questions
  - Unit Assessment Items: All items
  - Summative – EoC: All items
Sample Assessment Questions:

- Are working drawings always necessary in order to communicate the design of a consumer product? Justify your answer.
- Animated assemblies are not typically included as part of the technical documentation of a design. How can 3D animated assembly models of an object or a proposed design be used in the design process? Beyond the design process?

Instructional Resources/Tools:

- P8.1 Model Button Maker
- P8.1a Model Miniature Train (optional)
- A8.2 Parametric Constraints
- A8.3 Auxiliary Views (optional)
- A8.4 Working Drawings (Button Maker)
- A8.4a Working Drawings Miniature Train (optional)
- A8.5 Instant Challenge: Air Vehicle

Cross Curricular Connections:

- ELA:
  - Reading
  - Writing
  - Speaking and listening
- Math:
  - Seeing structure in expressions
  - Creating equations
  - Reasoning with equations and exponential models
  - Modeling with geometry

**Depth of Knowledge (Section 5)**

DOK: 4
Curriculum: Introduction to Engineering Design (PLTW)

Curricular Unit: Design Team

Instructional Unit: I. Apply communication skills to work collaboratively with team members working through the design process

- Communicate effectively using virtual/remote communication tools
- Function effectively on a multidisciplinary team
- Perform research to gather information, define problems, provide evidence, and/or justify decisions in the process of solving a problem
- Apply the design process to design a system, component, or process to meet desired needs within realistic constraints
- Understand professional and ethical responsibilities related to engineering
- Communicate technical information or ideas in multiple formats including orally, graphically, textually and mathematically, as appropriate

Standard Alignments (Section 2)

| MGGLE: PS.2.A,C; PS.3.A
| VAGLE: PP.1.A (HS level 1); PP.1.C (HS level 4); EP.1.A,F,G (HS level 4);
|                EP.2.A-F (HS level 4)
| Knowledge: (CA) 1,3,4,6 (MA) 1,2,4,5
| 9-10.SL.1b-d; 9-10.SL.4; 9-10.SL.5; 9-10.SL.6; 9-10.L.1; 9-10.L.2c; 9-10.L.6;
| 9-10.RST.4; 9-10.WHST.1; 9-10.WHST.2a,b,d-f; 9-10.WHST.4; 9-10.WHST.7;
| 9-10.WHST.8; 9-10.WHST.9; 9-10.WHST.10; G-MG.1; G-MG.3
| NETS: 1a,b; 2; 3a,b; 4; 5; 6
| Performance: 1.4, 1.8, 2.5, 2.7, 3.1, 3.4-3.6, 4.4-4.6, 4.8

Unit (Section 3)

Learning Targets:

- Knowledge:
  - 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
- **Skills:**
  - 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
  - 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

<table>
<thead>
<tr>
<th>Instructional Strategies:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- The teacher will:</td>
</tr>
<tr>
<td>- facilitate group discussions</td>
</tr>
<tr>
<td>- direct instruction</td>
</tr>
<tr>
<td>- instructional videos</td>
</tr>
<tr>
<td>- Students will implement the design process and use knowledge and skill gained in the course to solve a culminating design challenge and document and communicate their proposed solution</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assessments/Evaluations:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Formative:</td>
</tr>
<tr>
<td>- Product Lifecycle activity:</td>
</tr>
<tr>
<td>- Self/peer-evaluation</td>
</tr>
<tr>
<td>- Conclusion questions</td>
</tr>
<tr>
<td>- Engineering Design Ethics Design Brief problem: Peer assessment of deliverables</td>
</tr>
</tbody>
</table>
- Virtual Design Challenge project – Periodic:
  - teammate evaluation
  - self-evaluation
- Small group/class discussion (essential questions 1 and/or 2): The teacher will consider student responses and preconceptions in order to inform effective teaching
- Product Research Documentation activity: Teacher questioning and student verbal justification of the product choices
- Unit Assessment Items: All items

- Summative:
  - Product Lifecycle activity:
    - Scoring guide
    - Conclusion questions
  - Engineering Design Ethics Design Brief problem: Conclusion questions
  - Journal entry (essential question 3): Teacher assesses student responses
  - Virtual Design Challenge project – Periodic:
    - Multiple scoring guides
    - Conclusion questions
  - Team Norms activity: Conclusion questions
  - Journal entry (essential question 4): Teacher assesses student responses
  - Unit Assessment Items: All items
  - Summative – EoC: All items

Sample Assessment Questions:

- Is it ever advantageous to create a design or solve a problem individually as opposed to using a team approach? Explain.
- What strategy would you use to form a design team in order to obtain the best solution possible?
- What does it mean to be “ethical” in your work? Do engineers need to be taught to be “ethical”? 
- It has been said that, “Having a vision without action is a daydream; Taking action without a vision is a nightmare!” How does this apply to engineering design?

Instructional Resources/Tools:

- A9.1 Product Lifecycle
- B9.2 Engineering Design Ethics Design Brief
- P9.3 Virtual Design Challenge
- A9.4 Team Norms
- A9.5 Product Research Documentation

Cross Curricular Connections:

- ELA:
  - Reading
  - Writing
  - Speaking and listening
- Math: Modeling with geometry
Depth of Knowledge (Section 5)

<table>
<thead>
<tr>
<th>DOK: 4</th>
</tr>
</thead>
</table>
Curriculum: Introduction to Engineering Design (PLTW)

Curricular Unit: Design Challenges

Instructional Unit: J. Implement the design process and use skill and knowledge to develop a solution to a proposed challenge

• Engineering has been referred to as the “stealth” profession. Do you think this is an appropriate label? Explain.
• If you had to describe one strategy that would most help an engineer be a good and effective designer, what would it be?

Standard Alignments (Section 2)

<table>
<thead>
<tr>
<th>MGGLE: PS.2.A,C; PS.3.A</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAGLE: PP.1.A (HS level 1); PP.1.C (HS level 4); EP.1.A,F,G (HS level 4); EP.2.A-F (HS level 4)</td>
</tr>
<tr>
<td>Knowledge: (CA) 1,3,4,6 (MA) 1,2,4,5</td>
</tr>
<tr>
<td>CCSS: 9-10.W.2a,b,d-f; 9-10.W.4; 9-10.W.10; 9-10.SL.1; 9-10.SL.5; 9-10.L.1; 9-10.L.2c; 9-10.L.6; 9-10.WHST.2a,b,d,e; 9-10.WHST.4; 9-10.WHST.10; G-MG.1; G-MG.3</td>
</tr>
<tr>
<td>NETS: 1a,b; 2; 3a,b; 4; 5; 6</td>
</tr>
<tr>
<td>Performance: 1.4, 1.8, 2.5, 2.7, 3.1, 3.4-3.6, 4.4-4.6, 4.8</td>
</tr>
</tbody>
</table>

Unit (Section 3)

Learning Targets:

• Knowledge:
  • Identify the steps in an engineering design process and describe the activities involved in each step of the process

• Skills:
  • 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

Instructional Strategies:

• The teacher will:
  • facilitate discussions
  • guide teams

• Students will utilize:
  • collaborative teams
  • knowledge and skills from previous units in order to:
    • implement the design process
    • solve a culminating design challenge
    • document their proposed solutions
### Assessments/Evaluations:

- **Formative:**
  - Design Challenges: Self/peer review or evaluation prior to final submittal
  - Small group/class discussion (essential question 1): The teacher will consider student responses and preconceptions in order to inform effective teaching

- **Summative:**
  - Design Challenges:
    - Scoring guide
    - Conclusion questions
  - Journal entry (essential question 2): The teacher will assess student responses

### Sample Assessment Questions:

- Engineering has been referred to as the “stealth” profession. Do you think this is an appropriate label? Explain.
- If you had to describe one strategy that would most help an engineer be a good and effective designer, what would it be?

### Instructional Resources/Tools:

- P10.1 Design Challenges

### Cross Curricular Connections:

- **ELA:**
  - Reading
  - Writing
  - Speaking and listening
- **Math:** Modeling with geometry

### Depth of Knowledge (Section 5)

**DOK: 4**