<table>
<thead>
<tr>
<th>Integration Teacher Notes</th>
<th><strong>Curriculum</strong></th>
<th>Instructional Strategies</th>
<th>Resources</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What do we want students to learn?</strong></td>
<td><strong>How will we deliver the curriculum?</strong></td>
<td><strong>What materials/resources will we need to ensure mastery.</strong></td>
<td><strong>How will we know if students learn?</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Year long instructional strategies, processes, skill development, or content expectations</strong></td>
<td><strong>Unit 1</strong></td>
<td><strong>Introduction to Design</strong></td>
<td>This unit is an introduction to different facets of design and will emphasize the following: evolution and history of design, the steps in a design process, the importance of proper sketching techniques, measurement and tools used in design, and the use of those tools and techniques to innovate or invent solutions to problems. Students will be introduced to a variety of skill building opportunities that will enhance their design skills and prepare them for the remaining units in this course.</td>
<td>25 computers with Autodesk software and internet access 3-ring binders for each student wooden cubes calipers printer paper colored pencils</td>
</tr>
<tr>
<td><strong>Unit 2</strong></td>
<td><strong>Design Solutions</strong></td>
<td>Access to computers after school</td>
<td>The Essential Questions and Conclusion questions at the end of each activity may be used along with the Assessment suggestions provided in each lesson to develop summative assessment tools, such as tests or end of unit projects.</td>
<td></td>
</tr>
</tbody>
</table>

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**Unit 2 Design Solutions**

This unit advances the students design skills in the area of geometric shapes and solids, dimensioning, 3D modeling software, and an advanced design. Students will learn how to calculate area and properties of solids. They will be introduced to working in teams and what it takes to come to a consensus. The unit will end with students using the design process to create a solution to a prescribed problem.
| Unit 3 | Reverse Engineering | Reverse Engineering is an important process in the redesign of products. Designers get an opportunity to breakdown and analyze each part of the product to see how they operate. The information gathered during this process can help the designer or team determine what they can do to make the product better and optimize manufacturing potential to increase company profits.

The process of Reverse Engineering involves analyzing the product’s function, structure, and visual elements. In this unit, students will get an opportunity to visit all three aspects of a product. They will use the information learned during these procedures and suggest possible changes they would make to improve a product. |

|  | Toys that can be taken apart | Water wands |
|  | 3-fold poster boards | |
| Unit 4 | Design Problems | This unit is designed to combine the knowledge and information learned in the previous units to an open ended design problem. Students will apply the design process to create a solution to a problem that currently exists. Students will also learn that by-products are created as a result of the solution, and what impacts they have on the environment and society. The students will also learn how to affectively market a product. They will also have an opportunity to create a virtual team to complete the tasks needed to solve real world problems. |

|  | Email accounts | |

The Essential Questions and Conclusion questions at the end of each activity may be used along with the Assessment suggestions provided in each lesson to develop summative assessment tools, such as tests or end of unit projects.
<table>
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<th>Integration Teacher Notes</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>What do we want students to learn?</td>
<td>How will we deliver the curriculum?</td>
<td>What materials/resources will we need to ensure mastery?</td>
<td>How will we know if students learn?</td>
</tr>
</tbody>
</table>

**Quarterly focused instructional strategies, processes, skill development, or content expectations**

<table>
<thead>
<tr>
<th>1st Quarter</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lesson 1.1 Intro to a design process</strong></td>
</tr>
<tr>
<td><strong>Standards for Technological Literacy</strong></td>
</tr>
<tr>
<td><strong>Standard 8:</strong> Students will develop an understanding of the attributes of design.</td>
</tr>
<tr>
<td><strong>BM B:</strong> Design is a creative process.</td>
</tr>
<tr>
<td><strong>BM C:</strong> The design process is a purposeful method of planning practical solutions to problems.</td>
</tr>
<tr>
<td><strong>BM H:</strong> The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results.</td>
</tr>
<tr>
<td><strong>Standard 9:</strong> Students will develop an understanding of engineering design.</td>
</tr>
<tr>
<td><strong>BM C:</strong> The engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.</td>
</tr>
<tr>
<td><strong>Standard 10:</strong> Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.</td>
</tr>
<tr>
<td><strong>BM E:</strong></td>
</tr>
<tr>
<td><strong>Day 1:</strong></td>
</tr>
<tr>
<td>· The teacher will present Concepts, Key Terms, and Essential Questions, in order to provide a lesson overview.</td>
</tr>
<tr>
<td>· The teacher will present Engineers.ppt.</td>
</tr>
<tr>
<td>· The teacher will distribute an engineer’s notebook to each student or have students create their own.</td>
</tr>
<tr>
<td>· Note: The teacher will determine whether students will record their notes in a daily journal, portfolio, or their engineer’s notebook. For purposes of written directions in the day-by-day for each lesson in this course, it will be assumed students will record their notes in a journal. The journal may be a three-ring binder, spiral bound notebook, or an electronic document.</td>
</tr>
<tr>
<td><strong>PowerPoint® Presentations</strong></td>
</tr>
<tr>
<td>Engineer’s Notebook</td>
</tr>
<tr>
<td>Engineer’s Notebook long version</td>
</tr>
<tr>
<td>Rules for Brainstorming</td>
</tr>
<tr>
<td>Evolution of Product Design</td>
</tr>
<tr>
<td>Introduction to Research</td>
</tr>
<tr>
<td>Design Process Overview</td>
</tr>
<tr>
<td><strong>Word Documents</strong></td>
</tr>
<tr>
<td>Activity 1.1.1 Beverage Container</td>
</tr>
<tr>
<td>Activity 1.1.2 Product Evolution</td>
</tr>
<tr>
<td>Activity 1.1.3 Gossamer Condor Design Brief</td>
</tr>
</tbody>
</table>

**Explanation**

1. Students will explain how knowledge of brainstorming and sketching aid in the design of a product, such as a coffee cup, and depict their explanation in a bookmark.

2. Students will explain the significance of effective communication to a young student in grades six through eight.

3. Students will explain the process of the development of the first controlled, sustainable human-powered aircraft to a
The process of experimentation, which is common in science, can also be used to solve technological problems.

**BM G:**
Invention is a process of turning ideas and imagination into devices and systems.

**BM H:**
Some technological problems are best solved through experimentation.

**BM I:**
Research and development is a specific problem-solving approach that is used intensively in business and industry.

**Standard 17:**
Students will develop an understanding of and be able to select and use information and communication technologies.

**BM J:**
The design of a message is influenced by such factors as the intended audience, medium, purpose, and nature of the message.

**BM Q:**
Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.

**National Science Education Standards**

**Unifying Concepts and Processes Standard K-12:** As a result of activities in grades 9-12, all students should develop
- Systems, order, and organization

**Science and Technology Standard E:** As a result of activities in grades 9-12, all students should develop
- Abilities of technological design

<table>
<thead>
<tr>
<th>Answer Keys and Rubrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity 1.1.2 Product Evolution Rubric</td>
</tr>
<tr>
<td>Activity 1.1.3 Gossamer Condor Design Brief Answer Key</td>
</tr>
</tbody>
</table>

**Teacher Guidelines**

**Lesson 1.1**

**Teacher Notes**

**Sample Engineering Notebook Entries**

**Example Design Process**

**Lesson 1.1 Key Terms Only in Word**

**Lesson 1.1 Key Terms and definitions in Excel**

**Teacher Guidelines**

<table>
<thead>
<tr>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Students will interpret and explain how the design process may be used in preparing for a sports competition or in common everyday events, such as writing a paper.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Students will apply their knowledge of research, the design process, and documentation in the critique of a product that they use everyday, such as a cell phone or MP3 player.</td>
</tr>
</tbody>
</table>
**Principles and Standards for School Mathematics**

**Representation:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to use representations to model and interpret physical, social, and mathematical phenomena.

**Standards for English Language Arts**

**Standard 3:**
Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and other texts, their word identification strategies, and their understanding of textual features (e.g. sound-letter correspondence, sentence structure, context, graphics).

**Standard 4:**
Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.

**Standard 5:**
Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences and for a variety of purposes.

**Standard 7:**
Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and nonprint texts, artifacts, and people) to communicate their discoveries in ways that suit their purpose and audience.

**Performance Objectives**

- Students will begin work on Activity 1.1.1 Beverage Container.
- Note: The teacher may have other common objects to show that will offer students different experiences in learning about the parts of the design process in an impromptu way.
- The teacher may want to provide graph paper for the sketching located in the Teacher Guidelines located at the end of this lesson.
- The teacher will serve as a facilitator and keep students on task by offering cues and reiterating the problem statement.
- Students will present Activity 1.1.1 Beverage Container ideas to the class.
- The teacher will lead a discussion using the steps in the design process and possible constraints that would have to be addressed when redesigning the item. Refer to the Teacher Notes for a detailed explanation.

**Day 4 - 6:**

- The teacher will present the Evolution of Product Design.ppt.
- Students will take notes
It is expected that students will:

- Apply engineering notebook standards and protocols when documenting their work during the school year.
- Identify and apply group brainstorming techniques and the rules associated with brainstorming.
- Research a product’s history, develop a PowerPoint presentation, list chronologically the major innovations to a product, and present findings to a group.
- Use online and published works to research aspects of design problems.
- Identify the design process steps used in given scenarios and be able to list the steps, if any are missing.

<table>
<thead>
<tr>
<th>Day 7 - 8:</th>
</tr>
</thead>
<tbody>
<tr>
<td>The teacher will introduce and distribute Activity 1.1.2 Product Evolution and Activity 1.1.2 Product Evolution Rubric.</td>
</tr>
<tr>
<td>Optional: The teacher may want to present Introduction to Research.ppt even though the design of this lesson is to assess students’ knowledge and ability without additional instruction or guidance.</td>
</tr>
<tr>
<td>The teacher and students will discuss the expectations of the activity and how the rubric will be used to assess the activity.</td>
</tr>
<tr>
<td>Students will begin work on Activity 1.1.2 Product Evolution using an approved product from their hobby or interest.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Day 7 - 8:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will deliver their PowerPoint presentations to the class.</td>
</tr>
<tr>
<td>Note: The teacher may want to invite an administrator, counselor, or member from the partnership team to view presentations.</td>
</tr>
<tr>
<td>The teacher will assess the presentations using the Activity 1.1.2 Product Evolution Rubric.</td>
</tr>
</tbody>
</table>
Day 9 - 11:

- The teacher will distribute Example Design Process.
- The teacher will present the Design Process Overview.ppt.
- Students will take notes in their journals.
- The teacher will distribute Activity 1.1.3 Gossamer Condor.
- The teacher will show The Flight of the Gossamer Condor.
- Note: The teacher may wish to use another video from his or her past experiences that covers the design process. However, the teacher will need to create a working document to accompany the video of choice.
- Students will watch the film and complete Activity 1.1.3 Gossamer Condor.
- The teacher will review Activity 1.1.3 Gossamer Condor Design and lead the class in a discussion on the iterative nature, the use of a design process, and the way it will be used throughout the remainder of the course.
- The teacher will assess the students using Activity
<table>
<thead>
<tr>
<th>Day 1:</th>
</tr>
</thead>
<tbody>
<tr>
<td>· The teacher will present Concepts, Key Terms, and Essential Questions, and provide a lesson overview.</td>
</tr>
<tr>
<td>· The teacher will present slide one through seven of the Line Conventions.ppt.</td>
</tr>
<tr>
<td>· Students will take notes in their journals.</td>
</tr>
</tbody>
</table>

**Standards for Technological Literacy**

**Standard 9:**
Students will develop an understanding of engineering design.

**BM B:**
Expressing ideas to others verbally and through sketches and models is an important part of the design process.

**Standard 11:**
Students will develop the abilities to apply the design process.

**BM E:**
The process of designing involves presenting some possible solutions in visual form and then selecting the best solution(s) from many.

**Standard 17:**
Students will develop an understanding of and be able to select and use information and communication technologies.

**BM C:**
People use symbols when they communicate by technology.

**BM G:**
Letters, characters, icons, and signs are symbols that represent ideas, quantities, elements, and operations.

**BM K:**
The use of symbols, measurements, and drawings promotes clear communication by providing a common language to express ideas.

**BM P:**
There are many ways to communicate information, such as graphic and electronic means.

**National Science Education Standards**

**Unifying Concepts and Processes Standard K-12:** As a result of activities in grades 9-12, all students will...

**Explanation**

1. Students will explain the difference between one-point, two-point, and three-point perspectives.

**Application**

2. Students will explain to a younger audience how sketching and shading techniques are used by engineers and in an art class.

3. Students will analyze and interpret ways in which political, cultural, social, and psychological concepts are explored in the world of art.
students should develop

- Evidence, models, and explanation

Science and Technology Standard E: As a result of activities in grades 9-12, all students should develop
- Abilities of technological design

Principles and Standards for School Mathematics

Geometry:
Instructional programs from pre-kindergarten through grade 12 should enable all students to analyze characteristics and properties of two- and three-dimensional geometric shapes; specify locations and describe spatial relationships using coordinate geometry and other representational systems; apply transformations and use symmetry to analyze mathematical situations; and use visualization, spatial reasoning, and geometric modeling to solve problems.

Measurement:
Instructional programs from pre-kindergarten through grade 12 should enable all students to understand measurable attributes of objects and the units, systems, and processes of measurement; and apply appropriate techniques, tools, and formulas to determine measurements.

Connections:
Instructional programs from pre-kindergarten through grade 12 should enable all students to recognize and apply mathematics in contexts outside of mathematics.

Representation:
Instructional programs from pre-kindergarten through grade 12 should enable all students to create and use representations to organize, record, and communicate mathematical ideas; select, apply, and translate among mathematical representations to solve problems; and use representations to model and interpret physical, sketches.

- The teacher will assess student work using Activity 1.2.1 Isometric Sketches Answer Key.

Day 4:

- The teacher will present the Oblique Pictorials.ppt.
- Students will take notes in their journals.
- The teacher will distribute Activity 1.2.2 Oblique Sketches.
- Students will begin work on Activity 1.2.2 Oblique Sketches.

Day 5:

- Students will complete Activity 1.2.2 Oblique Sketches.
- The teacher will assess student work using Activity 1.2.2 Oblique Sketches Answer Key.

Day 6:

- The teacher will present the Perspective Sketches.ppt.
- Students will take notes in their journals.
- The teacher will distribute Activity 1.2.3 Perspective Sketches.
- Students will begin work on Activity 1.2.3 Perspective Sketches.

Teacher Guidelines
- Lesson 1.2
- Teacher Notes
- Lesson 1.2 Key
- Terms
- Lesson 1.2 Key
- Terms and definitions in Excel
- Isometric graph paper
- Orthographic graph paper

Student Resources
- Activity 1.2.1 Isometric Graph Paper
social, and mathematical phenomena.

**Standards for English Language Arts**

**Standard 4:** Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.

**Standard 5:** Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences and for a variety of purposes.

**Standard 12:** Students use spoken, written and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).

**Performance Objectives**

*It is expected that students will:*

- Identify, sketch, and explain the function of points, construction lines, object lines, and hidden lines.
- Plot points on grid paper to aid in the creation of sketches and drawings.
- Explain the concepts of technical sketching and drawing.
- Sketch an isometric view of simple geometric solids.
- Explain how an oblique view of simple geometric solids differs from an isometric view.
- Sketch one-point, two-point, and three-point perspectives of simple geometric solids.
- Describe the concept of proportion as it relates to freehand sketching.
- Sketch multiview drawings of simple geometric solids.

*Note: The purpose of the activity is to show students how to quickly sketch a perspective view.*

**Day 7:**

- Students will complete Activity 1.2.3 Perspective Sketches.
- The teacher will assess student work using Activity1.2.3 Perspective Sketches Answer Key.

**Day 8-11:**

- The teacher will present the Multiview Sketching.ppt.
- Students will take notes in their journals.
- The teacher will distribute Activity 1.2.4 Multiview Sketches.
- The teacher will provide instruction to the class on hidden lines and center lines and their use in technical sketches.
- The teacher may use parts of the Line Conventions.ppt used earlier in the lesson to provide instruction.
- Students will begin work on Activity 1.2.4 Multiview Sketches.
- Students will complete Activity 1.2.4 Multiview Sketches.
<table>
<thead>
<tr>
<th>Lesson 1.3 Measurement and Statistics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standards for Technological Literacy</strong></td>
<td><strong>Explanation</strong></td>
</tr>
<tr>
<td>Standard 1: Students will develop an understanding of the characteristics and scope of technology. BM B: All people use tools and techniques to help them do things.</td>
<td>1. Students will explain the history of measurement to a younger student using their book jacket or CD cover as an example.</td>
</tr>
<tr>
<td>Standard 2: Students will develop an understanding of the core concepts of technology. BM K: Tools and machines extend human capabilities, such as holding, lifting, carrying, fastening, separating, and computing.</td>
<td>Application</td>
</tr>
<tr>
<td>Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study. BM A: The study of technology uses many of the same ideas and skills as other subjects. BM F: Knowledge gained from other fields of study has a direct effect on the development of technological products and systems.</td>
<td>2. Assess a student's journal for evidence of effective communication of ideas such as,</td>
</tr>
<tr>
<td>Standard 7: Students will develop an understanding of the influence of technology on history. BM E:</td>
<td>a. Do students’ sketches and drawings clearly communicate their ideas?</td>
</tr>
<tr>
<td></td>
<td>b. Have students used a variety of methods to communicate their ideas?</td>
</tr>
<tr>
<td>Time: 10 days</td>
<td>c. Have students integrated information from a variety of sources into their work?</td>
</tr>
<tr>
<td>NOTE: In preparation for teaching this lesson, it is strongly recommended that the teacher read Teacher Notes.</td>
<td></td>
</tr>
<tr>
<td>Day 1-2:</td>
<td></td>
</tr>
<tr>
<td>· The teacher will present Concepts, Key Terms, and Essential Questions to provide a lesson overview.</td>
<td></td>
</tr>
<tr>
<td>· The teacher will distribute and introduce Project 1.3.1 History of Measurement.</td>
<td></td>
</tr>
<tr>
<td>· Students will work on and complete Project 1.3.1 History of Measurement.</td>
<td></td>
</tr>
<tr>
<td>· The teacher will assess student work using Project 1.3.1 History of Measurement Rubric.</td>
<td></td>
</tr>
<tr>
<td>Day 3:</td>
<td></td>
</tr>
<tr>
<td>· The teacher will distribute Activity 1.3.2 English and Metric Linear Measurements.</td>
<td></td>
</tr>
<tr>
<td>Powerpoint® Presentations</td>
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<tr>
<td>Scale Reading Basics</td>
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<tr>
<td>Dial Calipers</td>
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<td>Dimension Practices</td>
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<td>Introduction to Basic Statistics</td>
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<tr>
<td>Word Documents</td>
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<tr>
<td>Project 1.3.1 History of Measurement</td>
<td></td>
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<tr>
<td>Activity 1.3.2 English and Metric Linear Measurements</td>
<td></td>
</tr>
<tr>
<td>Activity 1.3.3 fischertechniks® Block Measurement</td>
<td></td>
</tr>
<tr>
<td>Activity 1.3.4 Linear Dimensions</td>
<td></td>
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<tr>
<td>Activity 1.3.5</td>
<td></td>
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</tbody>
</table>
The design and construction of structures for service or convenience have evolved from the development of techniques for measurement, controlling systems, and the understanding of spatial relationships.

**Standard 17:**
Students will develop an understanding of and be able to select and use information and communication technologies.

**BM Q:**
Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.

### National Science Education Standards

**Unifying Concepts and Processes Standard K-12:** As a result of activities in grades 9-12, all students should develop
- Change, constancy, and measurement

**Science as Inquiry Standard A:** As a result of activities in grades 9-12, all students should develop
- Abilities necessary to do scientific inquiry

**Science and Technology Standard E:** As a result of activities in grades 9-12, all students should develop
- Abilities of technological design

### Principles and Standards for School Mathematics

**Number Operations:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to understand numbers, ways of representing

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| 3. Students will demonstrate and explain to another student how to measure objects using a scale or dial caliper. |
| **Teacher Guidelines** |
| **Lesson 1.3** |
| **Teacher Notes** |
| **Activity 1.3.2a Decimal Conversion Chart** |
| **Lesson 1.3 Key Terms** |
| **Lesson 1.3 Key Terms and definitions in Excel** |

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| 4. Students will make journal entries reflecting on their learning and experiences. Example of prompts for the general entries: Write about what you learned in class today. How do you know when your sketches are ready to transfer into a drawing? What is something you learned today that you did not understand or know before? |
| **Self-Knowledge** |
| **Project 1.3.1 History of Measurement Rubric** |
| **Activity 1.3.2 English and Metric Linear Measurements Answer Key** |
| **Activity 1.3.3 fischertechniks® Block Measurement Answer Key** |

### Applied Statistics

Teacher Guidelines

**Lesson 1.3**

**Teacher Notes**

**Activity 1.3.2a Decimal Conversion Chart**

**Lesson 1.3 Key Terms**

**Lesson 1.3 Key Terms and definitions in Excel**

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| 6. Students will be required to reflect on their work in their journals by recording their thoughts and ideas. They may use their self-assessments as a basis for |
| **Answer Keys and Rubrics** |
| **Project 1.3.1 History of Measurement Rubric** |
| **Activity 1.3.2 English and Metric Linear Measurements Answer Key** |
| **Activity 1.3.3 fischertechniks® Block Measurement Answer Key** |

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| 3. Students will demonstrate and explain to another student how to measure objects using a scale or dial caliper. |
| **Teacher Guidelines** |
| **Lesson 1.3** |
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| **Activity 1.3.2a Decimal Conversion Chart** |
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| **Self-Knowledge** |
| **Project 1.3.1 History of Measurement Rubric** |
| **Activity 1.3.2 English and Metric Linear Measurements Answer Key** |
| **Activity 1.3.3 fischertechniks® Block Measurement Answer Key** |

### Applied Statistics

Teacher Guidelines

**Lesson 1.3**

**Teacher Notes**

**Activity 1.3.2a Decimal Conversion Chart**

**Lesson 1.3 Key Terms**

**Lesson 1.3 Key Terms and definitions in Excel**

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| 6. Students will be required to reflect on their work in their journals by recording their thoughts and ideas. They may use their self-assessments as a basis for |
numbers, relationships among numbers, and number systems; understand meanings of operations and how they relate to one another; and compute fluently and make reasonable estimates. **Measurement:** Instructional programs from pre-kindergarten through grade 12 should enable all students to understand measurable attributes of objects and the units, systems, and processes of measurement; and apply appropriate techniques, tools, and formulas to determine measurements. **Data Analysis and Probability:** Instructional programs from pre-kindergarten through grade 12 should enable all students to formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them. **Representation:** Instructional programs from pre-kindergarten through grade 12 should enable all students to create and use representations to organize, record, and communicate mathematical ideas; select, apply, and translate among mathematical representations to solve problems; and use representations to model and interpret physical, social, and mathematical phenomena.

**Standards for English Language Arts**

**Standard 4:** Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes. **Standard 8:** Students use a variety of technological and informational resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge. **Standard 12:** Students use spoken, written and visual language teacher presents Dial Calipers.ppt.
- Students will complete Activity 1.3.3 fischertechniks® Block Measurement.
Day 6-7:
- The teacher will assess the students on Activity 1.3.3 using Activity 1.3.3 fischertechniks® Block Measurement Answer Key.
- Note: Activity 1.3.3 fischertechniks® Block Measurement Answer Key may have different answers than those the students get due to variance in the blocks.
- Optional: The teacher will want to present slide 9-10 of the Line Convention.ppt
- The teacher will present Dimension Practices .ppt.
- Students will take notes in their journal.
- The teacher will distribute and explain Activity 1.3.4 Linear Dimensions.
- Students will work on the Activity 1.3.4 Linear Dimensions.
- The teacher will assess Activity 1.3.4 Linear Dimensions using Activity 1.3.4 Linear Dimensions Answer Key.

**Perspective**

6. Students will select an engineering blunder and prepare an essay that expresses two points of view about the role played by measurement.

- Today, the hardest part for me to understand was...
- When I work in a group, I find that...
- When I work by myself, I find that...
- What did I accomplish today?
- Now that I have done this, what is next?
to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).

**Performance Objectives**

*It is expected that students will:*

- Research and design a CD cover or book jacket on the origins of the measurement systems.
- Measure and record linear distances using a scale to a precision of 1/16 inch and 1 µm.
- Measure and record linear distances using a dial caliper to a precision of 0.001 in.
- Add and subtract U.S. standard and metric linear measurements.
- Convert linear distance measurements from inches to millimeters and vice versa.
- Apply linear dimensions to a multiview drawing.
- Calculate the mean, mode, median, and range of a data set.
- Create a histogram of recorded measurements showing data elements or class intervals, and frequency.

**Lesson 1.4 Puzzle cube**

**Standards for Technological Literacy**

**Standard 3:** Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

**BM A:** The study of technology uses many of the same ideas and skills as other subjects.

**BM C:** Various relationships exist between technology and other fields of study.

**BM F:**

**Time:** 17 days

**NOTE:** In preparation for teaching this lesson, it is strongly recommended that the teacher read the Teacher Notes. At the end of this lesson, present Portfolios.ppt and allow students time to begin work on portfolios.

**Day 1:**

- Optional: The teacher will introduce students to the 3-D modeling software prior to the start of Activity 1.3.5.
- The teacher will present Introduction to Basic Statistics.ppt.
- Students will take notes in their journal.
- The teacher will distribute a dial caliper, 27 hardwood cubes, and Activity 1.3.5 Applied Statistics to each student.
- Students will begin work on Activity 1.3.5 Applied Statistics.
- Students will complete Activity 1.3.5 Applied Statistics.
- The teacher will assess student work. Answers will vary due to variance in cubes.

**Explanation**

1. Students will explain why design options of a project are determined by criteria and constraints.

**Application**

2. Students will design a
Knowledge gained from other fields of study has a direct effect on the development of technological products and systems.

**Standard 9:**
Students will develop an understanding of engineering design.

**BM A:**
The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others.

**BM B:**
Expressing ideas to others verbally and through sketches and models is an important part of the design process.

**BM D:**
When designing an object, it is important to be creative and consider all ideas.

**BM F:**
Design involves a set of steps, which can be performed in different sequences and repeated as needed.

**BM G:**
Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.

**BM J:**
Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.

**Standard 11**
Students will develop the abilities to apply the design process.

**BM H:**
Apply a design process to solve problems in and beyond the laboratory-classroom.

**BM I:**
Specify criteria and constraints for the design.

**BM J:**
Make two-dimensional and three-dimensional representations of the designed solution.

**BM R:**

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<td>Puzzle Cube Package</td>
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**Answer Keys and Rubrics**
- Project 1.4.1 Puzzle Design Rubric
- Activity 1.4.3 Puzzle Cube Package Rubric

**Teacher Guidelines**
- Lesson 1.4 Teacher Notes
- Activity 1.4.2 Isometric Graph Paper
- Sketched Puzzle Parts Example
- Example Sketched Puzzle Solution
- Lesson 1.4 Key Terms
- Lesson 1.4 Key Terms and definitions in Excel
- Isometric graph paper

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**Interpretation**

3. Students will illustrate their proposed project and use their illustration to explain how the project relates to everything they have learned thus far.

4. Students will explain the role of geometric shapes to the design of their puzzle cube.

5. Students will be assessed (Puzzle Cube Package Rubric) on their ability to create a package for their puzzle cubes.
| Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models. **Standard 17** Students will develop an understanding of and be able to select and use information and communication technologies. **BM K:** The use of symbols, measurements, and drawings promotes clear communication by providing a common language to express ideas. **BM Q:** Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli. |
| National Science Education Standards | Day3-15: |
| Unifying Concepts and Processes Standard K-12: As a result of activities in grades 9-12, all students should develop— |  |
| Change, constancy, and measurement | · The teacher will review the requirements for Project 1.4.1 Puzzle Design Challenge. |
| Form and function | · Students will continue working on materials to be completed. |
| Science and Technology Standard E: As a result of activities in grades 9-12, all students should develop— | · The teacher will review Example Sketched Puzzle Solution for details on how students could hand in their decision solution. |
| Abilities of technological design | · Note: The teacher will give an introduction to the 3-D Modeling software if he or she did not introduce it in Lesson 1.3. |
| Principles and Standards for School Mathematics | · The teacher will keep students on task and demonstrate any details on the 3-D modeling software needed for completion of the project. |
| Number Operations: Instructional programs from pre-kindergarten through grade 12 should enable all students to understand numbers, ways of representing numbers, relationships among numbers, and | · The teacher will assess Project 1.4.1 Puzzle Design Challenge using Project 1.4.1 Puzzle Design Rubric. |
| Orthographic graph paper | · Optional: The teacher will have students challenge each other on their cube to see the time needed to assemble puzzles. This could be set up as a trial game to see which student’s puzzle cube is the most difficult to assemble and solve. |
number systems; understand meanings of operations and how they relate to one another; and compute fluently and make reasonable estimates.

**Algebra:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to understand patterns, relations, and functions; represent and analyze mathematical situations and structures using algebraic symbols; use mathematical models to represent and understand quantitative relationships; and **analyze change** in various contexts.

**Geometry:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships; specify locations and describe spatial relationships using coordinate geometry and other representational systems; apply transformations and use symmetry to analyze mathematical situations; and use visualization, spatial reasoning, and geometric modeling to solve problems.

**Measurement:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to understand measurable attributes of objects and the units, systems, and processes of measurement; and apply appropriate techniques, tools, and formulas to determine measurements.

**Communication:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to organize and consolidate their mathematical thinking through communication; and communicate their mathematical thinking coherently and clearly to peers, teachers, and others.

**Connections:**
Instructional programs from pre-kindergarten through grade 12 should enable all students recognize and apply mathematics in contexts outside of mathematics.

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**Day 16:**
- The teacher will present Marketing.ppt.
- Students will take notes in their engineer’s notebook.
- The teacher will introduce and distribute Activity 1.4.3 Puzzle Cube Package and Activity 1.4.3 Puzzle Cube Package Rubric.
- Students will begin work on Activity 1.4.3 Puzzle Cube Package.

**Day 17:**
- Students will complete Activity 1.4.3 Puzzle Cube Package.
- The teacher will assist the students with their package designs.
Standards for English Language Arts

Standard 4:
Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.

Standard 5:
Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences and for a variety of purposes.

Standard 8:
Students use a variety of technological and informational resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.

Standard 12:
Students use spoken, written and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).

Performance Objectives

It is expected that students will:

- Brainstorm and sketch possible solutions to an existing design problem
- Select an approach that meets or satisfies the constraints given in a design brief.
- Create simple extruded solid Computer Aided Design (CAD) models from dimensioned sketches.
- Generate dimensioned multiview drawings from simple CAD models.
- Measure and Fabricate parts for a functional prototype from the CAD multiview drawings.
- Assemble the product using the CAD modeling software.
- Test and evaluate the prototype and record
<table>
<thead>
<tr>
<th>result</th>
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</thead>
<tbody>
<tr>
<td>· Apply geometric and numeric constraints to CAD sketches.</td>
<td></td>
<td></td>
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<tr>
<td>· Identify the purpose of packaging in the design of consumer products</td>
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</tbody>
</table>
## Integration Teacher Notes

**Curriculum**  
*What do we want students to learn?*

**Instructional Strategies**  
*How will we deliver the curriculum?*

**Assessment**  
*How will we know if students learn?*

**Resources**  
*What materials/resources will we need to ensure mastery?*

### Quarterly focused instructional strategies, processes, skill development, or content expectations

#### 2nd Quarter

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<tr>
<th>Lesson 2.1 Geometric shapes and solids</th>
<th>Standards for Technological Literacy</th>
<th>Time: 10 days</th>
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<tbody>
<tr>
<td><strong>Standards for Technological Literacy</strong></td>
<td><strong>Standard 1:</strong> Students will develop an understanding of the characteristics and scope of technology. <strong>BM D:</strong> Tools, materials, and skills are used to make things and carry out tasks.</td>
<td>NOTE: In preparation for teaching this lesson, it is strongly recommended that the teacher read the Teacher Notes. <strong>Standard 2:</strong> Students will develop an understanding of the core concepts of technology. <strong>BM I:</strong> Tools are used to design, make, use, and assess technology. <strong>BM J:</strong> Materials have many different properties. <strong>BM AA:</strong> Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development. <strong>Standard 3:</strong> Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study. <strong>BM C:</strong> Various relationships exist between technology and other fields of study. <strong>BM F:</strong> Knowledge gained from other fields of study has a direct effect on the development of technological products and systems.</td>
</tr>
<tr>
<td><strong>PowerPoint Presentations</strong></td>
<td>Geometric Shapes and Area Properties of Geometric Solids Additive and Subtractive Solid Modeling</td>
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<tr>
<td><strong>Word Documents</strong></td>
<td>Project 2.1.1 Shape and Measurement Madness Activity 2.1.2 Calculating Properties of Shapes Activity 2.1.3 Making Sketches in CAD</td>
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<tr>
<td><strong>Activity 2.1.5</strong></td>
<td>Activity 2.1.4 Calculating Properties of Solids</td>
<td></td>
</tr>
<tr>
<td><strong>Explanation</strong></td>
<td>1. Students will explain the advantages of using a 3-D CAD modeling program when creating drawings for production.</td>
<td></td>
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<tr>
<td><strong>Application</strong></td>
<td>2. Students will create a three-dimensional computer model of a piece of furniture in the classroom.</td>
<td></td>
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<tr>
<td><strong>Interpretation</strong></td>
<td>3. Students will explain to a younger student why he or she should learn</td>
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</tbody>
</table>

Day 1-2:

- The teacher will present Concepts, Key Terms, and Essential Questions, and provide a lesson overview.
- Note: The teacher will need to create a customized title block for the classroom before teaching this lesson. A tutorial is located in the Teacher Notes for this lesson.
- The teacher will present Geometric Shapes and Area.ppt.
- Students will take notes in their journals.
| Standard 9: | The teacher will distribute Project 2.1.1 Shape and Measurement Madness. Students will work on Project 2.1.1 Shape and Measurement Madness and complete the project for homework. The teacher will assess students’ work based on completion. Day 3: The teacher will distribute Activity 2.1.2 Calculating Properties of Shapes. Students will work on Activity 2.1.2 Calculating Properties of Shapes and complete the activity for homework. The teacher will assess student work using Activity 2.1.2 Calculating Properties of Shapes Answer Key. Day 4-5: The teacher will distribute Activity 2.1.3 Making Sketches in CAD. The teacher will demonstrate how to use the sketch tools within a CAD solid modeling program needed to complete the activity. Note: The files needed for this project can be found in CAD Model Features, Project 2.1.6 Modeling Creation, Answer Keys and Rubrics Activity 2.1.2 Calculating Properties of Shapes Answer Key, Activity 2.1.4 Calculating Properties of Solids Answer Key, Teacher Guidelines Lesson 2.1 Teacher Notes Lesson 2.1 Key Terms Lesson 2.1 Key Terms and definitions in Excel Inventor Files IED Considerations. |
| Standard 11: | National Science Education |
| Students will develop the abilities to apply the design process. BM J: Make two-dimensional and three-dimensional representations of the designed solution. BM P: Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed. |
| Standard 12: | Students will develop the abilities to use and maintain technological products and systems. BM P: Use computers and calculators to access, retrieve, organize process, maintain, interpret, and evaluate data and information in order to communicate. |
| Students will develop an understanding of engineering design. BM B: Expressing ideas to others verbally and through sketches and models is an important part of the design process. BM E: Models are used to communicate and test design ideas and processes. | |
| Standard 17: | Students will develop an understanding of and be able to select and use information and communication technologies. BM Q: Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli. | |
| Students will develop an understanding of and be able to select and use information and communication technologies. BM Q: Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli. | National Science Education |

4. Students will document and show the importance of using geometric principles to aid in the design of an object.

5. In a journal entry or lesson test, students will explain how calculating properties of a geometric solid works and why these criteria or constraints are needed when designing.
Standards
Unifying Concepts and Processes Standard K-12: As a result of activities in grades 9-12, all students should develop—
- Systems, order, and organization
- Evidence, models, and explanation
- Change, constancy, and measurement
- Form and function

Science as Inquiry Standard A: As a result of activities in grades 9-12, all students should develop—
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Science and Technology Standard E: As a result of activities in grades 9-12, all students should develop—
- Abilities of technological design

Principles and Standards for School Mathematics
Number Operations: Instructional programs from pre-kindergarten through grade 12 should enable all students to understand numbers, ways of representing numbers, relationships among numbers, and number systems; understand meanings of operations and how they relate to one another; and compute fluently and make reasonable estimates.
Algebra: Instructional programs from pre-kindergarten through grade 12 should enable all students to understand patterns, relations, and functions; represent and analyze mathematical situations and structures using algebraic symbols; use the Inventor files folder. The teacher can access how to assemble and apply motion to the train from the tutorial on the Virtual Academy.
- Students will begin work on Activity 2.1.3 Making Sketches in CAD.
- The teacher will assist students when needed.
- Students will complete Activity 2.1.3 Making Sketches in CAD.
- The teacher will assess students’ work based on completion.

Day 6:
- The teacher will present Properties of Geometric Solids.ppt.
- Students will take notes in their journals.
- The teacher will distribute Activity 2.1.4 Calculating Properties of Solids.
- Students will begin work on Activity 2.1.4 Calculating Properties of Solids.
- Students will complete Activity 2.1.4 Calculating Properties of Solids for homework.
- The teacher will assess student work using Activity 2.1.4 Calculating Properties of Solids Answer Key
mathematical models to represent and understand quantitative relationships; analyze change in various contexts.

**Geometry:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to analyze characteristics and properties of two-and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships; specify locations and describe spatial relationships using coordinate geometry and other representational systems; apply transformations and use symmetry to analyze mathematical situations; use visualization, spatial reasoning, and geometric modeling to solve problems.

**Measurement:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to understand measurable attributes of objects and the units, systems, and processes of measurement; apply appropriate techniques, tools, and formulas to determine measurements.

**Communication:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to organize and consolidate their mathematical thinking through communication.

**Connections:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to understand how mathematical ideas interconnect and build on one another to produce a coherent whole; recognize and apply mathematics in contexts outside of mathematics.

**Representation:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to create and use representations to organize, record, and communicate mathematical ideas; select, apply, and translate among mathematical representations to solve problems; use

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**Day 7-8:**
- The teacher will distribute Activity 2.1.5 CAD Model Features.
- The teacher will discuss the Cartesian coordinate system along with the axes and planes associated with this system.
- The teacher will demonstrate how to use the feature tools within a CAD solid modeling program needed to complete the activity.
  - Note: The files needed for this project can be found in the Inventor files folder. The teacher can access how to assemble and apply motion to the train from the tutorial on the Virtual Academy.
- Students will begin work on Activity 2.1.5 CAD Model Features.
- The teacher will assist students when needed.
- Students will complete Activity 2.1.5 CAD Model Features.
- The teacher will assess students’ work based on completion.

**Day 9-10:**
- The teacher will present Additive and Subtractive
representations to model and interpret physical, social, and mathematical phenomena.

**Standards for English Language Arts**

**Standard 4:**
Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.

**Standard 8:**
Students use a variety of technological and informational resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.

**Performance Objectives**

*It is expected that students will:*

· Identify common geometric shapes and forms by name.
· Calculate the area of simple geometric shapes.
· Calculate the surface area and volume of simple geometric forms.
· Identify and explain the various geometric relationships that exist between the elements of two-dimensional shapes and three-dimensional forms.
· Identify and define the axes, planes, and sign conventions associated with the Cartesian coordinate system.
· Apply geometric and numeric constraints to CAD sketches.
· Utilize sketch-based, work reference, and placed features to develop solid CAD models from dimensioned drawings.
· Explain how a given object’s geometry is the result of sequential additive and subtractive processes.
| Lesson 2.2 Dimensions and tolerances | **Standards for Technological Literacy** | Time: 10 days  
NOTE: In preparation for teaching this lesson, it is strongly recommended that the teacher read the Teacher Notes.  
NOTE: The files needed for this lesson can be found in the Inventor files folder.  
Day 1-2:  
· The teacher will present Concepts, Key Terms, and Essential Questions, and provide a lesson overview.  
· Note: The teacher will need to create a customized title block for the classroom before teaching this lesson.  
A tutorial is located in the Teacher Notes for this lesson.  
· The teacher will present Geometric Shapes and Area.ppt.  
· Students will take notes in their journals.  
· The teacher will distribute Project 2.1.1 Shape and Measurement Madness.  
· Students will work on Project 2.1.1 Shape and Measurement Madness and complete the project for |  | **Assessment**  
**Explanation**  
1. Students will explain the advantages of using a 3-D CAD modeling program when creating drawings for production.  
**Application**  
2. Students will create a three-dimensional computer model of a piece of furniture in the classroom.  
**Interpretation**  
3. Students will explain to a younger student why he or she should learn how to calculate the area of a shape.  
4. Students will **|
BM E: Models are used to communicate and test design ideas and processes.  
**Standard 11:** Students will develop the abilities to apply the design process.  
BM J: Make two-dimensional and three-dimensional representations of the designed solution.  
BM P: Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed.  
**Standard 12:** Students will develop the abilities to use and maintain technological products and systems.  
BM P: Use computers and calculators to access, retrieve, organize process, maintain, interpret, and evaluate data and information in order to communicate.  
**Standard 17:** Students will develop an understanding of and be able to select and use information and communication technologies.  
BM Q: Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.  

**National Science Education Standards**  
**Unifying Concepts and Processes Standard K-12:** As a result of activities in grades 9-12, all students should develop—  
- Systems, order, and organization  
- Evidence, models, and explanation  
- Change, constancy, and measurement

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<td>Activity 2.1.4 Calculating Properties of Solids Answer Key</td>
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<td>Inventor Files</td>
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<tr>
<td>IED Considerations</td>
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</tbody>
</table>

Self-knowledge  
5. In a journal entry or lesson test, students will explain how calculating properties of a geometric solid works and why these criteria or constraints are needed when designing.

- The teacher will assess students’ work based on completion.  
  Day 3:  
  - The teacher will distribute Activity 2.1.2 Calculating Properties of Shapes.  
  - Students will work on Activity 2.1.2 Calculating Properties of Shapes and complete the activity for homework.  
  - The teacher will assess student work using Activity 2.1.2 Calculating Properties of Shapes Answer Key  
  Day 4-5:  
  - The teacher will distribute Activity 2.1.3 Making Sketches in CAD.  
  - The teacher will demonstrate how to use the sketch tools within a CAD solid modeling program needed to complete the activity.  
  - Note: The files needed for this project can be found in the Inventor files folder. The teacher can access how to assemble and apply motion to the train from the tutorial on the Virtual Academy.  
  - Students will begin work on Activity 2.1.3 Making
• **Form and function**

**Science as Inquiry Standard A:** As a result of activities in grades 9-12, all students should develop—
- **Abilities necessary to do scientific inquiry**
- **Understandings about scientific inquiry**

**Science and Technology Standard E:** As a result of activities in grades 9-12, all students should develop—
- **Abilities of technological design**

**Principles and Standards for School Mathematics**

**Number Operations:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to understand numbers, ways of representing numbers, relationships among numbers, and number systems; understand meanings of operations and how they relate to one another; and compute fluently and make reasonable estimates.

**Algebra:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to understand patterns, relations, and functions; represent and analyze mathematical situations and structures using algebraic symbols; use mathematical models to represent and understand quantitative relationships; analyze change in various contexts.

**Geometry:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to analyze characteristics and properties of two-
and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships; specify locations and describe spatial relationships using coordinate geometry and other representational systems; apply transformations and use symmetry to analyze mathematical situations; use visualization, spatial reasoning, and geometric modeling to solve problems.

**Measurement:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to understand measurable attributes of objects and the units, systems, and processes of measurement; apply appropriate techniques, tools, and formulas to determine measurements.

**Communication:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to organize and consolidate their mathematical thinking through communication.

**Connections:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to understand how mathematical ideas interconnect and build on one another to produce a coherent whole; recognize and apply mathematics in contexts outside of mathematics.

**Representation:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to create and use representations to organize, record, and communicate mathematical ideas; select, apply, and translate among mathematical representations to solve problems; use representations to model and interpret physical, social, and mathematical phenomena.

**Standards for English Language Arts**

**Standard 4:**

- System along with the axes and planes associated with this system.
- The teacher will demonstrate how to use the feature tools within a CAD solid modeling program needed to complete the activity.
- Note: The files needed for this project can be found in the Inventor files folder. The teacher can access how to assemble and apply motion to the train from the tutorial on the Virtual Academy.
- Students will begin work on Activity 2.1.5 CAD Model Features.
- The teacher will assist students when needed.
- Students will complete Activity 2.1.5 CAD Model Features.
- The teacher will assess students’ work based on completion.

**Day 9-10:**

- The teacher will present Additive and Subtractive Solid Modeling.ppt.
- Students will take notes in their journals.
- The teacher will distribute Project 2.1.6 Modeling Creation.
- Students will begin work
Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes. **Standard 8:** Students use a variety of technological and informational resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.

**Performance Objectives**

*It is expected that students will:*

- Identify common geometric shapes and forms by name.
- Calculate the area of simple geometric shapes.
- Calculate the surface area and volume of simple geometric forms.
- Identify and explain the various geometric relationships that exist between the elements of two-dimensional shapes and three-dimensional forms.
- Identify and define the axes, planes, and sign conventions associated with the Cartesian coordinate system.
- Apply geometric and numeric constraints to CAD sketches.
- Utilize sketch-based, work reference, and placed features to develop solid CAD models from dimensioned drawings.
- Explain how a given object’s geometry is the result of sequential additive and subtractive processes.

### Lesson 2.3 Advanced modeling and skills

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<th><strong>Standards for Technological Literacy</strong></th>
<th><strong>Time:</strong> 19 days</th>
<th><strong>PowerPoint presentations</strong></th>
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<tbody>
<tr>
<td><strong>Standard 1:</strong> Students will develop an understanding of the characteristics and scope of technology.</td>
<td></td>
<td><strong>Work Points, Work Axes, and Work Planes</strong></td>
</tr>
<tr>
<td>BM D:</td>
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</tbody>
</table>

**NOTE:** In preparation for teaching this lesson, it is strongly recommended that the teacher read the Teacher Explanation 1. Students will explain the difference between geometric.
Tools, materials, and skills are used to make things and carry out tasks.

**Standard 2:**
Students will develop an understanding of the core concepts of technology.

**BM AA:**
Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.

**Standard 3:**
Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

**BM F:**
Knowledge gained from other fields of study has a direct effect on the development of technological products and systems.

**BM J:**
Technological progress promotes the advancement of science and mathematics. Likewise, progress in science and mathematics leads to advances in technology.

**Standard 9:**
Students will develop an understanding of engineering design.

**BM B:**
Expressing ideas to others verbally and through sketches and models is an important part of the design process.

**BM H:**
Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.

**Standard 11:**
Students will develop abilities to apply the design process.

**BM J:**
Make two-dimensional and three-dimensional representations of the designed solution.

**Standard 12:**
Students will develop the abilities to use and maintain technological products and systems.

Notes.
Note: The files needed for this lesson can be found in the Inventor files folder.

Day 1-2:
- The teacher will present Concepts, Key Terms, and Essential Questions, and provide a lesson overview.
- The teacher will present Work Points, Work Axes, and Work Planes.ppt.
- Students will take notes in their journals.
- The teacher will introduce and distribute Project 2.3.1 Arbor Press or Project 2.3.1a Miniature Train depending on available time and teacher preference.
- Note: The files needed for this project can be found in the Inventor files folder. The teacher can access how to assemble and apply motion to the train from the tutorial on the Virtual Academy.

Optional: The teacher may want to divide the students with half of them working on Project 2.3.1 Arbor Press and the other half on Project 2.3.1a Miniature Train. The students could then discuss differences and similarities with each project.

**Parametric Modeling**

**Auxiliary Views**

**Sectional Views**

**Basic Assembly Constraints and Concepts**

**Exploded CAD Assembly Models**

**Animating Assembly Models and Exporting Video**

**Assembly Drawings, Balloons, and Parts List**

**Word Documents**

- Project 2.3.1 Arbor Press
- Project 2.3.1a Miniature Train
- Activity 2.3.2 Parametric Constraints
- Activity 2.3.3 Auxiliary Views
- Activity 2.3.4 Sectional Views
- Activity 2.3.5 Assembly Models

parametric, and assembly constraints.

2. Students will explain the degrees of freedom an object has before any constraints are applied to a student who was absent.

**Interpretation**

3. Students will analyze and evaluate another classmate’s dimensioned multiview drawings and pictorials developed in a 3D CAD modeling program.

4. Students will derive algebraic equations from a given part’s dimensions that will be used to maintain that part’s geometric proportions.

**Application**

5. Students will demonstrate and explain how to fully constrain objects to the
**BM D:**
Follow step-by-step directions to assemble a product.

**Standard 17:**
Students will develop an understanding of and be able to select and use information and communication technologies.

**BM K:**
The use of symbols, measurements, and drawings promotes clear communication by providing a common language to express ideas.

**BM Q:**
Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.

**Standard 19:**
Students will develop an understanding of and be able to select and use manufacturing technologies.

**BM F:**
Manufacturing systems use mechanical processes that change the form of materials through the processes of separating, forming, combining, and conditioning them.

**National Science Education Standards**

**Unifying Concepts and Processes Standard K-12:** As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes—
- Systems, order, and organization
- Evidence, models, and explanation
- Change, constancy, and measurement
- Form and function

**Science as Inquiry Standard A:** As a result of activities in grades 9-12, all students should

| Activity 2.3.6 Arbor Press Drawings Answer Keys and Rubrics |
| Activity 2.3.2 Parametric Constraints Answer Key |
| Activity 2.3.3 Auxiliary Views Answer Key |
| Activity 2.3.4 Sectional Views Answer Key |
| Activity 2.3.6 Detail Drawing Rubric |

**Teacher Guidelines**
- **Lesson 2.3**
- **Teacher Notes**
- **Lesson 2.3 Key Terms**
- **Lesson 2.3 Key Terms and definitions in Excel**
- **Inventor Files**

**IED Considerations**

| Perspective |
| Students will select a product available in the classroom, write detailed instructions on how the product would be made using a CAD modeling software, and discuss an alternate way of creating the same part. |

| Day 3-4: |
| The teacher will introduce and distribute Activity 2.3.2 Parametric Constraints. |
| The teacher will present Parametric Modeling.ppt. |
| Students will take notes in their journals. |
| Students will begin work on Activity 2.3.2 Parametric Constraints. |
| The teacher will assist the students with Activity 2.3.2 Parametric Constraints. |
| Students will complete Activity 2.3.2 Parametric Constraints. |
| The teacher will assess student work using Activity 2.3.2 Parametric Constraints Answer Key. |
| Students will continue working on Project 2.3.1 Arbor Press or Project 2.3.1a Miniature Train. |

| Day 5-6: |
| The teacher will present Auxiliary Views.ppt. |
| Students will take notes in their journals. |
develop—
· Abilities necessary to do scientific inquiry
· Understandings about scientific inquiry

**Principles and Standards for School Mathematics**

**Number Operations:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to understand numbers, ways of representing numbers, relationships among numbers, and number systems; understand meanings of operations and how they relate to one another; and compute fluently and make reasonable estimates.

**Algebra:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to represent and analyze mathematical situations and structures using algebraic symbols; use mathematical models to represent and understand quantitative relationships.

**Geometry:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships; and use visualization, spatial reasoning, and geometric modeling to solve problems.

**Measurement:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to understand measurable attributes of objects and the units, systems, and processes of measurement; and apply appropriate techniques, tools, and formulas to determine measurements.

**Communication:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to understand and represent mathematical ideas using language, physical models, and symbols; use the language of mathematics to express mathematical ideas precisely.

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· The teacher will introduce and distribute Activity 2.3.3 Auxiliary Views.
· Students will begin work on Activity 2.3.3 Auxiliary Views.
· The teacher will assist the students with Activity 2.3.3 Auxiliary Views.
· Students will finish work on Activity 2.3.3 Auxiliary Views.
· The teacher will assess student work using Activity 2.3.3 Auxiliary Views Answer Key.
· Students will continue working on Project 2.3.1 Arbor Press or Project 2.3.1a Miniature Train.

Day 7-8

· The teacher will present Sectional Views.ppt.
· Students will take notes in their journals.
· The teacher will introduce and distribute Activity 2.3.4 Sectional Views.
· Students will begin work on Activity 2.3.4 Sectional Views.
· The teacher will assist the students with Activity 2.3.4 Sectional Views.
· Students will finish work on Activity 2.3.4 Sectional Views.
through grade 12 should enable all students to organize and consolidate their mathematical thinking through communication; communicate their mathematical thinking coherently and clearly to peers, teachers, and others; and analyze and evaluate the mathematical thinking and strategies of others.

**Presentation:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to create and use representations to organize, record, and communicate mathematical ideas.

**Standards for English Language Arts**

**Standard 4:**
Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.

**Standard 5:**
Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences and for a variety of purposes.

**Performance Objectives**

*It is expected that students will:*

- Sketch and model an auxiliary view of a given object to communicate the true size and shape of its inclined surfaces.
- Describe the purpose and demonstrate the application of section lines and cutting plane lines in a section view drawing.
- Sketch a full and half section view of a given object to communicate its interior features.
- Identify algebraic relationships between the dimensional values of a given object.
- Apply assembly constraints to individual CAD models to create mechanical systems.

- The teacher will assess student work using Activity 2.3.4 Sectional Views Answer Key.
- Students will continue working on Project 2.3.1 Arbor Press or Project 2.3.1a Miniature Train.

**Day 9-10**

- The teacher will present Basic Assembly Constraints and Concepts.ppt.
- Students will take notes in their journals.
- The teacher will introduce and demonstrate the exercises in Activity 2.3.5 Assembly Models.
- Students will begin work on Activity 2.3.5 Assembly Models.
- The teacher will assist the students with Activity 2.3.5 Assembly Models.
- Students will complete Activity 2.3.5 Assembly Models.

**Day 11-12**

- Optional: The teacher will present Exploded CAD Assembly Models.ppt. The teacher may want to demonstrate this to students
- Perform part manipulation during the creation of an assembly mode.
- Explain how assembly constraints are used to systematically remove the degrees of freedom for a set of components in a given assembly.
- Create an exploded model of a given assembly.
- Determine ratios and apply algebraic formulas to animate multiple parts within an assembly mode.
- Create and describe the purpose of the following items: exploded isometric assembly view, balloons, and parts list.

Day 13-14

- Optional: The teacher will present Animating Assembly Models and Exporting Video.ppt. The teacher may want to demonstrate this to students instead of showing the presentation.
- Students will take notes in their journals.
- The teacher will demonstrate how to animate an assembly using the Arbor Press or the Miniature Train project.
- Students will animate their Arbor Press or Miniature Train assembly.
- The teacher will assist the students when needed.
Day 15-19

- The teacher will introduce and distribute Activity 2.3.6 Arbor Press Drawings and Activity 2.3.6 Detail Drawing Rubric.
- The teacher will let students know they can use the same activity set up for the Miniature Train.
- The teacher will demonstrate creating a dimensioned multiview drawing from one of the Arbor Press part models or Miniature Train part. The demonstration will include the creation of section and auxiliary views, centerlines, dimensions, and tolerances.
- Students will take notes in their journals.
- Students will begin work on Activity 2.3.6 Arbor Press Drawings.
- The teacher will use the Activity 2.3.6 Detail Drawing Rubric to assess the students’ drawings.
- The teacher can use the same rubric set up for the Miniature train set-up.
- Optional: The teacher will present Assembly Drawings, Balloons, and Parts Lists.ppt. The teacher may want to demonstrate this to
### Integration Teacher Notes

<table>
<thead>
<tr>
<th>Curriculum</th>
<th>Instructional Strategies</th>
<th>Resources</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do we want students to learn?</td>
<td>How will we deliver the curriculum?</td>
<td>What materials/resources will we need to ensure mastery?</td>
<td>How will we know if students learn?</td>
</tr>
</tbody>
</table>

#### Quarterly focused instructional strategies, processes, skill development, or content expectations

**3rd Quarter**

**Lesson 2.4 Advanced design**

**Standards for Technological Literacy**

**Standard 2:** Students will develop an understanding of the core concepts of technology.

**BM AA:** Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.

**Standard 3:** Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

**BM A:** The study of technology uses many of the same

<table>
<thead>
<tr>
<th>Time: 12 days</th>
</tr>
</thead>
</table>

**NOTE:** In preparation for teaching this lesson, it is strongly recommended that the teacher read the Teacher Notes.

**Day 1-2:**

- The teacher will present Concepts, Key Terms, and Essential Questions to provide a lesson overview.

**PowerPoint Presentations**

- Teamwork
- Fluid Power
- Decision Making Matrix

**Word Documents**

- Project 2.4.1 Design Challenge

**Explanation**

1. Students will explain why design options of a project are determined by criteria and constraints.

**Application**

2. Students will design an alternate solution to the same
<table>
<thead>
<tr>
<th>BM C:</th>
<th>Various relationships exist between technology and other fields of study.</th>
</tr>
</thead>
<tbody>
<tr>
<td>BM F:</td>
<td>Knowledge gained from other fields of study has a direct effect on the development of technological products and systems.</td>
</tr>
</tbody>
</table>

**Standard 6:**
Students will develop an understanding of the role of society in the development and use of technology.

**BM A:**
Products are made to meet individual needs and wants.

**Standard 8:**
Students will develop an understanding of the attributes of design.

**BM H:**
The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results.

**Standard 9:**
Students will develop an understanding of engineering design.

**BM A:**
The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others.

**BM B:**
Expressing ideas to others verbally and through sketches and models is an important part of the design process.

**BM D:**
When designing an object, it is important to be creative and consider all ideas.

| · The teacher will distribute and introduce Project 2.4.1 Design Challenge and Project 2.4.1 Design Challenge Rubric. |
|---|---|
| · The teacher will divide the class into groups of two. |
| · The teacher will discuss constraints, requirements and design briefs for each project. |
| · The teacher will review the design process using Example Design Process distributed in Lesson 1.1. |
| · Students will keep Example Design Process document available throughout this lesson. |
| · The teacher will distribute the graph paper located in the Teacher Guidelines at the end of this lesson. |
| · Students will begin work on Project 2.4.1 Design Challenge. Day3-12: |
| · The teacher will distribute Decision Matrix Template |

**Rubrics**
- Project 2.4.1 Design Challenge Rubric
- Decision Matrix Template in Word
- Decision Matrix Template in Excel
- Isometric graph paper
- Orthographic graph paper
- Isometric graph paper

**Teacher Guidelines**
- Lesson 2.4 Teacher Notes
- Lesson 2.4 Key Terms
- Lesson 2.4 Key Terms and definitions in Excel
- Decision Matrix Template in Word
- Decision Matrix Template in Excel
- Isometric graph paper

**Interpretation**
3. Students will illustrate their proposed solution and use their illustration to explain how it relates to what they have learned about engineering design.

4. Students will explain the advantages and disadvantages of working in teams answering questions, such as:
   a. When I work with I team I find that I …
   b. The hardest thing for me to do when working with...
BM F: Design involves a set of steps, which can be performed in different sequences and repeated as needed.

BM G: Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.

BM J: Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.

Standard 11 Students will develop the abilities to apply the design process.

BM E: The process of designing involves presenting some possible solutions in visual form and then selecting the best solution(s) from many.

BM I: Specify criteria and constraints for the design.

BM J: Make two-dimensional and three-dimensional representations of the designed solution.

BM R: Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.

Standard 17 Students will develop an understanding of and be able to select and use information and communication technologies.

BM Q: Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.

National Science Education

- The teacher will present the Decision Making Matrix.ppt.
- Students will take notes in their journals.
- Students will continue working on materials to be completed for Project 2.4.1 Design Challenge.
- The teacher will keep students on task and answer any questions during the process.
- Students will complete Project 2.4.1 Design Challenges.
- Students will present their design solution using their three-fold brochure and an oral report to the class.
- The teacher will assess students using Project 2.4.1 Design Challenges Rubric.

a team is …

b. The easiest part of working on a team is …

c. The easiest part of working on a team is …
### Standards

**Unifying Concepts and Processes Standard K-12:** As a result of activities in grades 9-12, all students should develop—
- Change, constancy, and measurement
- Form and function

**Science and Technology Standard E:** As a result of activities in grades 9-12, all students should develop—
- Abilities of technological design

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### Principles and Standards for School Mathematics

**Number Operations:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to understand numbers, ways of representing numbers, relationships among numbers, and number systems; understand meanings of operations and how they relate to one another; and compute fluently and make reasonable estimates.

**Algebra:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to understand patterns, relations, and functions; represent and analyze mathematical situations and structures using algebraic symbols; use mathematical models to represent and understand quantitative relationships; and analyze change in various contexts.

**Geometry:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships; specify locations and describe spatial relationships using coordinate
geometry and other representational systems; apply transformations and use symmetry to analyze mathematical situations; and use visualization, spatial reasoning, and geometric modeling to solve problems.

**Measurement:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to understand measurable attributes of objects and the units, systems, and processes of measurement; and apply appropriate techniques, tools, and formulas to determine measurements.

**Problem Solving**
Instructional programs from pre-kindergarten through grade 12 should enable all students to solve problems that arise in mathematics and in other contexts; apply and adapt a variety of appropriate strategies to solve problems.

**Communication:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to organize and consolidate their mathematical thinking through communication; and communicate their mathematical thinking coherently and clearly to peers, teachers, and others.

**Connections:**
Instructional programs from pre-kindergarten through grade 12 should enable all students recognize and apply mathematics in contexts outside of mathematics.

**Standards for English Language Arts**

**Standard 4:**
Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.

**Standard 5:**
Students employ a wide range of strategies as they write and use different writing process
elements appropriately to communicate with different audiences and for a variety of purposes.

**Standard 8:**
Students use a variety of technological and informational resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.

**Standard 12:**
Students use spoken, written and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).

**Performance Objectives**

*It is expected that students will:*

- Brainstorm and sketch possible solutions to an existing design problem.
- Create a decision making matrix.
- Select an approach that meets or satisfies the constraints given in a design brief.
- Create solid computer-aided design (CAD) models of each part from dimensioned sketches using a variety of methods.
- Apply geometric numeric and parametric constraints to form CAD modeled parts.
- Generate dimensioned multiview drawings from simple CAD modeled parts.
- Assemble the product using the CAD modeling software.
- Explain what constraints are and why they are included in a design brief.
- Create a three-fold brochure marketing the designed solution for the chosen problem, such as a consumer product, a dispensing system, a new form of control system, or extend a product design to meet a new requirement.
- Explain the concept of fluid power, and the difference between hydraulic and pneumatic power systems.
<table>
<thead>
<tr>
<th>Lesson 3.1 Visual analysis</th>
<th><strong>Standards for Technological Literacy</strong></th>
<th>Time: 8 days</th>
<th><strong>PowerPoint® Presentations</strong></th>
<th><strong>Explanation</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard 1:</strong> Students will develop an understanding of the characteristics and scope of technology.</td>
<td><strong>BM I:</strong> Corporations can often create demand for a product by bringing it onto the market and advertising it.</td>
<td><strong>NOTE:</strong> In preparation for teaching this lesson, it is strongly recommended that the teacher read Teacher Notes.</td>
<td><strong>Visual Design Principles and Elements</strong></td>
<td>1. Students will list the elements of design.</td>
</tr>
<tr>
<td><strong>BM M:</strong> Most development of technologies these days is driven by the profit motive and the market.</td>
<td><strong>BM J:</strong> A number of different factors, such as advertising, the strength of the economy, the goals of a company and the latest fads contribute to shaping the design of and demand for various technologies.</td>
<td><strong>Day 1:</strong></td>
<td><strong>Graphic Design</strong></td>
<td>2. Students will list the principles of design.</td>
</tr>
<tr>
<td><strong>Standard 6:</strong> Students will develop an understanding of the role of society in the development and use of technology.</td>
<td><strong>BM L:</strong> Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques.</td>
<td><strong>Day 2:</strong></td>
<td><strong>Activity 3.1.1 Visual Design Principles and Elements Identification</strong></td>
<td>3. Students will explain vocabulary associated with marketing a graphic design.</td>
</tr>
<tr>
<td><strong>Standard 12:</strong> Students will develop the abilities to use and maintain technological products and systems.</td>
<td><strong>BM P:</strong> There are many ways to communicate information, such as graphic and electronic means.</td>
<td><strong>Day 1:</strong></td>
<td><strong>Activity 3.1.2 Visual Design Principles and Elements Study</strong></td>
<td><strong>Interpretation</strong></td>
</tr>
<tr>
<td><strong>BM L:</strong> Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques.</td>
<td></td>
<td></td>
<td><strong>Activity 3.1.3 What’s going on in this graphic design?</strong></td>
<td>1. Students will define and explain the elements of design.</td>
</tr>
<tr>
<td><strong>Standard 17:</strong> Students will develop an understanding of and be able to select and use information and communication technologies.</td>
<td></td>
<td></td>
<td><strong>Assessment</strong></td>
<td>2. Students will define and explain the principles of design.</td>
</tr>
<tr>
<td><strong>BM P:</strong> There are many ways to communicate information, such as graphic and electronic means.</td>
<td></td>
<td></td>
<td><strong>Lesson 3.1 Visual Design Principles and Elements Quiz</strong></td>
<td><strong>Application</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Answer Keys and Rubrics</strong></td>
<td>1. Students will utilize their knowledge of the principles and elements of design.</td>
</tr>
</tbody>
</table>
**National Science Education Standards**

**Unifying Concepts and Processes Standard K-12:** As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes—

- Systems, order, and organization
- Evidence, models, and explanation
- Change, constancy, and measurement
- Form and function

**Science and Technology Content Standard E:**
As a result of activities in grades 9-12, all students should develop—

- Abilities of technological design
- Understandings about science and technology

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**Principles and Standards for School Mathematics**

**Number Operations:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to—

- understand numbers, ways of representing numbers, relationships among numbers, and number systems;
- understand meanings of operations and how they relate to one another;
- compute fluently and make reasonable estimates.

**Algebra:**

Instructional programs from pre-kindergarten through grade 12 should enable all students to use mathematical models to represent and understand quantitative relationships.

**Geometry:**

working on Activity 3.1.1 Visual Design Principles and Elements Identification.

- The teacher will provide comments and additional information as needed to clarify student understanding and to prevent misconceptions.

Day 3:

- The teacher will ask students at random to explain the principles and elements of one of their objects.
- The teacher will assign each student to bring to class one mechanical artifact consisting of no more than 12 component parts.

Day 4:

- The teacher will review and distribute Activity 3.1.2 Visual Design Principles and Elements Study.
- Students will work in teams on Activity 3.1.2 Visual Design Principles and Elements Study.

Day 5:

- Students will work in teams on Activity 3.1.2 Visual Design Principles and Elements Study.
- Alert students that they design to identify their use within products, art forms, and print media during a teacher directed lesson.

2. Students will express their understanding of the principles and elements of design by incorporating them in their design solutions.

**Self-Knowledge**

1. Students will collect and display examples of the application of the principles and elements of design utilized in products, art forms and print media.
Instructional programs from pre-kindergarten through grade 12 should enable all students to—
- analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships;
- specify locations and describe spatial relationships using coordinate geometry and other representational systems;
- apply transformations and use symmetry to analyze mathematical situations;
- use visualization, spatial reasoning, and geometric modeling to solve problems.

**Measurement:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to—
- understand measurable attributes of objects and the units, systems, and processes of measurement.

**Problem Solving:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to build new mathematical knowledge through problem solving; solve problems that arise in mathematics and in other contexts; and apply and adapt a variety of appropriate strategies to solve problems.

**Data Analysis and Probability:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to—
- formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them;
- develop and evaluate inferences and predictions that are based on data.

**Communication:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to—
- organize and consolidate their mathematical thinking through communication;
- communicate their mathematical thinking

will need to bring in advertisements for upcoming Activity 3.1.3.

**Day 6:**
- The teacher will distribute Lesson 3.1 Visual Design Principles and Elements Quiz.
- Students will complete Visual Design Principles and Elements Test.
- Students will submit their engineer’s notebooks for evaluation of Activity 3.1.2 Visual Design Principles and Elements Study.
- The teacher will evaluate the students’ work using the Activity 3.1.2 Visual Design Principles and Elements Study Rubric.

**Day 7:**
- The teacher will present Graphic Design.ppt.
- Students will take notes in their engineer’s notebook.
- The teacher will introduce and distribute Activity 3.1.3 What’s going on in this graphic design? and Activity 3.1.3 Graphic Design Rubric.
- Students will work in groups of two on Activity 3.1.3 What’s going on in
coherently and clearly to peers, teachers, and others.

**Connections:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to—
· recognize and apply mathematics in contexts outside of mathematics.

**Representation:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to—
· create and use representations to organize, record, and communicate mathematical ideas;
· select, apply, and translate among mathematical representations to solve problems;
· use representations to model and interpret physical, social, and mathematical phenomena.

**Standards for English Language Arts**

**Standard 1:**
Students read a wide range of print and non-print texts to build an understanding of texts of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classical and contemporary works.

**Standard 4:**
Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.

**Standard 6:**
Students apply knowledge of language structure, language conventions (e.g., spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss print and non-print texts.

**Standard 7:**
Students conduct research on issues and

this graphic design?
· Students will complete the activity for homework.

Day 8:
· Students will present and defend their analyses orally, in a round table discussion.
· The teacher will monitor and chair the discussion.
· Students will submit their analysis for teacher evaluation according to Graphic Design Rubric.
interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and non-print texts, artifacts, and people) to communicate their discoveries in ways that suit their purpose and audience.

**Standard 8:**
Students use a variety of technological and informational resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.

**Standard 11:**
Students participate as knowledgeable reflective, creative, and critical members of a variety of literacy communities.

**Standard 12:**
Students use spoken, written and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).

**Performance Objectives**

*It is expected that students will:*

- Identify visual design elements within a given object.
- Explain how visual design principles were used to manipulate design elements within a given object.
- Explain what aesthetics is, and how it contributes to a design’s commercial success.
- Identify the purpose of packaging in the design of consumer products.
- Identify visual design principles and elements that are present within marketing ads.
- Identify the intent of a given marketing ad and demographics of the target consumer group for which it was intended.
Lesson 3.2

Standards for Technological Literacy

Standard 8:
Students will develop an understanding of the attributes of design.

BM D:
Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.

BM E:
Design is a creative planning process that leads to useful products and systems.

Standard 11:
Students will develop abilities to apply the design process.

BM R:
Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.

National Science Education Standards

Unifying Concepts and Processes Standard K-12: As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes—

- Systems, order, and organization
- Evidence, models, and explanation
- Change, constancy, and measurement
- Form and function

Science as Inquiry Standard A: As a result of activities in grades 9-12, all students should develop—

- Abilities necessary to do scientific inquiry

PowerPoint® Presentations

- Reverse Engineering and Functional Analysis

Word Documents

- Activity 3.2.1
- Product Observation

Teacher Guidelines

Lesson 3.2

Teacher Notes

Activity 3.2.1a

Example Product Observation

Lesson 3.2 Key Terms and definitions in Excel

Explanation

1. Students develop a black box model to identify the inputs and outputs associated with a system.

2. Students identify the significance of using the black box approach for explaining products.

Interpretation

3. Students observe a product and hypothesize its intended function.

Time: 4 days

NOTE: In preparation for teaching this lesson, it is strongly recommended that the teacher read Teacher Notes.

Day 1:

- The teacher will present Concepts, Key Terms, and Essential Questions to provide a lesson overview.
- The teacher will show SX-70.
- Students will take notes in their engineer’s notebook.
- The teacher will lead the class in a group discussion on how design objects may be described as a sequence of operations, using the SX-70 camera as an example.

Day 2:

- The teacher will present Reverse Engineering and Functional Analysis.ppt.
- Students will take notes in their engineer’s notebook.
- The teacher will introduce and distribute Activity 3.2.1a Example Product Observation and Activity 3.2.1 Product Observation.
- Students will begin work on Activity 3.2.1 Product Observation.
Understandings about scientific inquiry

Principles and Standards for School Mathematics

Algebra:
Instructional programs from pre-kindergarten through grade 12 should enable all students to—
· analyze change in various contexts.

Geometry:
Instructional programs from pre-kindergarten through grade 12 should enable all students to—
· use visualization, spatial reasoning, and geometric modeling to solve problems.

Measurement:
Instructional programs from pre-kindergarten through grade 12 should enable all students to—
· understand measurable attributes of objects and the units, systems, and processes of measurement;
· apply appropriate techniques, tools, and formulas to determine measurements.

Communication:
Instructional programs from pre-kindergarten through grade 12 should enable all students to—
· analyze and evaluate the mathematical thinking and strategies of others;
· use the language of mathematics to express mathematical ideas precisely.

Representation Standard:
Instructional programs from pre-kindergarten through grade 12 should enable all students to—
· use representations to model and interpret physical, social, and mathematical phenomena.

Observation.
Days 3-4:
· Students will complete Activity 3.2.1 Product Observation.
· The teacher will assist the students with Activity 3.2.1 Product Observation.
<table>
<thead>
<tr>
<th>Standards for English Language Arts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard 3:</strong> Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and other texts, their word identification strategies, and their understanding of textual features (e.g., sound-letter correspondence, sentence structure, context, graphics).</td>
</tr>
<tr>
<td><strong>Standard 6:</strong> Students apply knowledge of language structure, language conventions (e.g., spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss print and non-print texts.</td>
</tr>
<tr>
<td><strong>Standard 7:</strong> Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and non-print texts, artifacts, and people) to communicate their discoveries in ways that suit their purpose and audience.</td>
</tr>
<tr>
<td><strong>Standard 8:</strong> Students use a variety of technological and informational resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.</td>
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<td><strong>Standard 12:</strong> Students use spoken, written and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).</td>
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**Performance Objectives**

*It is expected that students will:*

- Identify the reasons why engineers perform
reverse engineering on product.  
- Describe the function of a given manufactured object as a sequence of operations through visual analysis and inspection (prior to dissection).
<table>
<thead>
<tr>
<th>Integration Teacher Notes</th>
<th>Curriculum</th>
<th>Instructional Strategies</th>
<th>Resources</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>What do we want students to learn?</td>
<td>How will we deliver the curriculum?</td>
<td>What materials/resources will we need to ensure mastery.</td>
<td>How will we know if students learn?</td>
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Quarterly focused instructional strategies, processes, skill development, or content expectations

**4th Quarter**

<table>
<thead>
<tr>
<th>Standards for Technological Literacy</th>
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<th>Total Time: 15 days</th>
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<tr>
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<td>Wood Fasteners, Joinery, &amp; Adhesives</td>
<td>1. Students will classify a sampling of fasteners, joinery and adhesives.</td>
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<td>Students will develop an understanding of the attributes of design.</td>
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<td>Product Disassembly</td>
<td>2. Students will explain the value of the disassembly process, what information was discovered, and how it may be used to improve the product's design.</td>
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<td>The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved.</td>
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<tr>
<td><strong>BM K:</strong></td>
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<td></td>
<td>Plastic Fasteners, Welding &amp; Bonding</td>
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<td>Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other.</td>
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<tr>
<td><strong>Standard 9:</strong></td>
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<td></td>
<td>Optional Activity 3.3.1a Wood Joinery Identification</td>
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<td>Optional Activity 3.3.1b Wood Fasteners and Adhesives Classification</td>
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<td><strong>BM H:</strong></td>
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<td></td>
<td>Optional Activity 3.3.1c Metal</td>
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<td>Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.</td>
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**National Science Education Standards**

**Unifying Concepts and Processes Standard K-12:** As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes—

- Systems, order, and organization
- Evidence, models, and explanation
- Change, constancy, and measurement
- Evolution and equilibrium
- Form and function

**Quarterly focused instructional strategies, processes, skill development, or content expectations**

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### Science as Inquiry Standard A
As a result of activities in grades 9-12, all students should develop—
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

### Science and Technology Standard E
As a result of activities in grades 9-12, all students should develop—
- Abilities of technological design
- Understandings about science and technology

### Principles and Standards for School Mathematics
**Number Operations:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to—
- understand numbers, ways of representing numbers, relationships among numbers, and number systems;
- understand meanings of operations and how they relate to one another;
- compute fluently and make reasonable estimates.

**Algebra:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to—
- represent and analyze mathematical situations and structures using algebraic symbols;
- use mathematical models to represent and understand quantitative relationships.

**Geometry:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to—
- analyze characteristics and properties of two- and three-dimensional geometric shapes and
- Adhesives, Metal Fasteners, Joining & Adhesives, and Plastic Fasteners, Welding & Bonding.ppt.
- Students will take notes on the nomenclature and how the terms are used to distinguish between the types of processes and materials being used in joining, fastening, and adhering a product. It is imperative that students understand the basic differences between joinery, fasteners, and adhesives.
- Optional: The teacher may have students work through the following optional activities in class or as homework assignments after having students view the related PowerPoint presentations:
  - Optional Activity 3.3.1a Wood Joinery Identification
  - Optional Activity 3.3.1b Wood Fasteners Adhesives Classification
  - Optional Activity 3.3.1c Metal Joining Process Identification
  - Optional Activity 3.3.1d Metal Fasteners and Adhesive Classification

**Joining Process Identification**
- Optional Activity 3.3.1e Plastic Welding Procedure Identification
- Optional Activity 3.3.1f Plastic Fasteners & Bonding Classification

**Activity 3.3.2**
- Product Disassembly
- Activity 3.3.2a Product Disassembly Chart
- Activity 3.3.2b Materials Usages Charts
- Activity 3.3.3 Mass Property Analysis
- Optional Activity 3.3.3a-g Mass Property Analysis Extras
- Project 3.3.4 Product Disassembly

### Problems
1. Students will explain the importance of considering different materials for a product's production.
2. Students will explain what effect changing the surface area of a product will have on the finishing and packaging processes.
3. Students will research various materials, properties and processes to identify characteristics similar to their product.
4. Students will explain the importance of considering different materials for a product's production.
5. Students will explain what effect changing the surface area of a product will have on the finishing and packaging processes.
6. Students will research various materials, properties and processes to identify characteristics similar to their product.
7. Students will apply what they have learned.
develop mathematical arguments about geometric relationships; use visualization, spatial reasoning, and geometric modeling to solve problems.

**Measurement:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to—understand measurable attributes of objects and the units, systems, and processes of measurement; apply appropriate techniques, tools, and formulas to determine measurements.

**Standards for English Language Arts**

**Standard 4:** Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.

**Standard 5:** Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences and for a variety of purposes.

**Standard 12:** Students use spoken, written and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).

**Performance Objectives**

*It is expected that students will:*

- Describe the differences between joinery, fasteners, and adhesives.
- Identify the types of structural connections that exist in a given object.
- Use dial calipers to precisely measure outside and inside diameter, hole depth, and object.

- **Optional Activity 3.3.1e** Plastic Welding Procedure Identification
- **Optional Activity 3.3.1f** Plastic Fasteners Bonding Classification
  - The teacher will present Product Disassembly.pdf and explain to students the need to take a product apart in order to learn more about how it functions.
  - Days 2-4:
    - The teacher will review and distribute Activity 3.3.2 Product Disassembly, Activity 3.3.2a Product Disassembly Chart, and Activity 3.3.2b Materials Usages Charts.
    - Students will use Activity 3.3.2a Product Disassembly Chart to record their work, and Activity 3.3.2b Materials Usages Chart to identify the various materials that exist in their reverse engineered products.
    - Students will begin disassembling their product used in prior lessons for this unit.

Day 5:

- **Optional Activity 3.3.3a-g Mass Property Analysis Extras Answer Key**
- **Activity 3.3.3** Mass Property Analysis Answer Key
  - Students will use a solid modeling software to find the mass, surface area, and volume of a part.

8. Students will use Activity 3.3.1b Wood Fasteners and Adhesives Answer Key

9. Students will change materials and revise the mass analysis of a part.
<table>
<thead>
<tr>
<th>Students will complete Activity 3.3.2a Product Disassembly Chart.</th>
<th>The teacher will remind students about Activity 3.3.2b Materials and their Usages information sheet and explain how to use the document with the activity.</th>
</tr>
</thead>
<tbody>
<tr>
<td>The teacher will present Activity 3.3.3 Mass Property Analysis and offer students additional practice with the following extra activity: Optional Activity 3.3.3a-g Mass Property Analysis Extras</td>
<td>Students will begin drawing the parts with a 3D modeling program and complete Activity 3.3.3 Mass Property Analysis. The teacher will assist students as needed.</td>
</tr>
</tbody>
</table>

Days 6-10:

| The teacher will introduce Mass Property Analysis.ppt. Students will take notes in their engineer’s notebook. The teacher will present Activity 3.3.3 Mass Property Analysis and offer students additional practice with the following extra activity: Optional Activity 3.3.3a-g Mass Property Analysis Extras | Students will begin drawing the parts with a 3D modeling program and complete Activity 3.3.3 Mass Property Analysis. The teacher will assist students as needed. |

Days 11-12:

| Students will complete Activity 3.3.2a Product Disassembly Chart. The teacher will remind students about Activity 3.3.2b Materials and their Usages information sheet and explain how to use the document with the activity. | The teacher will present Activity 3.3.3 Mass Property Analysis and offer students additional practice with the following extra activity: Optional Activity 3.3.3a-g Mass Property Analysis Extras | Students will begin drawing the parts with a 3D modeling program and complete Activity 3.3.3 Mass Property Analysis. The teacher will assist students as needed. |
Lesson 3.4
Product improvement by design

**Standards for Technological Literacy**

**Standard 1:** Students will develop an understanding of the characteristics and scope of technology.

**BM L:** Inventions and innovations are the results of specific, goal-directed research.

**Standard 2:**

---

**PowerPoint® Presentations**

- Writing a Design Brief
- The Deep Dive
- Technical Report Elements

**Explanation**

1. Students will explain the differences between a problem statement and a design.
Students will develop an understanding of the core concepts of technology.

**BM AA:** Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.

**Standard 3:** Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

**BM G:** Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function.

**Standard 4:** Students will develop an understanding of the cultural, social, economic, and political effects of technology.

**BM J:** Ethical considerations are important in the development, selection, and use of technologies.

**Standard 5:** Students will develop an understanding of the effects of technology on the environment.

**BM C:** The use of technology affects the environment in good and bad ways.

**Standard 6:** Students will develop an understanding of the role of society in the development and use of technology.

**BM I:** The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures.

**Standard 7:** Students will develop an understanding of the influence of technology on history.

**BM G:** Most technological development has been evolutionary, the result of a series of refinements.

- The teacher will present Concepts, Key Terms, and Essential Questions to provide a lesson overview.
- The teacher will introduce and distribute Activity 3.4.1a Child Toy Design Brief.
- The teacher will present Writing a Design Brief.ppt.
- Students will take notes in their engineer’s notebook.
- The teacher will introduce and distribute Activity 3.4.1 Writing a Design Brief and Activity 3.4.1b Design Brief Template.
- Students will begin work on Activity 3.4.1 Writing a Design Brief.

Days 2-3:

- Students will complete Activity 3.4.1 Writing a Design Brief.
- The teacher will assist the students with Activity 3.4.1 Writing a Design Brief.
- The teacher will assess student work using Activity 3.4.1 Writing a Design Brief Answer Key.

Days 4-5:

- The teacher will administer Activity 3.4.1c Framing a Design Brief
- The teacher will administer Activity 3.4.1c Framing a Design Brief Quiz

**Assessment**

- Activity 3.4.1c Framing a Design Brief Quiz

**Answer Keys and Rubrics**

- Activity 3.4.1 Writing a Design Brief Answer Key
- Activity 3.4.1c Framing a Design Brief Quiz Answer Key
- Activity 3.4.2 The Deep Dive Answer Key
to a basic invention.

**Standard 8:**
Students will develop an understanding of the attributes of design.

**BM A:**
Everyone can design solutions to a problem.

**BM C:**
The design process is a purposeful method of planning practical solutions to problems.

**BM D:**
Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.

**BM E:**
Design is a creative planning process that leads to useful products and systems.

**BM F:**
There is no perfect design.

**Standard 9:**
Students will develop an understanding of engineering design.

**BM A:**
The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others.

**BM B:**
Expressing ideas to others verbally and through sketches and models is an important part of the design process.

**BM D:**
When designing an object, it is important to be creative and consider all ideas.

**BM F:**
Design involves a set of steps, which can be performed in different sequences and repeated as needed.

**BM G:**
Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.

**BM J:**

**Quiz.**
- Students will complete the quiz.
- The teacher will assess student work using Activity 3.4.1c Framing a Design Brief Quiz Answer Key.
- The teacher will introduce and distribute Activity 3.4.2 The Deep Dive.
- The teacher will show The Deep Dive DVD.
- Students will watch the film and complete Activity 3.4.2 The Deep Dive.

Day 6-7:
- The teacher will present The Deep Dive.ppt, review Activity 3.4.2 The Deep Dive, and lead the students in a discussion on the difference between invention and innovation.
- Students will take notes in their engineer’s notebook.
- The teacher will introduce and distribute Problem 3.4.3 Product Improvement Design Brief Template.
- Students will begin working in teams to identify a visual, structural, or functional shortcoming in their reverse engineered products, and create design briefs to address those problems for homework.

Day 8:
- Students will brainstorm as a class team to generate ideas for various product innovation needs.

**Perspective**
1. Students will generate a design brief for their reverse engineered product from the perspective of a designer.
Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.

**Standard 10:**
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

**BM D:**
Invention and innovation are creative ways to turn ideas into real things.

**BM G:**
Invention is a process of turning ideas and imagination into devices and systems.

**BM J:**
Technological problems must be researched before they can be solved.

**Standard 11:**
Students will develop abilities to apply the design process.

**BM C:**
Investigate how things are made and how they can be improved.

**BM E:**
The process of designing involves presenting some possible solutions in visual form and then selecting the best solution(s) from many.

**BM I:**
Specify criteria and constraints for the design.

**BM Q:**
Develop and produce a product or system using a design process.

**BM R:**
Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.

**Standard 12:**
Students will develop the abilities to use and maintain technological products and systems.

| BM P: | Students will submit their design briefs from Problem 3.4.3 Product Improvement. |
|       | The teacher will review the design briefs with the class. |
|       | Students will begin brainstorming ideas for each design brief as a class team. Days 9-13: |
|       | Students will continue brainstorming ideas for each design brief as a class team. |
|       | The teacher will facilitate the brainstorming session and collect the ideas generated. |
|       | Students will continue working on Problem 3.4.3 Product Improvement. |
|       | The teacher will assist the students with Problem 3.4.3 Product Improvement. Day 14: |
|       | The teacher will present Technical Report Elements.ppt. |
|       | Students will take notes in their engineer’s notebook. |
|       | Students will continue working on Problem 3.4.3 Product Improvement. Days 15-16: |
|       | Students will complete |
Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate.

**Standard 13:**
Students will develop the abilities to assess the impacts of products and systems.

**BM K:**
Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and environment.

**Standard 17:**
Students will develop an understanding of and be able to select and use information and communication technologies.

**BM Q:**
Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.

**National Science Education Standards**
**Unifying Concepts and Processes Standard K-12:** As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes—
- Evidence, models, and explanation
- Evolution and equilibrium
- Form and Function

**Science as Inquiry Standard A:** As a result of activities in grades 9-12, all students should develop understanding of—
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Problem 3.4.3 Product Improvement and submit their technical reports to the teacher.
- The teacher will assist the students with Problem 3.4.3 Product Improvement.
Science and Technology Standard E: As a result of activities in grades 9-12, all students should develop—
- Abilities of technological design
- Understandings about science and technology

Principles and Standards for School Mathematics

Number Operations:
Instructional programs from pre-kindergarten through grade 12 should enable all students to—
- understand numbers, ways of representing numbers, relationships among numbers, and number system;
- understand meanings of operations and how they relate to one another;
- compute fluently and make reasonable estimates.

Measurement:
Instructional programs from pre-kindergarten through grade 12 should enable all students to—
- understand measurable attributes of objects and the units, systems, and processes of measurement;
- apply appropriate techniques, tools, and formulas to determine measurements.

Communication:
Instructional programs from pre-kindergarten through grade 12 should enable all students to—
- organize and consolidate their mathematical thinking through communication;
- communicate their mathematical thinking coherently and clearly to peers, teachers, and others;
- analyze and evaluate the mathematical thinking and strategies of others;
- use the language of mathematics to express mathematical ideas precisely.

Connections:
Instructional programs from pre-kindergarten through grade 12 should enable all students to—
   - recognize and apply mathematics in contexts outside of mathematics.

Representation:
Instructional programs from pre-kindergarten through grade 12 should enable all students to—
   - use representations to model and interpret physical, social, and mathematical phenomena.

**Standards for English Language Arts**

**Standard 4:**
Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.

**Standard 5:**
Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences and for a variety of purposes.

**Standard 12:**
Students use spoken, written and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).

**Performance Objectives**

*It is expected that students will:*
   - Write design briefs that focus on product innovation.
   - Identify group brainstorming techniques and the rules associated with brainstorming.
   - Use decision matrices to make design decisions.
   - Explain the difference between invention and innovation.
### Standards for Technological Literacy

**Standard 4:**
Students will develop an understanding of the cultural, social, economic, and political effects of technology.

**BM H:**
Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious.

**BM I:**
Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects.

**BM J:**
Ethical considerations are important in the development, selection, and use of technologies.

**BM K:**
The transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees.

**Standard 5:**
Students will develop an understanding of the effects of technology on the environment.

**BM I:**
With the aid of technology, various aspects of the environment can be monitored to provide information for decision-making.

**BM J:**
The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment.

**BM K:**
Humans devise technologies to reduce the negative consequences of other technologies.

**BM L:**
Decisions regarding the implementation of technologies involve the weighing of tradeoffs between predicted positive and negative effects on the environment.

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**Time:** 8 days

**NOTE:** In preparation for teaching this lesson, it is strongly recommended that the teacher read the Teacher Notes.

**Day 1:**
- The teacher will present Concepts, Key Terms, and Essential Questions, and provide a lesson overview.
- The teacher will present Global, Human, and Ethical Impacts.ppt and begin a dialogue with students on how products can provide positive and negative impacts.
- The teacher will explain the expectations of Activity 4.1.1 Product Lifecycle.
- Students will brainstorm possible products to be used.
- Students will divide into groups of two, pick an instructor approved product for Activity 4.1.1 Product Lifecycle and Recycling and begin work.

**Day 2:**
- Students will continue work on Activity 4.1.1 Product Lifecycle and Recycling and report

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**Explanation**

1. Students will explain what is meant by product lifecycle in their engineering notebooks. They may choose to express their explanation in one of the following forms:

2. Students will investigate materials used daily to make products, and classify the materials from easy to difficult in regards to each material’s recyclable processes.

3. Students will research design ethic issues and make a formal report of their findings.
### National Science Education Standards

**Unifying Concepts and Processes Standard K-12:** As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes—

- Evidence, models, and explanation
- Change, constancy, and measurement

**Science and Technology Standard E:** As a result of activities in grades 9-12, all students should develop—

- Understandings about science and technology

**Science in Personal and Social Perspectives Standard F:** As a result of activities in grades 9-12, all students should develop understanding of—

- Natural resources
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

### Principles and Standards for School Mathematics

**Number Operations Standard:** Instructional programs from pre-kindergarten through grade 12 should enable all students to compute fluently and make reasonable estimates.

**Data Analysis and Probability Standard:** Instructional programs from pre-kindergarten through grade 12 should enable all students to formulate questions that can be addressed with findings as described in the activity.

**Day 3:**

- Students will complete Activity 4.1.1 and present to the class.
- The teacher will assess Activity 4.1.1 using the Product Lifecycle Rubric.

**Day 4 – 8:**

- The teacher will introduce and distribute Problem 4.1.2 Engineering Design Ethics Design Brief, Problem 4.1.2a Sample Engineering Design Ethics Design Brief and Problem 4.1.2b Engineering Ethics Design Brief Template.
- Students will complete Problem 4.1.2 Engineering Design Ethics Design Brief.
- Optional: The teacher may have the students create their design briefs first and then have them exchange their design briefs with students in the class. The students would follow the design briefs in order to do the research and create the report either as a CD cover, book cover, or poster.
- The teacher will assess

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**Empathy**

5. Students will discuss in their engineering notebook concerns they may have for the environment regarding their chosen product. They will determine how they think they may be able to produce their product responsibly.
data and collect, organize, and display relevant data to answer them.

**Standards for English Language Arts**

**Standard 3:**
Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and other texts, their word identification strategies, and their understanding of textual features (e.g. sound-letter correspondence, sentence structure, context, graphics).

**Standard 4:**
Students adjust their use of spoken, written, and visual language (e.g. conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.

**Standard 5:**
Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences and for a variety of purposes.

**Standard 7:**
Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and non-print texts, artifacts, and people) to communicate their discoveries in ways that suit their purpose and audience.

**Standard 12:**
Students use spoken, written, and visual language to accomplish their own purposes (e.g. for learning, enjoyment, persuasion, and the exchange of information).

**Performance Objectives**

*It is expected that students will:*

- student work through the completion of the problem as well as students’ responses to the Conclusion questions of the problem.
- The teacher will lead students in a class discussion of their findings from their research.
- Optional: The teacher will have students present their findings or the CD cover, book cover, or posters and may them displayed around the school.
| Lesson 4.2 Design teams | **Standards for Technological Literacy**  
**Standard 1:** Students will develop an understanding of the characteristics and scope of technology.  
**BM F:** Creative thinking and economic and cultural influences shape technological development.  
**BM G:** The development of technology is a human activity and is the result of individual or corporate needs and the ability to be creative.  
**BM H:** Technology is closely linked to creativity, which has resulted in innovation.  
**BM L:** Inventions and innovations are the results of specific, goal-directed research.  
**Standard 2:** Students will develop an understanding of the core concepts of technology.  
**BM E:** People plan in order to get things done.  
**BM H:** Resources are the things needed to get a job done, such as tools and machines, materials, information, energy, people, capital, and time.  
**BM L:**  
| Time: 25 days  
**NOTE:** In preparation for teaching this lesson, it is strongly recommended that the teacher read the Teacher Notes.  
**Day 1:**  
· The teacher will present Concepts, Key Terms, and Essential Questions, and provide a lesson overview.  
· The teacher will introduce and distribute Project 4.2.1 Virtual Design Challenge, Design Project Tally Sheet, Engineer’s Notebook Evaluation, Periodic Self-Evaluation, Periodic Teammate 10-Point Evaluation, and Summary Presentation Evaluation.  
· Students will review the design briefs contained in  
| PowerPoint® presentations  
**Teamwork**  
**Word Documents**  
**Project 4.2.1 Virtual Design Challenge**  
**Activity 4.2.2 Team Norms**  
**Evaluation Documents**  
**Design Project Tally Sheet**  
**Engineer’s Notebook Evaluation**  
**Periodic Self-Evaluation**  
**Periodic Teammate 10-Point Evaluation**  
| **Explanation**  
1. Students will explain the advantages and disadvantages of virtual teams.  
**Application**  
2. Students will apply the design process to solve a design problem within a virtual team.  
**Perspective**  
3. Having the advantage of hind-sight, at the conclusion of the design experience
### Requirements
- **BM N:** Systems thinking involves considering how every part relates to others.
- **BM Q:** Malfunctions of any part of a system may affect the function and quality of the system.
- **BM R:** Requirements are the parameters placed on the development of a product or system.
- **BM S:** Trade-off is a decision process recognizing the need for careful compromises among competing factors.
- **BM W:** Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems.
- **BM Z:** Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.
- **BM AA:** Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.
- **BM EE:** Management is the process of planning, organizing, and controlling work.

### Standard 6
- **Students will develop an understanding of the role of society in the development and use of technology.**

### Standard 10
- **Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.**

### Project 4.2.1 Virtual Design Challenge and identify two challenges that they would be willing to pursue as a final design project.
- The teacher will collaborate with his/her IED colleague to pair students up into virtual teams based on their interests.

#### Day 2:
- The teacher will present Teamwork.ppt and relate the information to class experiences that have occurred since the beginning of the course.
- Students will take notes in their engineer’s notebook.
- The teacher will introduce and distribute Activity 4.2.2 Team Norms, assign students to their virtual teams, and identify their design challenges.
- Students will introduce themselves to their virtual teammates, and begin work on Activity 4.2.2 Team Norms.

#### Day 3-5:
- Students will work to complete Activity 4.2.2 Team Norms.

### Summary

#### Presentation
- **Summary Presentation Evaluation**
- **Teammate Performance Summary**

#### Teacher Guidelines
- **Lesson 4.2 Teacher Notes**
- **Counselor Conference Design Brief**
- **Open-Ended Design Problems.ppt**

#### Lesson 4.2 Key Terms and definitions in Excel

### Empathy
- **4. Students will play the role of the client and offer written constructive criticism to the other teams on their design solutions during their final summary presentations.**

### Self-Knowledge
- **5. Students will make thoughtful engineering notebook entries for every class day on the project.**
- **6. Students will conduct formal, periodic self-assessments.**

### Students will reflect on what they would have done differently if the project were to be repeated.
| BM F: | Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system. |
| BM G: | Invention is a process of turning ideas and imagination into devices and systems. |
| BM J: | Technological problems must be researched before they can be solved. |
| **Standard 11:** | Students will develop abilities to apply the design process. |
| BM K: | Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed. |
| BM L: | Make a product or system and document the solution. |
| BM M: | Identify the design problem to solve and decide whether or not to address it. |
| BM N: | Identify criteria and constraints and determine how these will affect the design process. |
| BM P: | Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed. |
| BM Q: | Develop and produce a product or system using a design process. |
| BM R: | Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models. |
| **Standard 12:** | Students will develop the abilities to use and... |

Day 6-18:
- Students will work in their virtual teams on Project 4.2.1 Virtual Design Challenge.
- The teacher will assist the students with their design projects.
- Students will fill out a Periodic Teammate 10-Point Evaluation and Periodic Self-Evaluation every three class periods and submit them to the instructor for assessment.
- The teacher will collaborate with his/her IED colleague to coordinate the exchange of evaluation materials and other related project correspondence.

Day 19-20:
- Students will work on
maintain technological products and systems.

**BM C:**
Recognize and use everyday symbols.

**BM E:**
Select and safely use tools, products, and systems for specific tasks.

**BM F:**
Use computers to access and organize information.

**BM G:**
Use common symbols, such as numbers and words, to communicate key ideas.

**BM H:**
Use information provided in manuals, protocols, or by experienced people to see and understand how things work.

**BM K:**
Operate and maintain systems in order to achieve a given purpose.

**BM L:**
Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques.

**BM P:**
Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate.

**Standard 13:**
Students will develop the abilities to assess the impacts of products and systems.

**BM I:**
Interpret and evaluate the accuracy of the information obtained and determine if it is useful.

**Standard 17:**
Students will develop an understanding of and be able to select and use information and communication technologies.

**BM B:**
Technology enables people to communicate by sending and receiving information over a distance.

**BM C:**
their final summary PowerPoint presentations.

- The teacher will assist the students with their presentations.

**Day 21:**
- Students will submit all of their associated project drawings and engineer’s notebooks for evaluation.
- Students will begin delivering five-minute summary presentations that chronicle their design experiences, and explain their solutions to the class.
- The teacher will evaluate the students’ presentations using the Summary Presentation Evaluation.
- Students will evaluate each others’ presentations using the Summary Presentation Evaluation.

**Day 22-24:**
- Students will continue delivering five-minute summary presentations that chronicle their design experiences, and explain their solutions to the class.
- The teacher will evaluate the students’ presentations using the Summary Evaluation.
People use symbols when they communicate by technology.

**BM D:**
The processing of information through the use of technology can be used to help humans make decisions and solve problems.

**BM E:**
Information can be acquired and sent through a variety of technological sources, including print and electronic media.

**BM F:**
Communication technology is the transfer of messages among people and/or machines over distances through the use of technology.

**BM H:**
Information and communication systems allow information to be transferred from human to human, human to machine, and machine to human.

**BM J:**
The design of a message is influenced by such factors as the intended audience, medium, purpose, and nature of the message.

**BM K:**
The use of symbols, measurements, and drawings promotes clear communication by providing a common language to express ideas.

**BM P:**
There are many ways to communicate information, such as graphic and electronic means.

**Standard 19:**
Students will develop an understanding of and be able to select and use manufacturing technologies.

**BM B:**
Manufactured products are designed.

**National Science Education Standards**

**Unifying Concepts and Processes Standard K-12:** As a result of activities in grades K-12, all students will:

- Develop an understanding of the unifying concepts and processes that underlie the content of science.
- Be able to apply these concepts and processes to the scientific inquiry process.
- Be able to use these concepts and processes to understand and explain the world around them.
- Be able to apply these concepts and processes to understand and solve problems in their lives.

**Presentation Evaluation.**
- Students will evaluate each others’ presentations using the Summary Presentation Evaluation.

**Day 25:**
- Students will evaluate the visual, structural, and functional qualities of each team’s solution, and submit their assessments to the instructor.
- Students will fill out a Teammate Performance Summary and submit it to the instructor.
- The teacher will evaluate all documents and collaborate with his/her IED colleague to share evaluation materials.
students should develop understanding and abilities aligned with the following concepts and processes—
  o Systems, order, and organization
  o Evidence, models, and explanation
  o Change, constancy, and measurement
  o Form and Function

**Science As Inquiry Standard A:** As a result of activities in grades 9-12, all students should develop understanding of—
  o Abilities necessary to do scientific inquiry

**Science and Technology Standard E:** As a result of activities in grades 9-12, all students should develop—
  o Abilities of technological design
  o Understandings about science and technology

**Principles and Standards for School Mathematics**

**Number Operations Standard:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to understand numbers, ways of representing numbers, relationships among numbers, and number systems; understand meanings of operations and how they relate to one another; compute fluently and make reasonable estimates.

**Geometry Standard:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to specify locations and describe spatial relationships using coordinate geometry and other representational systems; Use visualization, spatial reasoning, and geometric modeling to solve problems.

**Measurement Standard:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to understand measurable attributes of objects and the units, systems, and processes of measurement; apply appropriate techniques, tools, and formulas to determine measurements.

**Problem Solving Standard:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to solve problems that arise in mathematics and in other contexts; apply and adapt a variety of appropriate strategies to solve problems.

**Communication Standard:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to organize and consolidate their mathematical thinking through communication; communicate their mathematical thinking coherently and clearly to peers, teachers, and others; analyze and evaluate the mathematical thinking and strategies of others.

**Connections Standard:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to recognize and apply mathematics in contexts outside of mathematics.

**Representation Standard:**
Instructional programs from pre-kindergarten through grade 12 should enable all students to create and use representations to organize, record, and communicate mathematical ideas.

**Standards for English Language Arts**

**Standard 1:**
Students read a wide range of print and nonprint texts to build an understanding of texts of themselves, and of the cultures of the United States and the world; to acquire new information;
to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classical and contemporary works.

**Standard 4:**
Students adjust their use of spoken, written, and visual language (e.g. conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.

**Standard 5:**
Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences and for a variety of purposes.

**Standard 7:**
Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g. print and nonprint texts, artifacts, and people) to communicate their discoveries in ways that suit their purpose and audience.

**Standard 8:**
Students use a variety of technological and informational resources (e.g. libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.

**Standard 12:**
Students use spoken, written and visual language to accomplish their own purposes (e.g. for learning, enjoyment, persuasion, and the exchange of information).

**Performance Objectives**

*It is expected that students will.*

- Explain why teams of people are used to solve problems.
- Identify group norms that allow a virtual design team to function efficiently.
- Establish file management and file revision.
| protocols to ensure the integrity of current information. |
| · Use internet resources, such as email, to communicate with a virtual design team member throughout a design challenge. |
| · Identify strategies for addressing and solving conflicts that occur between team members. |
| · Create a Gantt chart to manage the various phases of their design challenge. |