# Introduction to Engineering & Design

NHS CTE

**Developed By**: Mr. Michael Tirrito & Mr. Vincent Vicchiariello
**Effective Date:** Fall 2022
Scope and Sequence

| Month | Unit | Activities/Assessments | Activites |
|---|---|---|---|
| September | Design & Problem Solving | Activities 1.1.1-1.1.4<br>Project 1.1.5 | • Design as a Process<br>• Iterate & Redesign<br>• Concept Sketching<br>• Targeting Success Using Data<br>• Design a Game |
| October | Design & Problem Solving | Activities 1.2.1-1.2.5<br>Project 1.2.6 | • Isometric Sketching<br>• 3D Solid Modeling<br>• Multiview Drawings<br>• Fundamentals of Dimensioning<br>• Sketches, Extrusions and Revolutions, Oh My!<br>• Charmed, I'm Sure |
| November | Design & Problem Solving | Activities 1.3.1-1.3.6<br>Project 1.3.7<br>Problem 1.4.1 | • Measure It!<br>• Making Holes in CAD<br>• Constraining a Sketch<br>• CAD Modeling Skills<br>• Documenting a Design<br>• I Section That!<br>• Design a Protective Case<br>• Sweet Improvement |
| December | Design & Problem Solving<br>Assembly Design | Problem 1.4.1<br>Activities 2.1.1-2.1.3 | • Sweet Improvement<br>• Tolerate This!<br>• Hold it Together!<br>• Putting it Together |
| January | Assembly Design | Activity 2.1.4<br>Project 2.1.5<br>Activities 2.2.1-2.2.6 | • Document the Assembly<br>• Redesign a Protective Case<br>• What is Reverse Engineering<br>• Visual Analysis<br>• Functional Analysis and the Black Box<br>• Structural Analysis and Product Disassembly<br>• CAD Design Tools<br>• Top-Down or Bottom-up? |
| February | Assembly Design | Activities 2.2.6-2.2.7<br>Project 2.2.8<br>Activity 231 | • Top-Down or Bottom-up?<br>• Design for Manufacturability and Assembly<br>• Design an Integrated Assembly<br>• Material Properties |
| March | Assembly Design<br>Thoughtful Product Design | Activities 2.3.2-2.3.3<br>Project 2.3.4<br>Problem 2.4.1<br>Activities 3.1.1-3.1.4 | • Evaluating Materials<br>• CAD Material Appearance and Analysis<br>• Imagine the Future |

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| | | Project 3.1.5 | • Troubleshoot an Assembly<br>• Reverse Engineer a Product<br>• Product Life Cycle<br>• Sustainable Design<br>• Design Criteria and Constraints |
| April | Thoughtful Product Design | Activities 3.2.1-3.2.4<br>Project 3.2.5<br>Activities 3.3.1-3.3.2 | • Human-Centered Design<br>• Whole-Systems Thinking<br>• Generative Design<br>• When is “Good” Good Enough?<br>• Gadget Design<br>• Establishing a Team<br>• Project Scheduling |
| May | Thoughtful Product Design<br>Making Things Move | Problem 3.3.3<br>Activities 4.1.1-4.1.7<br>Project 4.1.8 | • The Engineering Consultant<br>• Reverse Engineer a Mechanism<br>• Cams Make the World Go Round<br>• Mechanisms of Motion<br>• Modeling Mechanical Motion<br>• Cams in MOtion<br>• Design a Cam<br>• Simulating Cam Motion<br>• Shoebox Automaton |
| June | Making Things Move | Activities 4.2.1-4.2.4<br>Project 4.2.5<br>Activities 4.3.1-4.3.2<br>Project 4.3.3<br>Problem 4.1.1 | • Force Springs Eternal<br>• Friction is a Real Drag<br>• Fighting Friction<br>• Friction:  Design Friend or Foe?<br>• Automata Design Challenge<br>• Circuit Basics<br>• Fun with Motors<br>• Automata Redesign<br>• All Together Now<br>• End of Course Assessment (Kite Portal) |

| Unit 1 |
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| Design & Problem Solving |

## Summary and Rationale

In this unit, students will learn and apply an engineering design process to collaboratively design a carnival game. As part of the design process, they will practice the art of brainstorming and begin to develop skills in graphically representing ideas through concept sketching. They will develop and test a solution and improve the design through iteration. In addition, they will apply statistical techniques to evaluate design solutions and apply those techniques to inform design decisions related to your game design. They will use isometric and orthographic technical sketching as a means to model and communicate ideas, designs, and problem solutions. Students will develop basic 3D solid models of simple designs and produce technical drawings using CAD. Students will learn the importance of precision measurement. They will use dial calipers to make precise measurements as they come to understand the concepts of precision and accuracy and their implication on engineering design and manufacturing. Students will apply statistics to quantify the precision and accuracy of measurements and of measuring tools. Students will individually apply the design process and the skills and knowledge gained in this unit to evaluate and improve the design of a consumer product to meet stakeholder needs. Students will learn effective presentation techniques and present their solutions to an audience.

## Recommended Pacing

9 weeks

## Standards

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| **2020 New Jersey Student Learning Standards – Career Readiness, Life Literacies, and Key Skills** | |
| 9.4.12.CI.1 | Demonstrate the ability to reflect, analyze, and use creative skills and ideas |
| 9.4.12.CI.2 | Identify career pathways that highlight personal talents, skills, and abilities |
| 9.4.12.CI.3 | Investigate new challenges and opportunities for personal growth, advancement, and transition |
| **New Jersey Student Learning Standards for Mathematics** | |
| N.Q.1 - Quantities | Use units as a way to understand problems and to guide the solution of multi step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. |
| N.Q.2 - Quantities | Define appropriate quantities for the purpose of descriptive modeling. |
| N.Q.3 - Quantities | Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. |
| G.MG.1 - | Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder). |

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| Modeling with Geometry | |
| S.ID.1 - Interpreting Categorical and Quantitative Data | Represent data with plots on the real number line (dot plots, histograms, and box plots). |
| G.GMD.3 - Geometric Measurement and Dimension | Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems. |
| S.ID.4 - Interpreting Categorical and Quantitative Data | Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve. |
| Interdisciplinary Connections | |
| **New Jersey Student Learning Standards for English Language Arts** | |
| NJSLSA.W4. - Writing | Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |
| SL9-10.1. - Speaking and Listening | Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with peers on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. |
| NJSLSA.L6. - Language | Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression. |
| Integration of Technology | |

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| | Project Lead The Way - IED Digital Textbook is a comprehensive manual including but not limited to: informational text, activity guides, video recordings, presentations, resources, career connections, and distance learning support. |

## Instructional Focus

| **Enduring Understandings:** | **Essential Questions:** |
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| • The design process is applied to creatively solve problems.<br>• Collaboration is necessary to contribute to the efforts of a team to develop ideas.<br>• Practicing the art of brainstorming and spatial visualization will develop skills in graphically representing ideas through concept sketching and isometric sketching.<br>• Models are developed to represent a design idea.<br>• Using hand sketches, isometric views of a simple object or part at a given scale using the actual object, a detailed verbal description of the object, Orthographic projections of objects effectively communicates design intent.<br>• Giving and receiving effective feedback influences personal and professional development.<br>• As part of a design process, you develop conceptual models, graphical models, computer models, and physical models.<br>• Skills in producing basic 3D solid modeling of simple designs and technical drawings using CAD are gained.<br>• Applying an iterative design process, including developing appropriate models and/or simulations, creatively addresses a need or solve a problem.<br>• Creating technical drawings using 3D computer-aided design (CAD) software documents a design according to standard engineering practices.<br>• Demonstrating independent thinking and self-direction leads to accomplishing a goal.<br>• To communicate effectively with an audience is based on the characteristics of the intended audience. | • What are the steps of the engineering design process and how can they be used to solve problems?<br>• How can we evaluate data to determine the precision and accuracy of our solutions?<br>• How can we model effectively through concept sketching?<br>• How can we model effectively through technically drawing isometric pictorials?<br>• How can we model effectively through technically drawing orthographic projections?<br>• How do we properly dimension Multiview drawings?<br>• How can we model effectively through CAD design?<br>• How can we appropriately measure objects to appropriate levels of accuracy and precision?<br>• How can we appropriately document design intent using detailed views and title blocks? |

**Evidence of Learning (Assessments)**

Formative, Summative and Authentic Assessments:

- Design Process
- Bean Bag Toss Project
- Engineering Notebook Documentation
- Unit Conversion and Dimensional Analysis
- Descriptive Statistics: Mean, Median, Mode, Range
- Problem-solving Scenarios
- Technical Drawings
- Precision and Accuracy
- Measuring with a Dial Caliper
- Modeling of 3D Objects with CAD software
- Charmed Project
- Sweet Improvement Project
- Quizzes and Tests
- Unit Test
- Presentations:
    - Students will formally present all design challenge work through their engineering notebook documentation.
    - Students will orally present their solution to their projects and problem-solving scenarios as if they were pitching their idea to their client.

**Objectives (SLO)**

| Students will know: | Students will be able to: |
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| • How the design process is used to creatively solve a problem.<br>• Different forms of models can be used to represent an idea.<br>• How effectively documenting engineering work in an organized notebook so someone unfamiliar with the work can follow and understand the process.<br>• The difference between accuracy and precision of a measurement.<br>• The 6 primary views of any object.<br>• How to identify error and omissions in orthographic projections and multiview drawings.<br>• Models use abstraction to represent a simplified version of a complex object and there is no guarantee that the model accurately represents the real object.<br>• All measurements are an approximation of the true value of a quantity.<br>• How to read and interpret a hole note to identify the size and type of hole specified.<br>• Necessary/appropriate views to fully detail a part or assembly. | • Contribute to the efforts of a team to develop ideas.<br>• Develop a model to represent a design idea.<br>• Iterate on steps of the design process to improve a solution.<br>• Use statistics to compare the center and spread of two or more data sets.<br>• Draw conclusions related to a prediction and support conclusions using experimental data.<br>• Give and receive feedback to influence personal and professional development.<br>• Develop a model (a realistic sketch) to represent a design idea.<br>• Build a mathematical model to represent data and justify design decisions using data.<br>• Effectively use different types of models (conceptual, graphical, mathematical) to inform a design.<br>• Hand sketch isometric views of a simple object or part at a given scale using the actual object, a detailed verbal description of the object, or a pictorial view of the object.<br>• Build a 3D computer model to represent a physical object.<br>• Build a 3D computer model to represent a design idea. |

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| • Appropriate and sufficient annotation (including dimensioning) to a drawing to fully describe an object.<br>• Necessary/appropriate views, especially a section view, to fully detail a part or assembly.<br>• How to create technical drawings using 3D computer-aided design (CAD) software to document a design according to standard engineering practices. | • Hand sketch an isometric view or build a physical representation of an object based on a multiview drawing of the object.<br>• Use CAD software to generate orthographic projections and create a multiview drawing from a 3D solid model.<br>• Generate an annotated multiview drawing using CAD software.<br>• Identify three-dimensional objects generated by rotation of a two-dimensional object.<br>• Develop a model to represent important characteristics of an object for an intended purpose.<br>• Build a physical representation of an object based on graphical representations of the object.<br>• Choose a measurement device based on the level of precision and accuracy needed.<br>• Apply inferential reasoning to make and/or support claims about populations based on data.<br>• Create a computer model to represent a conceptual idea and inform design decisions.<br>• Create and constrain a 3D model to represent the physical characteristics of a design idea or physical object.<br>• Correctly build and constrain a three-dimensional solid computer model to accurately represent the physical characteristics and behaviors of a design idea or real object.<br>• Identify errors and omissions in a full- or half-section view (including errors in line locations, line types, location of cutting plane line, scale, dimensioning, and view orientation) to fully detail an object or part.<br>• Develop a potential solution and evaluate the solution with respect to design criteria and constraints.<br>• Apply an iterative design process, including developing appropriate models and/or simulations, to creatively address a need or solve a problem.<br>• Demonstrate independent thinking and self-direction in pursuit of accomplishing a goal.<br>• Communicate effectively with an audience based on the characteristics of the intended audience. |

## Suggested Resources/Technology Tools

- myPLTW learning module
- Schoology
- GoogleSheets
- GoogleDocs

- GoogleSlides
- OnShape
- Autodesk Fusion 360
- 3D Printer software
- Laser Engraver software
- Chromebooks
- Classroom iMacs/desktops
- LCD Projector

## Modifications

Special Education/IEP/504 -

- Adhere to all modifications and health concerns stated in each IEP.
- Accommodate instructional strategies: reading aloud text, graphic organizers, one-on-one instruction, class website (Schoology), handouts, definition list with visuals, extended time.
- Allow students to demonstrate understanding of a problem by drawing the picture of the answer and then explaining the reasoning orally and/or writing , such as Read-Draw-Write.
- Provide breaks between tasks, use positive reinforcement, use proximity.

ELL -

- Use manipulatives to promote conceptual understanding and enhance vocabulary usage.
- Use sentence frames and questioning strategies so that students will explain their thinking/process of how to solve word problems.
- Utilize graphic organizers which are concrete, pictorial ways of constructing knowledge and organizing information.
- Reword questions in simpler language

Gifted and Talented -

- Complex, in-depth research assignments
- Independent study where applicable
- Provide a variety of individualized work centers or student choice
- Lead demonstrations for class
- Individual presentation

## Career Readiness, Life Literacies, and Key Skills Practices (June 2020)

- ❏ Act as a responsible and contributing citizen and employee.
- ❏ Apply appropriate academic and technical skills.
- ❏ Attend to personal health and financial well being.
- ❏ Communicate clearly and effectively and with reason.
- ❏ Consider the environmental, social and economic impacts of decisions.
- ❏ Demonstrate creativity and innovation.
- ❏ Employ valid and reliable research strategies.
- ❏ Utilize critical thinking to make sense of problems and persevere in solving them.
- ❏ Model integrity, ethical leadership, and effective management.
- ❏ Plan education and career paths aligned to personal goals.
- ❏ Use technology to enhance productivity.

❏ Work productively in teams while using cultural global competence.

*LINKS TO CAREERS:*

- Field Trips -
  - CAD Design Firm
- Potential Guest Speakers -
  - CAD Drafter, Architect, Bakery Owner

| Unit 2 | |
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| Assembly Design | |
| Summary and Rationale | |
| In this unit, students learn methods to physically join parts in an assembly, including mechanical fasteners, adhesives, press fits, and hinges. They learn about different types of fit and how to specify tolerances to achieve desired fits between interacting parts. Students then learn how to assemble parts using CAD and create simple bottom-up assemblies that realistically simulate physical mechanical systems. Assemblies are documented in CAD with assembly drawings. Students apply engineering principles and practices to reverse engineer and improve a consumer product by disassembling and analyzing a product or system to understand and document the visual, functional, and/or structural aspects of its design. Students will also conduct a case study of a common consumer product to identify potential ways to improve the manufacturability and ease of assembly of the product. Students will also use top-down modeling to model the consumer product students have reverse engineered. They will apply the design process again to design and prototype (3D print) an integrated accessory for the reverse engineered product and present the design. Finally, in this unit students investigate a variety of materials through experimentation and are tasked with selecting materials to serve a specific purpose. The types of materials investigated include wood, metals, ceramics, plastics, and composites to identify properties that may impact material selection. Properties investigated can include density, conductivity, strength, flexibility, hardness, and so on. Students learn how to assign specific materials to CAD models and to differentiate between assigning the physical properties of a material to a part and only changing the visual appearance of the part. Students work within a team to imagine the future through research of innovative materials and the redesign of a product using advanced materials. Lastly, students work collaboratively to reverse engineer and troubleshoot a non-working, multi-component mechanical device. Then, team members work together to redesign the device, produce working drawings, and produce new parts to correct the design and manufacture a working physical model. | |
| Recommended Pacing | |
| 9 weeks | |
| Standards | |
| **2020 New Jersey Student Learning Standards – Career Readiness, Life Literacies, and Key Skills** | |
| 9.4.12.CI.1 | Demonstrate the ability to reflect, analyze, and use creative skills and ideas |
| 9.4.12.CI.2 | Identify career pathways that highlight personal talents, skills, and abilities |
| 9.4.12.CI.3 | Investigate new challenges and opportunities for personal growth, advancement, and transition |

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| **2020 New Jersey Student Learning Standards – Computer Science and Design Thinking** | |
| 8.2.12.ED.2 | Create scaled engineering drawings for a new product or system and make modification to increase optimization based on feedback. |
| 8.2.12.ED.5 | Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics). |
| **New Jersey Student Learning Standards for Mathematics** | |
| G.MG.1 - Modeling with Geometry | Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder). |
| G.MG.2 - Modeling with Geometry | Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot). |
| Interdisciplinary Connections | |
| **New Jersey Student Learning Standards for English Language Arts** | |
| NJSLSA.W2. - Writing | Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content. |
| NJSLSA.W4. - Writing | Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |
| SL9-10.1. - Speaking and Listening | Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with peers on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. |
| NJSLSA.L6. - Language | Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; |

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| | demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression. |
| Integration of Technology | |
| | Project Lead The Way - IED Digital Textbook is a comprehensive manual including but not limited to: informational text, activity guides, video recordings, presentations, resources, career connections, and distance learning support. |

## Instructional Focus

| **Enduring Understandings:** | **Essential Questions:** |
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| ● CAD skills are built upon.<br>● There are several methods used to physically join parts into an assembly (including mechanical fasteners and adhesives as well as press fits and hinges).<br>● It is important to learn Interference and clearance fits and to specify tolerances to achieve desired fits between interacting parts.<br>● CAD assembly modeling is used to create simple bottom-up assemblies that realistically simulate physical assemblies and document assemblies with CAD drawings.<br>● Iteration is applied to earlier design projects to incorporate new skills and knowledge learned.<br>● Applying appropriate engineering tolerances will specify the allowable variation, size of individual features, and orientation and location between features of an object. Using the mean and standard deviation of a data set will fit it to a normal distribution and using the Empirical Rule estimates population percentages.<br>● Applying engineering principles and practices to reverse engineer and improve a consumer product is also a part of the design process.<br>● The process of Reverse Engineering involves analyzing the product's function, structure, and visual elements.<br>● It is necessary to conduct a case study of a common consumer product to identify potential ways to improve the | ● What are the different types of tolerance and how can I use tolerance to achieve desired fits between interacting parts?<br>● What are the different types of joining techniques?<br>● What are assembly joints and how can I use them to create assembled products on CAD?<br>● How can we appropriately document design intent using exploded views and parts lists?<br>● What is reverse engineering?<br>● What is visual analysis and how can I use it to better understand a product?<br>● What is functional analysis and how can I use it to better understand a product?<br>● What is structural analysis and how can I use it to better understand a product?<br>● What is the difference between top down and bottom up modeling and what is it advantageous to use each?<br>● What are the principles of design for manufacturing and how can they be used to improve products?<br>● What are the different properties materials can have and how can they be used to identify materials, and to recommend the best materials for certain uses. |

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| manufacturability and ease of assembly of the product.<br>● You'll learn a second method of CAD assembly modeling, top-down modeling, to help you more efficiently model mechanical systems. And finally, you'll have an opportunity to design and prototype (3D print) an integrated accessory for a product that you have reverse engineered and present the design.<br>● Investigating a variety of materials through experimentation and selecting materials to serve a specific purpose is part of the engineering design process.<br>● Types of materials investigated include wood, metals, ceramics, plastics, and composites and that identifying properties may impact material selection.<br>● There are different properties investigated that may include density, conductivity, strength, flexibility, hardness, and so on.<br>● Assigning specific materials to CAD models differentiates between assigning the physical properties of a material to a part and only changing the visual appearance of the part.<br>● Listing material properties are important to design, including mechanical, chemical, electrical, and magnetic properties.<br>● Performing an experimental protocol investigates a phenomenon and/or helps to gain knowledge.<br>● Conducting non-destructive tests (hardness, flexure, conductivity) on different material types investigates material properties.<br>● Creating and interpreting a computer model or simulation of simple objects, assemblies, or systems to inform engineering decisions solve problems.<br>● Creating technical drawings using 3D computer-aided design (CAD) software documents a design according to standard engineering practices.<br>● Communicating effectively with an audience is based on audience characteristics. | |
| **Evidence of Learning (Assessments)** | |

Formative, Summative and Authentic Assessments:

- Design Process
- Engineering Notebook Documentation
- Modeling of 3D Objects with CAD software
- CAD part files
- Quizzes and Tests
- Unit Test
- Protective Case Project
- Assemble It! Project
- Presentations:
    - Students will formally present all design challenge work by documenting their work in their engineering notebooks.
    - Students will present on their assigned type of joining technique to inform the class.
    - Students will orally present their accessory for their reverse engineered product, acting as though they are pitching the idea to a client.
    - Students will orally present their design for an application of their chosen material.
    - Students will orally present their improvement to the trammel toy flaws, acting as though they are pitching the idea to a client.

**Objectives (SLO)**

| Students will know: | Students will be able to: |
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| ● How to use the mean and standard deviation of a data set to fit it to a normal distribution and use the Empirical Rule to estimate population percentages.<br>● Methods to rigidly join physical parts of an assembly.<br>● Joints that allow movement between parts in an assembly and the resulting degrees of freedom.<br>● Necessary and appropriate views to fully detail an assembly.<br>● How to apply appropriate engineering tolerances to specify the allowable variation, size of individual features, and orientation and location between features of an object.<br>● The processes and purposes of reverse engineering.<br>● The reverse engineering process of visual analysis.<br>● The reverse engineering process of functional analysis.<br>● The reverse engineering process of structural analysis.<br>● How to use sketches to clearly communicate information.<br>● How to create relationships among part features and dimensions using parametric relationships. | ● Apply appropriate engineering tolerances to specify the allowable variation, size of individual features, and orientation and location between features of an object.<br>● Present information, findings, and supporting evidence clearly, concisely, and logically in writing, in which the development, organization, and style are appropriate to task, purpose, and audience.<br>● Present information, findings, and supporting evidence clearly, concisely, and logically, such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.<br>● Correctly build and constrain a three-dimensional solid computer model to accurately represent the physical characteristics and behaviors of a physical object.<br>● Correctly apply joints to constrain multi-component models and/or simulate realistic relative motion of the component parts.<br>● Apply an iterative design process to creatively address a need or solve a problem.<br>● Generate an annotated assembly drawing of components and details of assembly.<br>● Generate an annotated multiview drawing to fully describe a simple part.<br>● Perform a visual analysis of an object and describe the apparent visual elements and principles of design. |

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| • How to correctly constrain multi-component models.<br>• Measurable visual, functional, and structural design requirements (criteria) and realistic constraints against which solution alternatives can be evaluated and optimized.<br>• Material properties that are important to design, including mechanical, chemical, electrical, and magnetic properties.<br>• How design criteria and constraints (cost, performance, safety, risk, aesthetics, environmental impact) often limit the material choices available for a given design.<br>• Different types of materials and their common usages in product design.<br>• Engineering as the creation of solutions, such as new and improved products, technologies, systems and processes, to meet the needs of people and society. | • Perform a functional analysis of a product or system to determine the purpose, inputs and outputs, and operation of a product or system.<br>• Perform a structural analysis of a product or system to determine the materials used, the form of component parts, as well as the configuration and interaction of component parts when assembled.<br>• Develop a model to accurately represent information or important characteristics of an object, data, process, or design idea for an intended purpose.<br>• Correctly build and constrain a three-dimensional solid computer model to accurately represent the physical characteristics and behaviors of a design idea or real object.<br>• Apply the principles of design for manufacturability and assembly of mechanical products.<br>• Identify design flaws of and potential enhancements to a proposed design solution.<br>• Apply effective techniques and appropriate guidelines to generate multiple creative ideas and solutions to a problem.<br>• Carry out a plan to compare competing solution ideas and justify the selection of a solution path with respect to design requirements and constraints.<br>• Present information, findings, and supporting evidence clearly, concisely, and logically in writing in which the development, organization, and style are appropriate to task, purpose, and audience.<br>• Perform an experimental protocol to investigate a phenomenon and/or gain knowledge.<br>• Conduct non-destructive tests (hardness, flexure, conductivity) on different material types to investigate material properties.<br>• Evaluate a solution to a complex, real-world problem and identify the need for trade-offs to address a range of criteria and constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.<br>• Select and justify the use of materials for prototyping and manufacturing products.<br>• Draw valid conclusions based on supporting evidence while acknowledging limitations, opposing views, and biases.<br>• Create a computer model or simulation to represent an object or conceptual idea and inform design decisions.<br>• Synthesize an ill-formed problem into a meaningful, well-defined problem using relevant information.<br>• Persevere to solve a problem or achieve a goal.<br>• Create and interpret a computer model or simulation of simple objects, assemblies, or systems to inform engineering decisions and solve problems.<br>• Create technical drawings using 3D computer-aided design (CAD) software to document a design according to standard engineering practices.<br>• Communicate effectively with an audience based on audience characteristics. |

## Suggested Resources/Technology Tools

- myPLTW learning module
- Schoology
- GoogleSheets
- GoogleDocs
- GoogleSlides
- OnShape
- Autodesk Fusion 360
- 3D Printer software
- Laser Engraver software
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- LCD Projector

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- Allow students to demonstrate understanding of a problem by drawing the picture of the answer and then explaining the reasoning orally and/or writing , such as Read-Draw-Write.
- Provide breaks between tasks, use positive reinforcement, use proximity.

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- Reword questions in simpler language

Gifted and Talented -

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- Independent study where applicable
- Provide a variety of individualized work centers or student choice
- Lead demonstrations for class
- Individual presentation

## Career Readiness, Life Literacies, and Key Skills Practices (June 2020)

- ❏ Act as a responsible and contributing citizen and employee.
- ❏ Apply appropriate academic and technical skills.
- ❏ Attend to personal health and financial well being.
- ❏ Communicate clearly and effectively and with reason.

- ❑ Consider the environmental, social and economic impacts of decisions.
- ❑ Demonstrate creativity and innovation.
- ❑ Employ valid and reliable research strategies.
- ❑ Utilize critical thinking to make sense of problems and persevere in solving them.
- ❑ Model integrity, ethical leadership, and effective management.
- ❑ Plan education and career paths aligned to personal goals.
- ❑ Use technology to enhance productivity.
- ❑ Work productively in teams while using cultural global competence.

*LINKS TO CAREERS:*

- Field Trips -
  - CAD Design Firm, Manufacturing company
- Potential Guest Speakers -
  - CAD Drafter, Product Designer, Manufacturer

| Unit 3 | |
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| Thoughtful Product Design | |
| Summary and Rationale | |
| In this unit, students reverse engineer a multi-material consumer product. Then they identify and research the component materials and the material properties that contribute to their selection for use in the product. Students are introduced to life cycle analysis, systems thinking, and ethical considerations in design, and they compare the life cycle of common competing products (such as plastic versus paper shopping bags). This lesson emphasizes the importance of identifying measurable design criteria that define a successful solution and that can be used to evaluate a potential solution. The concept of human-centered design is introduced as students are led through a design experience focused on user needs, perceptions and behaviors, and the design trade-offs necessary in every design process. Students also apply systems thinking to engineering design and consider the ethical implications of engineering decisions. A modern CAD feature, generative design is introduced as a tool to optimize design solutions. Students use the output from a generative design algorithm to explore and select a potential design alternative. In teams, students identify a problem worth solving and apply human-centered design principles and systems thinking to design a gadget to solve the problem as they practice collaboration and communication skills. In teams, students act as an engineering consulting group to solve a problem from a list of problems gathered from school and/or community stakeholders. As part of the design process, the team applies the engineering design process to develop a sustainable solution that includes consideration of material choices and the life cycle of the design. Students meet with the client to understand user needs, develop effective design criteria to inform the design, and create a project design brief. Students also practice important project management skills including developing a task and delivery schedule to manage and monitor project work and facilitating project meetings to report project progress. | |
| Recommended Pacing | |
| 9 weeks | |
| Standards | |
| **2020 New Jersey Student Learning Standards – Career Readiness, Life Literacies, and Key Skills** | |
| 9.4.12.CI.1 | Demonstrate the ability to reflect, analyze, and use creative skills and ideas |
| 9.4.12.CI.2 | Identify career pathways that highlight personal talents, skills, and abilities |

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| 9.4.12.CI.3 | Investigate new challenges and opportunities for personal growth, advancement, and transition |
| **2020 New Jersey Student Learning Standards – Computer Science and Design Thinking** | |
| 8.2.12.ED.2 | Create scaled engineering drawings for a new product or system and make modification to increase optimization based on feedback. |
| 8.2.12.ED.5 | Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics). |
| **2020 New Jersey Student Learning Standards – Science** | |
| HS-PS2-1 | Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. |
| HS-ETS1-3 | Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. |
| HS-ETS1-4 | Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. |
| **New Jersey Student Learning Standards for Mathematics** | |
| N.Q.2 - Quantities | Define appropriate quantities for the purpose of descriptive modeling. |
| G.MG.1 - Modeling with Geometry | Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder). |
| G.MG.2 - Modeling with Geometry | Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot). |
| S.ID.1 - Interpreting Categorical and | Represent data with plots on the real number line (dot plots, histograms, and box plots). |

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| Quantitative Data | |
| S.ID.4 - Interpreting Categorical and Quantitative Data | Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve. |
| Interdisciplinary Connections | |
| **New Jersey Student Learning Standards for English Language Arts** | |
| NJSLSA.W2. - Writing | Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content. |
| NJSLSA.W4. - Writing | Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |
| NJSLSA.W7. - Writing | Conduct short as well as more sustained research projects, utilizing an inquiry-based research process, based on focused questions, demonstrating understanding of the subject under investigation. |
| SL9-10.1. - Speaking and Listening | Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with peers on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. |
| NJSLSA.L6. - Language | Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression. |
| Integration of Technology | |
| | Project Lead The Way - IED Digital Textbook is a comprehensive manual including but not limited to: informational text, activity guides, video recordings, presentations, resources, career connections, and distance learning support. |
| Instructional Focus | |

| **Enduring Understandings:** | **Essential Questions:** |
| --- | --- |
| • All products have a life cycle.<br>• Analysis, systems thinking, and ethical considerations in design is conducted to compare the life cycle of common competing products (such as plastic versus paper shopping bags).<br>• The importance of identifying measurable design criteria that defines a successful solution and that can be used to evaluate a potential solution.<br>• Making strategic use of digital media in presentations enhances understanding of findings, reasoning, and evidence and to add interest.<br>• Analyzing a consumer product using reverse engineering techniques document visual, functional, and structural aspects of the design.<br>• Explaining the benefits of human-centered design and applying principles aligns to product design with intended use.<br>• Design quality concepts such as performance, usability, accessibility, reliability, and safety impact product development. | • What are the steps of a product life cycle and how can we use the product lifecycle to compare the environmental impact of products?<br>• What is sustainable design and how does the choice of material used for a product affect sustainable design?<br>• How do you create measurable criteria and constraints?<br>• What role does empathy play in human centered design?<br>• What can a systems model tell us about how a product interacts with its surroundings?<br>• What is generative design and how can we use generative design to determine the effectiveness of our solutions?<br>• How can we use statistics to optimize solutions?<br>• What behaviors lead to a successful team?<br>• What are the roles of a project manager and how can we use a Gantt Chart to schedule projects? |

**Evidence of Learning (Assessments)**

Formative, Summative and Authentic Assessments:

- Reverse Engineer a Product
- Application of the Design Process
- Identification of criteria and constraints
- CAD- Part models and Assembly models
- Engineering Notebook Documentation Quizzes and Tests
- Unit Test
- Presentations:
  - Students will present their findings about the product they reverse engineered.
  - Students will formally present all design challenge work by documenting their work in their engineering notebooks.
  - Students will present their gadget designs as if they were trying to sell their product to consumers.
  - Students will conduct a gallery walk to present their solutions to their engineering consultant design work.

**Objectives (SLO)**

| Students will know: | Students will be able to: |
| --- | --- |
| ● How to make strategic use of digital media in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.<br>● Different engineering solutions can have significantly different impacts on individuals, society, and the natural world.<br>● The life cycle of a product or service.<br>● How to present information, findings, and supporting evidence clearly, concisely, and logically.<br>● How design criteria and constraints often limit the material choices available for a given design.<br>● How to ask new probing questions to expand and build upon an idea and explore personal curiosities throughout a creative process.<br>● The benefits of human-centered design and apply principles to align product design with intended use.<br>● Design quality concepts such as performance, usability, accessibility, reliability, and safety impact product development.<br>● A system in terms of its components and/or subsystems and their interactions. Predict what the effect of making a change to a component of a system will have on the system as a whole.<br>● Sustainability and identify principles that help guide development of sustainable solutions (e.g. generative design and life cycle assessment).<br>● How to develop and follow team norms.<br>● One's individual role and expectations of performance within the team, including communication protocol and rules of engagement per the team norms.<br>● The project deliverables and constraints, such as scope, time, cost, quality, resources, and risk.<br>● How to develop a project schedule (with the critical path identified when appropriate), allocate tasks among team members, and track progress for successful completion of the project. | ● Analyze a consumer product using reverse engineering techniques to document visual, functional, and structural aspects of the design.<br>● Evaluate a solution to a complex, real-world problem and identify the need for trade-offs to address a range of criteria and constraints, including environmental impacts.<br>● Consider the impact of potential engineering solutions on future generations to inform the development of sustainable solutions.<br>● Apply an iterative design process, including developing appropriate models, to creatively address a need or solve a problem.<br>● Predict the local and global risks and impacts of an engineering decision/solution, including some that were not anticipated.<br>● Apply effective techniques and appropriate guidelines to generate multiple creative ideas and potential solutions to a problem.<br>● Collect, analyze, and interpret information relevant to the problem or opportunity at hand to support engineering decisions.<br>● Use computer-aided engineering tools to optimize design performance of a mechanical part or assembly.<br>● Select and use collaborative tools, such as cloud-based tools, document sharing, and video and text functions, to successfully complete a project.<br>● Facilitate an effective team environment to promote successful goal attainment.<br>● Apply systems thinking to consider how an engineering problem and its solution may be thought of as containing subsystems and as being a sub-system of a larger system.<br>● Develop models and simulations to represent information, processes, and/or objects to an appropriate level of abstraction for the intended purpose. |

| Suggested Resources/Technology Tools |
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- myPLTW learning module
- Schoology
- GoogleSheets
- GoogleDocs
- GoogleSlides
- OnShape
- Autodesk Fusion 360
- 3D Printer software
- Laser Engraver software
- Chromebooks
- Classroom iMacs/desktops
- LCD Projector

## Modifications

Special Education/IEP/504 -

- Adhere to all modifications and health concerns stated in each IEP.
- Accommodate instructional strategies: reading aloud text, graphic organizers, one-on-one instruction, class website (Schoology), handouts, definition list with visuals, extended time
- Allow students to demonstrate understanding of a problem by drawing the picture of the answer and then explaining the reasoning orally and/or writing , such as Read-Draw-Write
- Provide breaks between tasks, use positive reinforcement, use proximity

ELL -

- Use manipulatives to promote conceptual understanding and enhance vocabulary usage
- Use sentence frames and questioning strategies so that students will explain their thinking/process of how to solve word problems
- Utilize graphic organizers which are concrete, pictorial ways of constructing knowledge and organizing information
- Reword questions in simpler language

Gifted and Talented -

- Complex, in-depth research assignments
- Independent study where applicable
- Provide a variety of individualized work centers or student choice
- Lead demonstrations for class
- Individual presentation

## Career Readiness, Life Literacies, and Key Skills Practices (June 2020)

- ❑ Act as a responsible and contributing citizen and employee.
- ❑ Apply appropriate academic and technical skills.
- ❑ Attend to personal health and financial well being.
- ❑ Communicate clearly and effectively and with reason.
- ❑ Consider the environmental, social and economic impacts of decisions.
- ❑ Demonstrate creativity and innovation.

- ❑ Employ valid and reliable research strategies.
- ❑ Utilize critical thinking to make sense of problems and persevere in solving them.
- ❑ Model integrity, ethical leadership, and effective management.
- ❑ Plan education and career paths aligned to personal goals.
- ❑ Use technology to enhance productivity.
- ❑ Work productively in teams while using cultural global competence.

*LINKS TO CAREERS:*

- Field Trips -
  - Manufacturing company, lumber mill, metalworking facility
- Potential Guest Speakers -
  - CAD Drafter, Product Designer, Materials Scientist, Environmental Engineer

## Unit 4

## Making Things Move

### Summary and Rationale

This unit focuses on familiarizing students with basic engineering knowledge related to simple mechanical and electrical systems and the use of mathematical models to represent design ideas and to inform design decisions. Students begin by reverse engineering a mechanical device to identify simple machines and mechanisms that influence motion and contribute to the function of the device. Students identify different types of motion (rotary, oscillating, linear, and reciprocating) and investigate mechanisms that cause motion (including cams, gears, pulleys, chain and sprockets) and later use these mechanisms to create, transform, and control motion to solve a problem. Students practice CAD skills by developing assembly models of the mechanisms they investigate and simulating motion in the CAD environment. To support efficient CAD modeling, students will also learn to use mathematical functions to represent dimensional relationships in a 3D solid model. Students investigate forces that resist motion. First students study spring forces and develop a mathematical model to determine the relationship between spring displacement and force for a given spring. Students also learn about simple electrical circuits and how to transform electrical power to motion using a motor. Students design and install a circuit to run a hobby motor that powers their previously designed automaton. As part of the electrical circuit, students develop a mathematical model to inform the design of a simple potentiometer to control the speed of the motor. As an end of course project, students design and build a toy that includes an electro-mechanical system that will produce realistic motion of a figure(s) or object(s) resulting from the rotation of an axle powered by a motor with minimal frictional resistance. As part of the automaton design process, each student creates a CAD assembly model and creates a computer simulation of automata motion, CAD technical drawings, and a physical working model of their design.

### Recommended Pacing

9 weeks

### Standards

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| **2020 New Jersey Student Learning Standards – Career Readiness, Life Literacies, and Key Skills** | |
| 9.4.12.CI.1 | Demonstrate the ability to reflect, analyze, and use creative skills and ideas |
| 9.4.12.CI.2 | Identify career pathways that highlight personal talents, skills, and abilities |
| 9.4.12.CI.3 | Investigate new challenges and opportunities for personal growth, advancement, and transition |
| **2020 New Jersey Student Learning Standards – Computer Science and Design Thinking** | |
| 8.2.12.ED.2 | Create scaled engineering drawings for a new product or system and make modifications to increase optimization based on feedback. |
| 8.2.12.ED.5 | Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics). |
| **2020 New Jersey Student Learning Standards – Science** | |
| HS-PS2-1 | Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. |
| HS-ETS1-3 | Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. |
| HS-ETS1-4 | Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. |
| **New Jersey Student Learning Standards for Mathematics** | |
| N.Q.2 - Quantities | Define appropriate quantities for the purpose of descriptive modeling. |
| G.MG.1 - Modeling with Geometry | Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder). |
| G.MG.2 - | Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot). |

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| Modeling with Geometry | |
| S.ID.1 - Interpreting Categorical and Quantitative Data | Represent data with plots on the real number line (dot plots, histograms, and box plots). |
| S.ID.4 - Interpreting Categorical and Quantitative Data | Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve. |
| Interdisciplinary Connections | |
| **New Jersey Student Learning Standards for English Language Arts** | |
| NJSLSA.W2. - Writing | Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content. |
| NJSLSA.W4. - Writing | Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |
| NJSLSA.W7. - Writing | Conduct short as well as more sustained research projects, utilizing an inquiry-based research process, based on focused questions, demonstrating understanding of the subject under investigation. |
| SL9-10.1. - Speaking and Listening | Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with peers on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. |
| NJSLSA.L6. - Language | Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression. |

| Integration of Technology | |
|---|---|
| | Project Lead The Way - IED Digital Textbook is a comprehensive manual including but not limited to: informational text, activity guides, video recordings, presentations, resources, career connections, and distance learning support. |

## Instructional Focus

| **Enduring Understandings:** | **Essential Questions:** |
|---|---|
| ● There are different types of motion.<br>● Separating a complex process into multiple subprocesses is implemented in an organized way to complete a larger process.<br>● To create relationships among part features and dimensions, parametric formulas are used.<br>● Performing a functional analysis of a product or system to determine the purpose, inputs, outputs and operation of a product system.<br>● Correctly applying constraints to a multi-component model simulates realistic relative motion of the component parts.<br>● Making strategic use of digital media in presentations enhances understanding of findings, reasoning, and evidence and to add interest.<br>● Analyzing a consumer product using reverse engineering techniques document visual, functional, and structural aspects of the design.<br>● Explaining the benefits of human-centered design and applying principles aligns to product design with intended use.<br>● Design quality concepts such as performance, usability, accessibility, reliability, and safety impact product development. | ● What is a mechanical system? How can we effectively model mechanical systems?<br>● How can we use mathematical models to model linear motion?<br>● What is Hooke's Law? What are spring characteristics and how can they be modeled mathematically?<br>● What is friction? How does an object's coefficient of friction affect its motion?<br>● How can simple machines be used to transfer motion?<br>● How can friction be reduced using a bushing?<br>● What is a circuit and how can we use circuits to create motion?<br>● What is a variable resistor? |

**Evidence of Learning (Assessments)**

Formative, Summative and Authentic Assessments:

- Creating an Automaton
- Application of the Design Process
- Reverse Engineer a Product
- CAD- Cam Drawings
- Engineering Notebook Documentation
- Quizzes and Tests
- Unit Test

- Presentations:
  - Students will formally present all design challenge work by documenting their work in their engineering notebooks.
  - Students will conduct informal presentations (gallery walk style) of their automata designs, to make sure their designs are as good as possible before adding in motors.
  - Students will present their final automata design, focusing on how motion is transferred through the system, as well as the use of springs, friction and circuits within the design.

| **Objectives (SLO)** | |
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| Students will know:<br>● Different types of motion.<br>● How to separate a complex process into multiple subprocesses that can be implemented in an organized way to complete the larger process.<br>● How to use mathematical modeling to optimize design criteria.<br>● How to select and use simple mechanisms to create and control motion to solve a problem.<br>● How to use mechanisms in a design to transform a motion without changing its type.<br>● Cams and followers can be used to move objects in periodic motion.<br>● How to use sketches, tables, charts, and graphs when appropriate to clearly communicate information and in making arguments and claims in oral, written, and visual presentations.<br>● Friction is a force that opposes motion.<br>● The force of friction between two interacting components in a mechanism, explain how the frictional force impacts the function and efficiency of the mechanism, and recommend design revisions to improve performance.<br>● Frictional force impacts the function and efficiency of a mechanism, and recommend design revisions to improve performance.<br>● How to calculate and measure the resistance, current, and voltage of a circuit.<br>● Different machine elements influence motion of a mechanical system. | Students will be able to:<br>● Create relationships among part features and dimensions using parametric formulas.<br>● Perform a functional analysis of a product or system to determine the purpose, inputs and outputs, and operation of a product or system.<br>● Use a mathematical model to describe the relationship between the motion of objects.<br>● Correctly apply constraints to a multi-component model and/or simulate realistic relative motion of the component parts.<br>● Represent data for two quantitative variables on a scatter plot, and describe how the variables are related.<br>● Fit a function to data and use the function to make predictions in the context of the data.<br>● Build and use a mathematical model to represent data, describe relationships, describe processes, or to make predictions in the context of a problem.<br>● Correctly build and constrain a three-dimensional solid computer model to accurately represent the physical characteristics and behaviors of a design idea or real object.<br>● Generate an annotated multiview technical drawing using CAD software to fully describe a simple part.<br>● Develop a model to accurately represent the motion of a system with a series of cams.<br>● Correctly apply joints to constrain a multi-component model to simulate realistic relative motion.<br>● Develop a potential solution to a problem and implement a plan to test and evaluate the solution with respect to the design criteria and constraints.<br>● Collect, analyze, and interpret information relevant to the problem or opportunity at hand to support engineering decisions.<br>● Determine the coefficient of friction between two surfaces. |

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| | • Select and justify the use of materials for prototyping and manufacturing products.<br>• Select and use simple mechanisms (cams, gears, pulleys and belts, sprockets and chains, springs, levers) to create and control motion to solve a problem.<br>• Develop a project schedule and track progress for successful completion of the project.<br>• Design and build an electrical circuit that includes a DC power source, a motor, and a switch.<br>• Design and build an electrical circuit that includes a variable resistance to control the speed of a mechanism.<br>• Demonstrate persistence in accomplishing a difficult challenge.<br>• Make strategic use of digital media (textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence, and to add interest.<br>• Build a physical representation of an object or system based on graphical representations of the object or system. Includes building solid objects, electrical circuits, mechanical devices, and complex systems according to technical drawings.<br>• Apply systems thinking to consider how an engineering problem and its solution may be thought of as containing a subsystem and as being a subsystem of a larger system.<br>• Integrate an electrical circuit with a machine to solve a problem.<br>• Apply scientific knowledge related to frictional forces, to solve a problem or design a physical system.<br>• Synthesize an ill-formed problem into a meaningful, well-defined problem using relevant information.<br>• Consider the impact of potential engineering solutions on future generations to inform the development of sustainable solutions.<br>• Assess the sustainability of an engineering solution based on the impacts (within the system or interrelated systems) that result from implementation of the solution.<br>• Communicate effectively with an audience based on audience characteristics. |

## Suggested Resources/Technology Tools

- myPLTW learning module
- Schoology
- GoogleSheets

- GoogleDocs
- GoogleSlides
- OnShape
- Autodesk Fusion 360
- 3D Printer software
- Laser Engraver software
- Chromebooks
- Classroom iMacs/desktops
- LCD Projector

## Modifications

Special Education/IEP/504 -

- Adhere to all modifications and health concerns stated in each IEP.
- Accommodate instructional strategies: reading aloud text, graphic organizers, one-on-one instruction, class website (Schoology), handouts, definition list with visuals, extended time
- Allow students to demonstrate understanding of a problem by drawing the picture of the answer and then explaining the reasoning orally and/or writing , such as Read-Draw-Write
- Provide breaks between tasks, use positive reinforcement, use proximity

ELL -

- Use manipulatives to promote conceptual understanding and enhance vocabulary usage
- Use sentence frames and questioning strategies so that students will explain their thinking/process of how to solve word problems
- Utilize graphic organizers which are concrete, pictorial ways of constructing knowledge and organizing information
- Reword questions in simpler language

Gifted and Talented -

- Complex, in-depth research assignments
- Independent study where applicable
- Provide a variety of individualized work centers or student choice
- Lead demonstrations for class
- Individual presentation

## Career Readiness, Life Literacies, and Key Skills Practices (June 2020)

- ❑ Act as a responsible and contributing citizen and employee.
- ❑ Apply appropriate academic and technical skills.
- ❑ Attend to personal health and financial well being.
- ❑ Communicate clearly and effectively and with reason.
- ❑ Consider the environmental, social and economic impacts of decisions.
- ❑ Demonstrate creativity and innovation.
- ❑ Employ valid and reliable research strategies.
- ❑ Utilize critical thinking to make sense of problems and persevere in solving them.
- ❑ Model integrity, ethical leadership, and effective management.
- ❑ Plan education and career paths aligned to personal goals.

❑ Use technology to enhance productivity.
❑ Work productively in teams while using cultural global competence.

*LINKS TO CAREERS:*

- Field Trips -
  - Manufacturing company
- Potential Guest Speakers -
  - CAD Drafter, Product Designer, Electrical Engineer