PLANNED INSTRUCTION

A PLANNED COURSE FOR:

Introduction to Engineering Design

Curriculum writing committee:

Robert E. Curtis, Jr. P.E.

Grade Level:

9 - 12

Date of Board Approval: _____2021_____

Course Weighting: Introduction to Engineering Design

Major Assessments (Tests, Common Assessments)	45 %
Skills Application (Labs, Quizzes)	30 %
Skills Practice (Activities, Homework)	20 %
Participation	5 %
Total	100 %

Curriculum Map

Overview:

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

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

Introduction to Engineering Design is a full-year elective, 1 credit course that is eligible for college credit from Rochester Institute of Technology (RIT) upon successful completion of the course with a minimum overall course grade and minimum score on the PLTW End-Of-Course Assessment, as determined by RIT.

Goals:

Understanding of

Marking Period 1: Unit 1 (Design and Problem Solving) provides an overview of the engineering design process and helps students develop an understanding of the purpose and practice of modeling in engineering communication. Students are introduced to modeling methods and a new dimensioning approach, as well as build CAD skills early that will be applied throughout the course.

- Design Basics
- Visualization and Solid Modeling
- CAD Fundamentals
- Product Improvement

Marking Period 2: In Unit 2 (Assembly Design) students continue skill-building in CAD. Activities teach practical applications of different types of fit and tolerance and applications of building top-down and bottom-up assemblies. Students investigate a variety of materials through experimentation to identify properties that inform material selection. They learn how to assign specific materials to CAD model components and to differentiate between assigning the physical properties of a material to a part and changing only the visual appearance of the part.

- Put It Together [Advanced CAD Skills]
- Take It Apart [Reverse Engineer a Consumer Product]
- A Material World [Analyze Materials],
- Fix It [Redesign a Non-working Device]

Marking Period 3: Unit 3 (Thoughtful Product Design) introduces students to a broader interpretation of the word “design” to include universal principles that contribute to successful product design. Students are exposed to design principles that can impact the appeal, usability, safety, and sustainability of a product.

- Responsible Design
- More Than Parts [Apply Human-centered Design]
- Solve a Problem

Marking Period 4: The focus of Unit 4 (Making Things Move) is to familiarize students with basic engineering knowledge related to simple mechanical and electrical systems and with the use of mathematical models to represent design ideas and to inform design decisions. Students will apply their new knowledge in the design of an electromechanical solution—an automata. Students also learn advanced CAD skills to support the design, documentation, and communication of engineering solutions.

- You’ve Got to Move It [Analyze Simple Machines and Mechanisms]
- May the Force Be With You [Investigate Forces]
- Automating Motion [Electric Circuits and Motors]
- Make it Move [Design Electromechanical System])

Big Ideas:

BIG IDEA 1: Successful STEM professionals exhibit specific personal and professional characteristics that lend themselves to the creative, collaborative, and solution-driven nature of their profession.

BIG IDEA 2: STEM professionals use professional skills and knowledge to pursue opportunities and create sustainable solutions to improve and enhance the quality of life of individuals and society.

BIG IDEA 3: Project management involves planning, executing, controlling, and closing the work of a team to successfully meet goals.

BIG IDEA 4: Successful engineering professionals exhibit personal and professional characteristics and behaviors that involve considerations of the impact of their work on individuals, society, and the natural world.

BIG IDEA 5: Successful engineering professionals demonstrate an ability to function on multidisciplinary teams.

BIG IDEA 6: Successful engineering professionals demonstrate effective communication with a variety of audiences using multiple modalities.

BIG IDEA 7: The practice of engineering requires the application of mathematical principles and common engineering tools, techniques, and technologies.

BIG IDEA 8: Computational thinking is a critical part of a problem-solving process that supports the ability to interpret complex, open-ended problems across all disciplines.

BIG IDEA 9: Modeling is used to represent ideas and simulate objects, processes, or systems to help us understand, evaluate, and predict the behavior of real phenomena.

Textbook and Supplemental Resources:

Introduction to Engineering Design Course and Teacher Guide, Project Lead The Way, Inc., 3939 Priority Way South Drive, Suite 400, Indianapolis, IN 46240, Toll Free: 877-335-PLTW (7589), Local: 317-669-0200 Fax: 317-663-8296, Email: solutioncenter@pltw.org, © 2009–2020 Project Lead The Way, Inc.

Karsnitz, J. R., O'Brien, S., & Hutchinson, J. P. (2013). Engineering design: an introduction, 2nd Edition. Clifton Park, NY: Delmar Cengage Learning.

Curriculum Plan

Lesson 1.1: Design Basics Time/Days 12 days

Standards (by number): 3.4.10.A1, 3.4.10.A2, 3.4.12.A2, 3.4.10.A3, 3.4.10.B1, 3.4.12.B2, 3.4.10.B4, 3.4.10.C1, 3.4.10.C2, 3.4.12.C2, 3.4.12.C3, 3.4.10.D1, 3.4.10.D2, 3.4.12.D2, 3.4.10.D3, CC 3.5.9-10.B, CC 3.5.9-10.C, CC.3.5.11-12.C, C.3.5.9-10.D, CC.3.5.11-12.D, CC.3.5.9-10.E, CC.3.5.11-12.E, CC.3.5.9-10.G, CC.3.5.11-12.G, CC.3.5.9-10.I, CC.3.5.11-12.I, CC.3.5.9-10.J, CC.3.6.9-10.A, CC.3.6.11-12.A, CC.3.6.9-10.B, CC.3.6.11-12.B, CC.3.6.9-10.C, CC.3.6.11-12.C, CC.3.6.9-10.D, CC.3.6.11-12.D, CC.3.6.9-10.E, CC.3.6.11-12.E, CC.3.6.9-10.F, CC.3.6.11-12.F, CC.3.6.9-10.G, CC.3.6.11-12.G, CC.3.6.9-10.H, CC.3.6.11-12.H, CC.3.6.9-10.I, CC.3.6.11-12.I.

Anchors: n/a

Eligible Content: Design as a Process, Iterate and Redesign, Concept Sketching, Targeting Success Using Data, Design a Game

Objectives: Students shall:

- Apply a design process to creatively solve a problem. (DOK Level 4)
- Contribute to the efforts of a team to develop ideas. (DOK Level 1)
- Develop a model to represent a design idea. (DOK Level 3)
- Iterate on steps of the design process to improve a solution. (DOK Level 4)
- Use statistics to compare center and spread of two or more data sets. (DOK Level 2)
- Draw conclusions related to a prediction and support conclusions using experimental data. (DOK Level 3)
- Give and receive feedback to influence personal and professional development. (DOK Level 3)
- Effectively document engineering work in an organized notebook so someone unfamiliar with the work can follow and understand the process. (DOK Level 1)
- Describe the difference between accuracy and precision of a measurement. (DOK Level 1)
- Build a mathematical model to represent data and justify design decisions using data. (DOK Level 4)
- Effectively use different types of models (conceptual, graphical, mathematical) to inform a design. (DOK Level 4)

Core Activities and Corresponding Instructional Methods:

- Textbook Readings from Chapter 1 (Technology: The Human-Designed World), Chapter 2 (The Process of Design), Chapter 3 (Development of the Team), and Chapter 16 (Math and Science Applications)
- Direct Instruction (lecture and fill-in note pages to complete)
- Activity 1.1.1 Design as a Process (group activity – design and build a device to launch a small beanbag and send it as far as possible)
- Activity 1.1.2 Iterate and Redesign (group activity – redesign the device from Activity 1.1.1 to more consistently launch the beanbag a predetermined distance)
- Activity 1.1.3 Concept Sketching (paired and individual activity – sketch the correct shape and proportions of objects from a single straight-on view)

- Activity 1.1.4 Targeting Success Using Data (group activity - redesign the device from Activity 1.1.2 to hit a defined target with the beanbag)
- Project 1.1.5 Design a Game_Assessments (group project – design a carnival game incorporating the device from Activity 1.1.4)

Assessments:

Diagnostic: student responses during classroom discussions and warmups

Formative: student responses to and performance on Activities, Projects, and Quizzes

Summative: Lesson 1.1 Test

Lesson 1.2: Visualization and Solid Modeling Time/Days 14 days

Standards (by number): 3.4.10.A1, 3.4.10.A2, 3.4.12.A2, 3.4.10.A3, 3.4.10.B1, 3.4.10.C1, 3.4.10.C2, 3.4.12.C2, 3.4.12.C3, 3.4.10.D1, 3.4.10.D2, 3.4.12.D2, 3.4.10.D3, CC 3.5.9-10.B, CC 3.5.9-10.C, CC.3.5.11-12.C, C.3.5.9-10.D, CC.3.5.11-12.D, CC.3.5.9-10.E, CC.3.5.11-12.E, CC.3.5.9-10.G, CC.3.5.11-12.G, CC.3.5.9-10.I, CC.3.5.11-12.I, CC.3.5.9-10.J, CC.3.6.9-10.A, CC.3.6.11-12.A, CC.3.6.9-10.B, CC.3.6.11-12.B, CC.3.6.9-10.C, CC.3.6.11-12.C, CC.3.6.9-10.D, CC.3.6.11-12.D, CC.3.6.9-10.E, CC.3.6.11-12.E, CC.3.6.9-10.F, CC.3.6.11-12.F, CC.3.6.9-10.G, CC.3.6.11-12.G, CC.3.6.9-10.H, CC.3.6.11-12.H, CC.3.6.9-10.I, CC.3.6.11-12.I.

Anchors: n/a

Eligible Content: Isometric Sketching; 3D Solid Modeling; Multiview Drawings; Fundamentals of Dimensioning; Sketches, Extrusions, and Revolutions, Oh My!; Charmed I'm Sure

Objectives: Students shall:

- 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 pictorial view of the object. (DOK Level 2)
- Give and receive feedback to influence personal and professional development. (DOK Level 3)
- Build a 3D computer model to represent a physical object. (DOK Level 2)
- Build a 3D computer model to represent a design idea. (DOK Level 2)
- Identify errors and omissions in orthographic projections and multiview drawings. (DOK Level 2)
- Hand sketch an isometric view or build a physical representation of an object based on a multiview drawing of the object. (DOK Level 2)
- Use CAD software to generate orthographic projections and create a multiview drawing from a 3D solid model. (DOK Level 2)
- Generate an annotated multiview drawing using CAD software. (DOK Level 2)
- Recognize that 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. (DOK Level 1)
- Identify three-dimensional objects generated by rotation of a two-dimensional object. (DOK Level 4)
- Develop a model to represent important characteristics of an object for an intended purpose. (DOK Level 3)
- Build a physical representation of an object based on graphical representations of the object. (DOK Level 2)
- Generate an annotated multiview drawing using CAD software. (DOK Level 2)

Core Activities and Corresponding Instructional Methods:

- Textbook Readings from Chapter 5 (Drawing to Develop Ideas) and Chapter 8 (Technical Drawing)
- Direct Instruction (lecture and fill-in note pages to complete)
- Activity 1.2.1 Isometric Sketching (group and individual activity – hand sketch isometric views of simple objects)
- Activity 1.2.2 3D Solid Modeling (individual activity – create 3D CAD solid models of simple objects)

- Activity 1.2.3 Multiview Drawings (paired and individual activity – create multiview drawings by hand and by using 3D CAD solid modeling software)
- Activity 1.2.4 Fundamentals of Dimensioning (group and individual activity – correctly apply dimensions to multiview drawings)
- Activity 1.2.5 Sketches, Extrusions, and Revolutions, Oh My! (individual activity – create more complex 3D CAD solid models)
- Project 1.2.6 Charmed I'm Sure (group project – design and create a backpack charm using 3D Modeling CAD software and a 3D printer)

Assessments:

Diagnostic: student responses during classroom discussions and warmups

Formative: student responses to and performance on Activities, Projects, and Quizzes

Summative: Lesson 1.2 Test

Lesson 1.3: CAD Fundamentals Time/Days 14 days

Standards (by number): 3.4.10.A1, 3.4.10.A2, 3.4.12.A2, 3.4.10.A3, 3.4.10.B1, 3.4.10.C1, 3.4.10.C2, 3.4.12.C2, 3.4.12.C3, 3.4.10.D1, 3.4.10.D2, 3.4.12.D2, 3.4.10.D3, CC 3.5.9-10.B, CC 3.5.9-10.C, CC.3.5.11-12.C, C.3.5.9-10.D, CC.3.5.11-12.D, CC.3.5.9-10.E, CC.3.5.11-12.E, CC.3.5.9-10.G, CC.3.5.11-12.G, CC.3.5.9-10.I, CC.3.5.11-12.I, CC.3.5.9-10.J, CC.3.6.9-10.A, CC.3.6.11-12.A, CC.3.6.9-10.B, CC.3.6.11-12.B, CC.3.6.9-10.C, CC.3.6.11-12.C, CC.3.6.9-10.D, CC.3.6.11-12.D, CC.3.6.9-10.E, CC.3.6.11-12.E, CC.3.6.9-10.F, CC.3.6.11-12.F, CC.3.6.9-10.G, CC.3.6.11-12.G, CC.3.6.9-10.H, CC.3.6.11-12.H, CC.3.6.9-10.I, CC.3.6.11-12.I.

Anchors: n/a

Eligible Content: Measure It!, Making Holes in CAD, Constraining a Sketch, CAD Modeling Skills, Documenting a Design, I Section That, Design a Protective Case

Objectives: Students shall:

- Explain that all measurements approximate the true value of a quantity. (DOK Level 1)
- Choose a measurement device based on the level of precision and accuracy needed. (DOK Level 2)
- Apply inferential reasoning to make and/or support claims about populations based on data. (DOK Level 4)
- Read and interpret a hole note to identify the size and type of hole specified. (DOK Level1)
- Create and constrain a 3D model to represent the physical characteristics of a physical object. (DOK Level 3)
- Create a computer model to represent a conceptual idea and inform design decisions. (DOK Level 4)
- 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. (DOK Level 4)
- Identify necessary/appropriate views to fully detail a part or assembly. (DOK Level 3)
- Use CAD software to generate a multiview drawing from a 3D solid model. (DOK Level 3)
- Apply appropriate and sufficient annotation (including dimensioning) to a drawing to fully describe an object. (DOK Level 4)
- 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. (DOK Level 4)
- Generate an annotated, multiview technical drawing using CAD software to fully describe a simple part. (DOK Level 4)
- Develop a potential solution and evaluate the solution with respect to design criteria and constraints. (DOK Level 4)

Core Activities and Corresponding Instructional Methods:

- Textbook Readings from Chapter 5 (Drawing to Develop Ideas) and Chapter 8 (Technical Drawing)
- Direct Instruction (lecture and fill-in note pages to complete)

- Activity 1.3.1 Measure It! (group and individual activity – estimate and measure sizes of various objects)
- Activity 1.3.2 Making Holes in CAD (paired and individual activity – properly specify hole dimensions in 3D CAD solid modeling software)
- Activity 1.3.3 Constraining a Sketch (paired and individual activity – properly constrain sketches in 3D CAD solid modeling software)
- Activity 1.3.4 CAD Modeling Skills (individual activity – use 3D CAD solid modeling software to create more complex features such as lofts, tapered extrusions, patterns, and shells)
- Activity 1.3.5 Documenting a Design (individual activity – create documentation to communicate a design such that the design can be constructed by a third party)
- Activity 1.3.6 I Section That! (individual activity – use 3D CAD Solid Modeling Software to section views of complex objects)
- Project 1.3.7 Design a Protective Case (paired project – design and create a protective case for a pair of earbuds using 3D Modeling CAD software and a 3D printer)

Assessments:

Diagnostic: student responses during classroom discussions and warmups

Formative: student responses to and performance on Activities, Projects, and Quizzes

Summative: Lesson 1.3 Test

Lesson 1.4: Product Improvement Time/Days 5 days

Standards (by number): 3.4.10.A1, 3.4.10.A2, 3.4.12.A2, 3.4.10.A3, 3.4.10.B1, 3.4.12.B1, 3.4.10.B2, 3.4.10.B3, 3.4.10.C1, 3.4.10.C2, 3.4.12.C2, 3.4.12.C3, 3.4.10.D1, 3.4.10.D2, 3.4.12.D2, 3.4.10.D3, CC 3.5.9-10.B, CC 3.5.9-10.C, CC.3.5.11-12.C, C.3.5.9-10.D, CC.3.5.11-12.D, CC.3.5.9-10.E, CC.3.5.11-12.E, CC.3.5.9-10.G, CC.3.5.11-12.G, CC.3.5.9-10.I, CC.3.5.11-12.I, CC.3.5.9-10.J, CC.3.6.9-10.A, CC.3.6.11-12.A, CC.3.6.9-10.B, CC.3.6.11-12.B, CC.3.6.9-10.C, CC.3.6.11-12.C, CC.3.6.9-10.D, CC.3.6.11-12.D, CC.3.6.9-10.E, CC.3.6.11-12.E, CC.3.6.9-10.F, CC.3.6.11-12.F, CC.3.6.9-10.G, CC.3.6.11-12.G, CC.3.6.9-10.H, CC.3.6.11-12.H, CC.3.6.9-10.I, CC.3.6.11-12.I.

Anchors: n/a

Eligible Content: Sweet Improvement

Objectives: Students shall:

- Apply an iterative design process, including developing appropriate models and/or simulations, to creatively address a need or solve a problem. (DOK Level 4)
- Create technical drawings using 3D computer-aided design (CAD) software to document a design according to standard engineering practices. (DOK Level 3)
- Demonstrate independent thinking and self-direction in pursuit of accomplishing a goal. (DOK Level 4)
- Communicate effectively with an audience based on the characteristics of the intended audience. (DOK Level 3)

Core Activities and Corresponding Instructional Methods:

- Problem 1.4.1 Sweet Improvement (group project – design and create a shipping container for various bakery products)

Assessments:

Diagnostic: student responses during classroom discussions and warmups

Formative: n/a

Summative: performance on Problem 1.4.1

Lesson 2.1: Put It Together Time/Days 12 days

Standards (by number): 3.4.10.A1, 3.4.10.A2, 3.4.12.A2, 3.4.10.A3, 3.4.10.B1, 3.4.12.B2, 3.4.10.B4, 3.4.10.C1, 3.4.10.C2, 3.4.12.C2, 3.4.12.C3, 3.4.10.D1, 3.4.10.D2, 3.4.12.D2, 3.4.10.D3, CC 3.5.9-10.B, CC 3.5.9-10.C, CC.3.5.11-12.C, C.3.5.9-10.D, CC.3.5.11-12.D, CC.3.5.9-10.E, CC.3.5.11-12.E, CC.3.5.9-10.G, CC.3.5.11-12.G, CC.3.5.9-10.I, CC.3.5.11-12.I, CC.3.5.9-10.J, CC.3.6.9-10.A, CC.3.6.11-12.A, CC.3.6.9-10.B, CC.3.6.11-12.B, CC.3.6.9-10.C, CC.3.6.11-12.C, CC.3.6.9-10.D, CC.3.6.11-12.D, CC.3.6.9-10.E, CC.3.6.11-12.E, CC.3.6.9-10.F, CC.3.6.11-12.F, CC.3.6.9-10.G, CC.3.6.11-12.G, CC.3.6.9-10.H, CC.3.6.11-12.H, CC.3.6.9-10.I, CC.3.6.11-12.I.

Anchors: n/a

Eligible Content: Tolerate This!, Hold It Together!, Putting It Together, Document the Assembly, Redesign a Protective Case

Objectives: Students shall:

- Apply appropriate engineering tolerances to specify the allowable variation, size of individual features, and orientation and location between features of an object. (DOK Level 2)
- 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. (DOK Level 2)
- Describe methods to rigidly join physical parts of an assembly. (DOK Level 1)
- 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. (DOK Level 3)
- Identify joints that allow movement between parts in an assembly and the resulting degrees of freedom. (DOK Level 3)
- Correctly build and constrain a three-dimensional solid computer model to accurately represent the physical characteristics and behaviors of a physical object. (DOK Level 4)
- Correctly apply joints to constrain multi-component models and/or simulate realistic relative motion of the component parts. (DOK Level 4)
- Identify necessary and appropriate views to fully detail an assembly. (DOK Level 3)
- Generate an annotated assembly drawing of components and details of assembly. (DOK Level 2)
- Apply an iterative design process to creatively address a need or solve a problem. (DOK Level 4)
- Generate an annotated multiview drawing to fully describe a simple part. (DOK Level 3)

Core Activities and Corresponding Instructional Methods:

- Textbook Readings from Chapter 8 (Technical Drawing)
- Direct Instruction (lecture and fill-in note pages to complete)
- Activity 2.1.1 Tolerate This! (individual activity – learn that product dimensional variation is unavoidable and correctly specify tolerances on a mechanical drawing)
- Activity 2.1.2 Hold It Together! (group activity – research joining techniques)
- Activity 2.1.3 Putting It Together (paired and individual activity – create assemblies in 3D CAD Solid Modeling)
- Activity 2.1.4 Document the Assembly (individual activity – create an assembly drawing with notes and parts list)

- Project 2.1.5 Redesign a Protective Case (group project – redesign the protective case from Project 1.3.7 based on customer feedback)

Assessments:

Diagnostic: student responses during classroom discussions and warmups

Formative: student responses to and performance on Activities, Projects, and Quizzes

Summative: Lesson 2.1 Test

Lesson 2.2: Take It Apart Time/Days 18 days

Standards (by number): 3.4.10.A1, 3.4.10.A2, 3.4.12.A2, 3.4.10.A3, 3.4.10.B1, 3.4.12.B1, 3.4.10.B2, 3.4.10.C1, 3.4.10.C2, 3.4.12.C2, 3.4.12.C3, 3.4.10.D1, 3.4.10.D2, 3.4.12.D2, 3.4.10.D3, CC 3.5.9-10.B, CC 3.5.9-10.C, CC.3.5.11-12.C, C.3.5.9-10.D, CC.3.5.11-12.D, CC.3.5.9-10.E, CC.3.5.11-12.E, CC.3.5.9-10.G, CC.3.5.11-12.G, CC.3.5.9-10.I, CC.3.5.11-12.I, CC.3.5.9-10.J, CC.3.6.9-10.A, CC.3.6.11-12.A, CC.3.6.9-10.B, CC.3.6.11-12.B, CC.3.6.9-10.C, CC.3.6.11-12.C, CC.3.6.9-10.D, CC.3.6.11-12.D, CC.3.6.9-10.E, CC.3.6.11-12.E, CC.3.6.9-10.F, CC.3.6.11-12.F, CC.3.6.9-10.G, CC.3.6.11-12.G, CC.3.6.9-10.H, CC.3.6.11-12.H, CC.3.6.9-10.I, CC.3.6.11-12.I.

Anchors: n/a

Eligible Content: What is Reverse Engineering?, Visual Analysis, Functional Analysis and the Black Box, Structural Analysis and Product Disassembly, CAD Design Tools, Top-down or Bottom-up?, Design for Manufacturability and Assembly, Design an Integrated Assembly.

Objectives: Students shall:

- Describe the processes and purposes of reverse engineering. (DOK Level 1)
- Describe the reverse engineering process of visual analysis. (DOK Level 1)
- Perform a visual analysis of an object and describe the apparent visual elements and principles of design. (DOK Level 2)
- Describe the reverse engineering process of functional analysis. (DOK Level 1)
- Perform a functional analysis of a product or system to determine the purpose, inputs and outputs, and operation of a product or system. (DOK Level 2)
- Describe the reverse engineering process of structural analysis. (DOK Level 1)
- 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. (DOK Level 2)
- Develop a model to accurately represent information or important characteristics of an object, data, process, or design idea for an intended purpose. (DOK Level 4)
- 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. (DOK Level 4)
- Use sketches to clearly communicate information. (DOK Level 2)
- Develop a model to accurately represent information or important characteristics of an object. (DOK Level 4)
- Correctly build and constrain a three-dimensional solid computer model to accurately represent the physical characteristics of a real object. (DOK Level 4)
- Create relationships among part features and dimensions using parametric relationships. (DOK Level 3)
- Correctly constrain multi-component models. (DOK Level 2)
- Apply the principles of design for manufacturability and assembly of mechanical products. (DOK Level 4)
- Identify design flaws of and potential enhancements to a proposed design solution. (DOK Level 3)

- Define measurable visual, functional, and structural design requirements (criteria) and realistic constraints against which solution alternatives can be evaluated and optimized. (DOK Level 3)
- Apply effective techniques and appropriate guidelines to generate multiple creative ideas and solutions to a problem. (DOK Level 4)
- Carry out a plan to compare competing solution ideas and justify the selection of a solution path with respect to design requirements and constraints. (DOK Level 4)
- 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. (DOK Level 4)

Core Activities and Corresponding Instructional Methods:

- Textbook Readings from Chapter 6 (Reverse Engineering)
- Direct Instruction (lecture and fill-in note pages to complete)
- Activity 2.2.1 What is Reverse Engineering? (group activity – learn the basics of reverse engineering and discuss the ethical issues involved with it)
- Activity 2.2.2 Visual Analysis (individual and group activity – analyze and discuss the visual design elements of a consumer product)
- Activity 2.2.3 Functional Analysis and the Black Box (individual activity – analyze the inputs, outputs, and function of a consumer product)
- Activity 2.2.4 Structural Analysis and Product Disassembly (group activity – disassemble a consumer product and document it internal structure)
- Activity 2.2.5 CAD Design Tools (individual activity – create more complex 3D CAD solid modeling features such as sweep, revolve, and construction features)
- Activity 2.2.6 Top-down or Bottom-up? (individual and group activity – create assemblies from subassemblies using 3D CAD Solid Modeling software while delving into top-down and bottom-up design strategies)
- Activity 2.2.7 Design for Manufacturability and Assembly (individual and group activity – redesign a common consumer product to improve its manufacturability)
- Project 2.2.8 Design an Integrated Assembly (paired project – design and create an accessory to a consumer product to improve its market appeal)

Assessments:

Diagnostic: student responses during classroom discussions and warmups

Formative: student responses to and performance on Activities, Projects, and Quizzes

Summative: Lesson 2.2 Test

Lesson 2.3: A Material World Time/Days 9 days

Standards (by number): 3.4.10.A1, 3.4.10.A2, 3.4.12.A2, 3.4.10.A3, 3.4.10.B1, 3.4.12.B1, 3.4.10.B3, 3.4.10.C1, 3.4.10.C2, 3.4.12.C2, 3.4.12.C3, 3.4.10.D1, 3.4.10.D2, 3.4.12.D2, 3.4.10.D3, CC 3.5.9-10.B, CC 3.5.9-10.C, CC.3.5.11-12.C, C.3.5.9-10.D, CC.3.5.11-12.D, CC.3.5.9-10.E, CC.3.5.11-12.E, CC.3.5.9-10.G, CC.3.5.11-12.G, CC.3.5.9-10.I, CC.3.5.11-12.I, CC.3.5.9-10.J, CC.3.6.9-10.A, CC.3.6.11-12.A, CC.3.6.9-10.B, CC.3.6.11-12.B, CC.3.6.9-10.C, CC.3.6.11-12.C, CC.3.6.9-10.D, CC.3.6.11-12.D, CC.3.6.9-10.E, CC.3.6.11-12.E, CC.3.6.9-10.F, CC.3.6.11-12.F, CC.3.6.9-10.G, CC.3.6.11-12.G, CC.3.6.9-10.H, CC.3.6.11-12.H, CC.3.6.9-10.I, CC.3.6.11-12.I.

Anchors: n/a

Eligible Content: Material Properties, Evaluating Materials, CAD Material Appearance and Analysis, Imagine the Future

Objectives: Students shall:

- List material properties that are important to design, including mechanical, chemical, electrical, and magnetic properties. (DOK Level 1)
- Perform an experimental protocol to investigate a phenomenon and/or gain knowledge. (DOK Level 3)
- Conduct non-destructive tests (hardness, flexure, conductivity) on different material types to investigate material properties. (DOK Level 2)
- 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. (DOK Level 3)
- Explain how design criteria and constraints (cost, performance, safety, risk, aesthetics, environmental impact) often limit the material choices available for a given design. (DOK Level 4)
- Select and justify the use of materials for prototyping and manufacturing products. (DOK Level 4)
- Draw valid conclusions based on supporting evidence while acknowledging limitations, opposing views, and biases. (DOK Level 4)
- Create a computer model or simulation to represent an object or conceptual idea and inform design decisions. (DOK Level 3)
- Synthesize an ill-formed problem into a meaningful, well-defined problem using relevant information. (DOK Level 4)
- Describe different types of materials and their common usages in product design. (DOK Level 1)
- Define engineering as the creation of solutions, such as new and improved products, technologies, systems and processes, to meet the needs of people and society. (DOK Level 1)

Core Activities and Corresponding Instructional Methods:

- Textbook Readings from Chapter 16 (Math and Science Applications)
- Direct Instruction (lecture and fill-in note pages to complete)
- Activity 2.3.1 Material Properties (paired and individual activity – investigate density and other material properties using various material samples)

- Activity 2.3.2 Evaluating Materials (paired and group activity – choose proper materials for a space habitat)
- Activity 2.3.3 CAD Material Appearance and Analysis (individual activity – use 3D CAD Solid Modeling software to properly specify material types for objects)
- Project 2.3.4 Imagine the Future (individual project – research a cutting-edge material and brainstorm a new product that will use this material to solve a problem)

Assessments:

Diagnostic: student responses during classroom discussions and warmups

Formative: student responses to and performance on Activities, Projects, and Quizzes

Summative: Lesson 2.3 Test

Lesson 2.4: Fix It Time/Days 6 days

Standards (by number): 3.4.10.A1, 3.4.10.A2, 3.4.12.A2, 3.4.10.A3, 3.4.10.B1, 3.4.12.B1, 3.4.10.B2, 3.4.10.B3, 3.4.10.C1, 3.4.10.C2, 3.4.12.C2, 3.4.12.C3, 3.4.10.D1, 3.4.10.D2, 3.4.12.D2, 3.4.10.D3, CC 3.5.9-10.B, CC 3.5.9-10.C, CC.3.5.11-12.C, C.3.5.9-10.D, CC.3.5.11-12.D, CC.3.5.9-10.E, CC.3.5.11-12.E, CC.3.5.9-10.G, CC.3.5.11-12.G, CC.3.5.9-10.I, CC.3.5.11-12.I, CC.3.5.9-10.J, CC.3.6.9-10.A, CC.3.6.11-12.A, CC.3.6.9-10.B, CC.3.6.11-12.B, CC.3.6.9-10.C, CC.3.6.11-12.C, CC.3.6.9-10.D, CC.3.6.11-12.D, CC.3.6.9-10.E, CC.3.6.11-12.E, CC.3.6.9-10.F, CC.3.6.11-12.F, CC.3.6.9-10.G, CC.3.6.11-12.G, CC.3.6.9-10.H, CC.3.6.11-12.H, CC.3.6.9-10.I, CC.3.6.11-12.I.

Anchors: n/a

Eligible Content: Troubleshoot an Assembly

Objectives: Students shall:

- Persevere to solve a problem or achieve a goal. (DOK Level 4)
- Create and interpret a computer model or simulation of simple objects, assemblies, or systems to inform engineering decisions and solve problems. (DOK Level 3)
- Create technical drawings using 3D computer-aided design (CAD) software to document a design according to standard engineering practices. (DOK Level 3)
- Communicate effectively with an audience based on audience characteristics. (DOK Level 4)

Core Activities and Corresponding Instructional Methods:

- Problem 2.4.1 Troubleshoot an Assembly (group project – design and create parts for a trammel system)

Assessments:

Diagnostic: student responses during classroom discussions and warmups

Formative: n/a

Summative: performance on Problem 2.4.1

Lesson 3.1: Responsible Design Time/Days 15 days

Standards (by number): 3.4.10.A1, 3.4.10.A2, 3.4.12.A2, 3.4.10.A3, 3.4.10.B1, 3.4.12.B1, 3.4.10.B2, 3.4.10.C1, 3.4.10.C2, 3.4.12.C2, 3.4.12.C3, 3.4.10.D1, 3.4.10.D2, 3.4.12.D2, 3.4.10.D3, CC 3.5.9-10.B, CC 3.5.9-10.C, CC.3.5.11-12.C, C.3.5.9-10.D, CC.3.5.11-12.D, CC.3.5.9-10.E, CC.3.5.11-12.E, CC.3.5.9-10.G, CC.3.5.11-12.G, CC.3.5.9-10.I, CC.3.5.11-12.I, CC.3.5.9-10.J, CC.3.6.9-10.A, CC.3.6.11-12.A, CC.3.6.9-10.B, CC.3.6.11-12.B, CC.3.6.9-10.C, CC.3.6.11-12.C, CC.3.6.9-10.D, CC.3.6.11-12.D, CC.3.6.9-10.E, CC.3.6.11-12.E, CC.3.6.9-10.F, CC.3.6.11-12.F, CC.3.6.9-10.G, CC.3.6.11-12.G, CC.3.6.9-10.H, CC.3.6.11-12.H, CC.3.6.9-10.I, CC.3.6.11-12.I.

Anchors: n/a

Eligible Content: Reverse Engineer a Product, Product Life Cycle, Sustainable Design, Design Criteria and Constraints, Consider the Impact

Objectives: Students shall:

- Make strategic use of digital media in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (DOK Level 4)
- Analyze a consumer product using reverse engineering techniques to document visual, functional, and structural aspects of the design. (DOK Level 4)
- Explain that different engineering solutions can have significantly different impacts on individuals, society, and the natural world. (DOK Level 3)
- Describe the life cycle of a product or service. (DOK Level 2)
- 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. (DOK Level 4)
- Consider the impact of potential engineering solutions on future generations to inform the development of sustainable solutions. (DOK Level 3)
- Present information, findings, and supporting evidence clearly, concisely, and logically. (DOK Level 3)
- Explain how design criteria and constraints often limit the material choices available for a given design. (DOK Level 2)
- Ask new probing questions to expand and build upon an idea and explore personal curiosities throughout a creative process. (DOK Level 3)
- Apply an iterative design process, including developing appropriate models, to creatively address a need or solve a problem. (DOK Level 4)

Core Activities and Corresponding Instructional Methods:

- Textbook Readings from Chapter 4 (Generating and Developing Ideas) and Chapter 6 (Reverse Engineering)
- Direct Instruction (lecture and fill-in note pages to complete)
- Activity 3.1.1 Reverse Engineer a Product (paired activity – reverse engineer a solar calculator)
- Activity 3.1.2 Product Life Cycle (paired activity – research and document the product life cycle of various products, including a solar calculator and a beverage cup)
- Activity 3.1.3 Sustainable Design (paired activity – research and discuss ethical considerations surrounding environmentally sustainable design)

- Activity 3.1.4 Design Criteria and Constraints (paired activity – create a design brief for one of the products from Activity 3.1.2)
- Project 3.1.5 Consider the Impact (group project – reverse engineer and improve a consumer product)

Assessments:

Diagnostic: student responses during classroom discussions and warmups

Formative: student responses to and performance on Activities, Projects, and Quizzes

Summative: Lesson 3.1 Test

Lesson 3.2: More Than Parts Time/Days 16 days

Standards (by number): 3.4.10.A1, 3.4.10.A2, 3.4.12.A2, 3.4.10.A3, 3.4.10.B1, 3.4.12.B1, 3.4.10.B2, 3.4.10.B3, 3.4.10.C1, 3.4.10.C2, 3.4.12.C2, 3.4.12.C3, 3.4.10.D1, 3.4.10.D2, 3.4.12.D2, 3.4.10.D3, CC 3.5.9-10.B, CC 3.5.9-10.C, CC.3.5.11-12.C, C.3.5.9-10.D, CC.3.5.11-12.D, CC.3.5.9-10.E, CC.3.5.11-12.E, CC.3.5.9-10.G, CC.3.5.11-12.G, CC.3.5.9-10.I, CC.3.5.11-12.I, CC.3.5.9-10.J, CC.3.6.9-10.A, CC.3.6.11-12.A, CC.3.6.9-10.B, CC.3.6.11-12.B, CC.3.6.9-10.C, CC.3.6.11-12.C, CC.3.6.9-10.D, CC.3.6.11-12.D, CC.3.6.9-10.E, CC.3.6.11-12.E, CC.3.6.9-10.F, CC.3.6.11-12.F, CC.3.6.9-10.G, CC.3.6.11-12.G, CC.3.6.9-10.H, CC.3.6.11-12.H, CC.3.6.9-10.I, CC.3.6.11-12.I.

Anchors: n/a

Eligible Content: Human-Centered Design, Whole-systems Thinking, Generative Design, When is "Good" Good Enough?, Gadget Design

Objectives: Students shall:

- Explain the benefits of human-centered design and apply principles to align product design with intended use. (DOK Levels 2, 4)
- Describe how design quality concepts such as performance, usability, accessibility, reliability, and safety impact product development. Describe the reverse engineering process of visual analysis. (DOK Level 2)
- Describe 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. (DOK Levels 2, 3)
- Predict the local and global risks and impacts of an engineering decision/solution, including some that were not anticipated. (DOK Level 4)
- Apply effective techniques and appropriate guidelines to generate multiple creative ideas and potential solutions to a problem. (DOK Level 4)
- Collect, analyze, and interpret information relevant to the problem or opportunity at hand to support engineering decisions. (DOK Level 4)
- Use computer-aided engineering tools to optimize design performance of a mechanical part or assembly. (DOK Level 3)
- Draw valid conclusions based on supporting evidence while acknowledging the limitations, opposing views, and biases. (DOK Level 3)
- Apply inferential reasoning to make and/or support claims about populations based on data. (DOK Level 4)
- Apply an iterative design process to creatively address a need or solve a problem. (DOK Level 4)
- Define sustainability and identify principles that help guide development of sustainable solutions (e.g. generative design and life cycle assessment). (DOK Level 2)
- Use computer-aided engineering tools to optimize design performance of a mechanical part or assembly. (DOK Level 3)
- 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. (DOK Level 4)

Core Activities and Corresponding Instructional Methods:

- Textbook Readings from Chapter 10 (Manufacturing) and Chapter 16 (Math and Science Applications)
- Direct Instruction (lecture and fill-in note pages to complete)
- Activity 3.2.1 Human-Centered Design (group activity – use human-centered design concepts to design a classroom chair)
- Activity 3.2.2 Whole-systems Thinking (group activity – consider and apply "big-picture" thinking to product design)
- Activity 3.2.3 Generative Design (individual activity – apply the concepts of generative design to optimize the design of a computer product utilizing 3D CAD Solid Modeling Software)
- Activity 3.2.4 When is "Good" Good Enough? (group activity – analyze a manufacturing process using statistics to determine the success of the process)
- Project 3.2.5 Gadget Design (paired project – design and create a useful gadget for consumer use)

Assessments:

Diagnostic: student responses during classroom discussions and warmups

Formative: student responses to and performance on Activities, Projects, and Quizzes

Summative: Lesson 3.2 Test

Lesson 3.3: Solve a Problem Time/Days 14 days

Standards (by number): 3.4.10.A1, 3.4.10.A2, 3.4.12.A2, 3.4.10.A3, 3.4.10.B1, 3.4.12.B1, 3.4.10.B2, 3.4.10.B3, 3.4.10.C1, 3.4.10.C2, 3.4.12.C2, 3.4.12.C3, 3.4.10.D1, 3.4.10.D2, 3.4.12.D2, 3.4.10.D3, CC 3.5.9-10.B, CC 3.5.9-10.C, CC.3.5.11-12.C, C.3.5.9-10.D, CC.3.5.11-12.D, CC.3.5.9-10.E, CC.3.5.11-12.E, CC.3.5.9-10.G, CC.3.5.11-12.G, CC.3.5.9-10.I, CC.3.5.11-12.I, CC.3.5.9-10.J, CC.3.6.9-10.A, CC.3.6.11-12.A, CC.3.6.9-10.B, CC.3.6.11-12.B, CC.3.6.9-10.C, CC.3.6.11-12.C, CC.3.6.9-10.D, CC.3.6.11-12.D, CC.3.6.9-10.E, CC.3.6.11-12.E, CC.3.6.9-10.F, CC.3.6.11-12.F, CC.3.6.9-10.G, CC.3.6.11-12.G, CC.3.6.9-10.H, CC.3.6.11-12.H, CC.3.6.9-10.I, CC.3.6.11-12.I.

Anchors: n/a

Eligible Content: Establishing a Team, Project Scheduling, The Engineering Consultant

Objectives: Students shall:

- Develop and follow team norms. (DOK Level 3)
- Describe one's individual role and expectations of performance within the team, including communication protocol and rules of engagement per the team norms. (DOK Level 2)
- Select and use collaborative tools, such as cloud-based tools, document sharing, and video and text functions, to successfully complete a project. (DOK Level 3)
- Define the project deliverables and constraints, such as scope, time, cost, quality, resources, and risk. (DOK Level 2)
- 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. (DOK Level 3)
- Facilitate an effective team environment to promote successful goal attainment. (DOK Level 3)
- 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. (DOK Level 4)
- Develop models and simulations to represent information, processes, and/or objects to an appropriate level of abstraction for the intended purpose. (DOK Level 4)

Core Activities and Corresponding Instructional Methods:

- Textbook Readings from Chapter 3 (Development of the Team)
- Direct Instruction (lecture and fill-in note pages to complete)
- Activity 3.3.1 Establishing a Team (individual and group project – establish team norms)
- Activity 3.3.2 Project Scheduling (group project – create and optimize a project schedule)
- Problem 3.3.3 The Engineering Consultant (individual and group project – work as an engineering consultant team to solve a problem)

Assessments:

Diagnostic: student responses during classroom discussions and warmups

Formative: n/a

Summative: performance on Problem 3.3.3

Lesson 4.1: You've Got to Move It Time/Days 17 days

Standards (by number): 3.4.10.A1, 3.4.10.A2, 3.4.12.A2, 3.4.10.A3, 3.4.10.B1, 3.4.12.B2, 3.4.10.B4, 3.4.10.C1, 3.4.10.C2, 3.4.12.C2, 3.4.12.C3, 3.4.10.D1, 3.4.10.D2, 3.4.12.D2, 3.4.10.D3, CC 3.5.9-10.B, CC 3.5.9-10.C, CC.3.5.11-12.C, C.3.5.9-10.D, CC.3.5.11-12.D, CC.3.5.9-10.E, CC.3.5.11-12.E, CC.3.5.9-10.G, CC.3.5.11-12.G, CC.3.5.9-10.I, CC.3.5.11-12.I, CC.3.5.9-10.J, CC.3.6.9-10.A, CC.3.6.11-12.A, CC.3.6.9-10.B, CC.3.6.11-12.B, CC.3.6.9-10.C, CC.3.6.11-12.C, CC.3.6.9-10.D, CC.3.6.11-12.D, CC.3.6.9-10.E, CC.3.6.11-12.E, CC.3.6.9-10.F, CC.3.6.11-12.F, CC.3.6.9-10.G, CC.3.6.11-12.G, CC.3.6.9-10.H, CC.3.6.11-12.H, CC.3.6.9-10.I, CC.3.6.11-12.I.

Anchors: n/a

Eligible Content: Reverse Engineer a Mechanism, Cams Make the World Go Round, Mechanisms of Motion, Modeling Mechanical Motion, Cams in Motion, Design a Cam, Simulating Cam Motion, Shoebox Automaton

Objectives: Students shall:

- Describe different types of motion. (DOK Level 1)
- Separate a complex process into multiple subprocesses that can be implemented in an organized way to complete the larger process. (DOK Level 3)
- Use mathematical modeling to optimize design criteria. (DOK Level 4)
- Create relationships among part features and dimensions using parametric formulas. (DOK Level 2)
- Perform a functional analysis of a product or system to determine the purpose, inputs and outputs, and operation of a product or system. (DOK Level 4)
- Select and use simple mechanisms to create and control motion to solve a problem. (DOK Level 3)
- Use mechanisms in a design to transform a motion without changing its type. (DOK Level 3)
- Use a mathematical model to describe the relationship between the motion of objects. (DOK Level 2)
- Correctly apply constraints to a multi-component model and/or simulate realistic relative motion of the component parts. (DOK Level 2)
- Explain how cams and followers can be used to move objects in periodic motion. (DOK Level 1)
- Represent data for two quantitative variables on a scatter plot and describe how the variables are related. (DOK Level 2)
- Fit a function to data and use the function to make predictions in the context of the data. (DOK Level 2)
- Build and use a mathematical model to represent data, describe relationships, describe processes, or to make predictions in the context of a problem. (DOK Level 3)
- 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. (DOK Level 2)
- Generate an annotated multiview technical drawing using CAD software to fully describe a simple part. (DOK Level 2)
- Develop a model to accurately represent the motion of a system with a series of cams. (DOK Level 3)

- Correctly apply joints to constrain a multi-component model to simulate realistic relative motion. (DOK Level 3)
- 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. (DOK Level 4)
- Use sketches, tables, charts, and graphs when appropriate to clearly communicate information and in making arguments and claims in oral, written, and visual presentations. (DOK Level 2)
- Select and use simple mechanisms to create and control motion to solve a problem. (DOK Level 4)

Core Activities and Corresponding Instructional Methods:

- Textbook Readings from Chapter 12 (Designing Mechanical Systems)
- Direct Instruction (lecture and fill-in note pages to complete)
- Activity 4.1.1 Reverse Engineer a Mechanism (paired activity – coordinate the input and output of an automaton by reverse engineering a windup toy)
- Activity 4.1.2 Cams Make the World Go Round (individual activity – use 3D CAD Modeling Software to create a sold model of a cam using parametric modeling and develop motion graphs)
- Activity 4.1.3 Mechanisms of Motion (paired and individual activity – create assemblies in 3D CAD Solid Modeling)
- Activity 4.1.4 Modeling Mechanical Motion (group activity – build and analyze several mechanisms that produce motion)
- Activity 4.1.5 Cams in Motion (individual and group activity – learn about motion graphs and create and interpret motion graphs of objects that move in a straight line)
- Activity 4.1.6 Design a Cam (individual and paired activity – design a cam to provide a desired motion)
- Activity 4.1.7 Simulating Cam Motion (individual activity – add 3D solid cam model to automaton assembly model, simulate the rotation of the cam, and study the resulting motion of the follower)
- Project 4.1.8 Shoebox Automaton (paired project – create mockup of the automaton that incorporate the previously design cams)

Assessments:

Diagnostic: student responses during classroom discussions and warmups

Formative: student responses to and performance on Activities, Projects, and Quizzes

Summative: Lesson 4.1 Test

Lesson 4.2: May the Force Be With You Time/Days 11 days

Standards (by number): 3.4.10.A1, 3.4.10.A2, 3.4.12.A2, 3.4.10.A3, 3.4.10.B1, 3.4.12.B1, 3.4.10.B2, 3.4.10.C1, 3.4.10.C2, 3.4.12.C2, 3.4.12.C3, 3.4.10.D1, 3.4.10.D2, 3.4.12.D2, 3.4.10.D3, CC 3.5.9-10.B, CC 3.5.9-10.C, CC.3.5.11-12.C, C.3.5.9-10.D, CC.3.5.11-12.D, CC.3.5.9-10.E, CC.3.5.11-12.E, CC.3.5.9-10.G, CC.3.5.11-12.G, CC.3.5.9-10.I, CC.3.5.11-12.I, CC.3.5.9-10.J, CC.3.6.9-10.A, CC.3.6.11-12.A, CC.3.6.9-10.B, CC.3.6.11-12.B, CC.3.6.9-10.C, CC.3.6.11-12.C, CC.3.6.9-10.D, CC.3.6.11-12.D, CC.3.6.9-10.E, CC.3.6.11-12.E, CC.3.6.9-10.F, CC.3.6.11-12.F, CC.3.6.9-10.G, CC.3.6.11-12.G, CC.3.6.9-10.H, CC.3.6.11-12.H, CC.3.6.9-10.I, CC.3.6.11-12.I.

Anchors: n/a

Eligible Content: Force Springs Eternal, Friction Is a Real Drag, Fighting Friction, Friction: Design Friend or Foe, Automata Design Challenge

Objectives: Students shall:

- Select and use simple mechanisms, such as springs, to create and control motion to solve a problem. (DOK Level 4)
- Fit a function to the data and use the function to solve problems and make predictions in the context of the data. (DOK Level 3)
- Develop a testable hypothesis and identify experimental controls, independent, and dependent variables to address a problem or answer a question. (DOK Level 4)
- Collect, analyze, and interpret information relevant to the problem or opportunity at hand to support engineering decisions. (DOK Level 4)
- Explain that friction is a force that opposes motion. (DOK Level 1)
- Determine the coefficient of friction between two surfaces. (DOK Level 3)
- Identify 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. (DOK Level 3)
- Select and justify the use of materials for prototyping and manufacturing products. (DOK Level 4)
- Explain how frictional force impacts the function and efficiency of a mechanism and recommend design revisions to improve performance. (DOK Level 4)
- Select and use simple mechanisms (cams, gears, pulleys and belts, sprockets and chains, springs, levers) to create and control motion to solve a problem. (DOK Level 4)
- Develop a project schedule and track progress for successful completion of the project. (DOK Level 4)
- Select and use simple mechanisms (cams, gears, pulleys and belts, sprockets and chains, springs, levers) to create and control motion to solve a problem. (DOK Level 4)
- Create a computer model to represent an object or conceptual idea and inform design decisions. (DOK Level 3)

Core Activities and Corresponding Instructional Methods:

- Textbook Readings from Chapter 12 (Designing Mechanical Systems) and Chapter 16 (Math and Science Applications)

- Direct Instruction (lecture and fill-in note pages to complete)
- Activity 4.2.1 Force Springs Eternal (group activity – investigate springs and how their predictable behavior can be useful in the automaton)
- Activity 4.2.2 Friction Is a Real Drag (individual and group activity – investigate how friction causes heat between surfaces)
- Activity 4.2.3 Fighting Friction (group activity – investigate sources of friction and brainstorm ways to reduce unwanted friction)
- Activity 4.2.4 Friction: Design Friend or Foe (paired activity – investigate how to use friction as a design tool to solve a problem.)
- Project 4.2.5 Automata Design Challenge (group project – design, build, and test an improved automaton that tells a story using mechanisms)

Assessments:

Diagnostic: student responses during classroom discussions and warmups

Formative: student responses to and performance on Activities, Projects, and Quizzes

Summative: Lesson 4.2 Test

Lesson 4.3: Automating Motion Time/Days 8 days

Standards (by number): 3.4.10.A1, 3.4.10.A2, 3.4.12.A2, 3.4.10.A3, 3.4.10.B1, 3.4.12.B1, 3.4.10.B3, 3.4.10.C1, 3.4.10.C2, 3.4.12.C2, 3.4.12.C3, 3.4.10.D1, 3.4.10.D2, 3.4.12.D2, 3.4.10.D3, CC 3.5.9-10.B, CC 3.5.9-10.C, CC.3.5.11-12.C, C.3.5.9-10.D, CC.3.5.11-12.D, CC.3.5.9-10.E, CC.3.5.11-12.E, CC.3.5.9-10.G, CC.3.5.11-12.G, CC.3.5.9-10.I, CC.3.5.11-12.I, CC.3.5.9-10.J, CC.3.6.9-10.A, CC.3.6.11-12.A, CC.3.6.9-10.B, CC.3.6.11-12.B, CC.3.6.9-10.C, CC.3.6.11-12.C, CC.3.6.9-10.D, CC.3.6.11-12.D, CC.3.6.9-10.E, CC.3.6.11-12.E, CC.3.6.9-10.F, CC.3.6.11-12.F, CC.3.6.9-10.G, CC.3.6.11-12.G, CC.3.6.9-10.H, CC.3.6.11-12.H, CC.3.6.9-10.I, CC.3.6.11-12.I.

Anchors: n/a

Eligible Content: Circuit Basics, Fun with Motors, Automata Redesign

Objectives: Students shall:

- Design and build an electrical circuit that includes a DC power source, a motor, and a switch. (DOK Level 2)
- Calculate and measure the resistance, current, and voltage of a circuit. (DOK Level 2)
- Use mechanisms in a design to transform a motion without changing its type, for example, slow to fast rotary motion. (DOK Level 4)
- Design and build an electrical circuit that includes a variable resistance to control the speed of a mechanism. (DOK Level 3)
- Organize and analyze data to make information usable. (DOK Level 2)
- Use a mathematical model to describe a relationship and to make predictions in the context of the problem. (DOK Level 2)
- Demonstrate persistence in accomplishing a difficult challenge. (DOK Level 4)
- 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. (DOK Level 3)
- 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. (DOK Level 4)

Core Activities and Corresponding Instructional Methods:

- Textbook Readings from Chapter 13 (Designing Electrical Systems)
- Direct Instruction (lecture and fill-in note pages to complete)
- Activity 4.3.1 Circuit Basics (paired and individual activity – automate the motion of the automaton with an electric motor)
- Activity 4.3.2 Fun with Motors (paired and individual activity – add a variable resistor to control the motor)
- Project 4.3.3 Automata Redesign (group and individual project – include variable speed control in the automata design and apply knowledge of electrical circuits. During this design iteration, add to the design documentation to reflect the new design concept.)

Assessments:

Diagnostic: student responses during classroom discussions and warmups

Formative: student responses to and performance on Activities, Projects, and Quizzes

Summative: Lesson 4.3 Test

Lesson 4.4: Make It Move Time/Days 9 days

Standards (by number): 3.4.10.A1, 3.4.10.A2, 3.4.12.A2, 3.4.10.A3, 3.4.10.B1, 3.4.12.B1, 3.4.10.B2, 3.4.10.B3, 3.4.10.C1, 3.4.10.C2, 3.4.12.C2, 3.4.12.C3, 3.4.10.D1, 3.4.10.D2, 3.4.12.D2, 3.4.10.D3, CC 3.5.9-10.B, CC 3.5.9-10.C, CC.3.5.11-12.C, C.3.5.9-10.D, CC.3.5.11-12.D, CC.3.5.9-10.E, CC.3.5.11-12.E, CC.3.5.9-10.G, CC.3.5.11-12.G, CC.3.5.9-10.I, CC.3.5.11-12.I, CC.3.5.9-10.J, CC.3.6.9-10.A, CC.3.6.11-12.A, CC.3.6.9-10.B, CC.3.6.11-12.B, CC.3.6.9-10.C, CC.3.6.11-12.C, CC.3.6.9-10.D, CC.3.6.11-12.D, CC.3.6.9-10.E, CC.3.6.11-12.E, CC.3.6.9-10.F, CC.3.6.11-12.F, CC.3.6.9-10.G, CC.3.6.11-12.G, CC.3.6.9-10.H, CC.3.6.11-12.H, CC.3.6.9-10.I, CC.3.6.11-12.I.

Anchors: n/a

Eligible Content: All Together Now

Objectives: Students shall:

- 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. (DOK Level 4)
- Understand how different machine elements influence motion of a mechanical system. (DOK Level 3)
- Integrate an electrical circuit with a machine to solve a problem. (DOK Level 4)
- Apply scientific knowledge related to frictional forces, to solve a problem or design a physical system. (DOK Level 4)

Core Activities and Corresponding Instructional Methods:

- Problem 4.4.1 All Together Now (paired and group project – design a mechanism to transfer rotation of the motor output shaft to each individual automata and drive as many automata as possible using a single motor)

Assessments:

Diagnostic: student responses during classroom discussions and warmups

Formative: n/a

Summative: performance on Problem 4.4.1

Checklist to Complete and Submit:

(Scan and email)

_____ Copy of the curriculum using the template entitled "Planned Instruction," available on the district website.

_____ The primary textbook form(s).

_____ The appropriate payment form, in compliance with the maximum curriculum writing hours noted on the first page of this document.

Each principal and/or department chair has a schedule of First and Second Readers/Reviewers. Each Reader/Reviewer must sign & date below.

First Reader/Reviewer Printed Name_____

First Reader/Reviewer Signature_____ Date_____

Second Reader/Reviewer Printed Name_____

Second Reader/Reviewer Signature _____ Date_____