

## High School Course Description for **Principles of Engineering**

**Course Title:** Principles of Engineering

**Curricular Area:** Math/Science

**Course Number:** SCI702

**Length:** One year

**Grade Level:** 09 - 10

**Prerequisite:** Introduction of Engineering Design or approval of teacher.

**Co-requisites:** enrollment in Algebra or Geometry

**Meets a UC a-g Requirement:** Yes

**Meets NCAA Requirement:** No

**Meets High School Graduation Requirement for:**  
Computer Literacy/Elective Credit

### Course Description

Principles of Engineering (POE) is a high school-level survey course in engineering. The course exposes students to some of the major concepts that they will encounter in a postsecondary engineering course of study. POE gives students the opportunity to develop skills and understanding of course concepts through project, and problem-based learning. Used in combination with a team approach, project-based learning challenges students to continually hone their interpersonal skills, creative abilities, and problem solving skills based upon engineering concepts. It also allows students to develop strategies to enable and direct their own learning, which is the ultimate goal of education.

Some of the outcomes are an ability to: apply knowledge of mathematics, science and engineering; design and conduct experiments, as well as analyze and interpret data; design a system, component, or process to meet desired needs; function on multi-disciplinary teams; identify, formulate, and solve engineering problems; communicate effectively; have a broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.

**Alignment:** All PLTW high school courses units are aligned to the Common Core State Standards for Mathematics and English Language Arts and the Next Generation Science Standards.

**Alignment with CCSS and NGSS.** Students explore Each semester, a project will be assigned to address the following practices. The NGSS framework defines the following 8 scientific and engineering practices that students should engage in throughout their K-12 education.

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out Investigations
4. Analyzing and interpreting data
5. Using mathematics, information and computer technology, and computational thinking
6. Construction explanations and designing solutions
7. Engaging in argument from evidence and
8. Obtaining, evaluating, and communicating information.

**Alignment with common core standards for Literacy in Science:** This course is created to meet these requirements. Quarterly projects requiring research projects and writing over an extended time frame to allow summarizing research, reflecting on the implications of the topics and revision of the written document will be completed. The key concepts of these standards that students will need to meet are:

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### **Instructional Materials**

#### Required Textbook(s)

None – use PLTW course materials  
Autodesk Inventor, autocad, fusion  
software and user manuals

#### Supplemental Materials

TBD

Web Sites: Web sites will be identified and utilized to offer opportunities outside of class to explore topics in greater detail and greater depth.

**Grading will be more heavily weighted toward Projects and Tests/Quizzes to prepare the students for the focus of the course which requires students to perform in a test environment.**

### **Grading Criteria**

<u>Activities</u>	<u>Percentage</u>
Homework/Class work/projects.....	40%
Benchmark Tests/ Quizzes.....	40%
Final Examination .....	20%
<b>Total:</b>	<b>100%</b>

**Development Team:** This course of study was written and updated by Rodger Gorgart, GTHS. Materials were reviewed by Ramona Martinez, GTHS, Abraham Ward, BHS, and, Michael Gill, BHS.

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**Learning Experiences and Instruction:**

Teachers utilize the Direct Interactive Instruction model to introduce new skills and concepts that are essential to the grade level content standards, then reinforce and develop those skills each quarter with the goal of bringing students to mastery by the end of the fourth quarter. All instruction will be based on the “I do, We do, You do” scaffolding model with an emphasis on individual differentiation as needed. Teachers will use a variety of the following:

- Inquiry-based learning
- Engaged reading opportunities
- Think-pair-share
- Reciprocal teaching
- Cloze reading & writing
- Guided reading & writing
- Cognitive modeling
- Questioning strategies
- Graphic organizers/concept attainment
- Student-led groups
- Peer pairing
- Metacognitive learning: self-regulation, goal-setting, self-monitoring, and self-questioning

**Support for English Language Learners:**

Extra time or modified versions of assignments will be given. The District will provide a language assistant. Additional strategies will be developed through the Response to Intervention plans –such as:

- SDAIE strategies
- Texts/materials in first language.
- Flexible grouping
- Structured engagement
- Peer pairing
- Academic vocabulary development
- Realia

**Stretching the Lesson for GATE Students:**

Differentiated curriculum will be provided to challenge the student and provide the student with opportunities to develop their identified talent. Teachers will use a variety of the following:

- Independent study supplemented with mentoring/tutoring
- Compacting
- Acceleration
- Depth & Complexity icons
- Modified texts
- Modified assignments
- Flexible grouping
- Inquiry-based Learning
- Enriched materials and learning experiences

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## Course Outline:

Course outline:

Unit 1 Energy and Power

Time Days: 49 days

Lesson 1.1 Mechanisms (15 days):

Concepts Addressed in Lesson:

1. Engineers and engineering technologists apply math, science, and discipline-specific skills to solve problems.
2. Engineering and engineering technology careers offer creative job opportunities for individuals with a wide variety of backgrounds and goals.
3. Technical communication can be accomplished in oral, written, and visual forms and must be organized in a clear and concise manner.
4. Most mechanisms are composed of gears, sprockets, pulley systems, and simple machines.
5. Mechanisms are used to redirect energy within a system by manipulating force, speed, and distance.
6. Mechanical advantage ratios mathematically evaluate input work versus output work of mechanisms.

Performance Objectives Addressed in Lesson:

It is expected that students will:

- Differentiate between engineering and engineering technology.
- Conduct a professional interview and reflect on it in writing.
- Identify and differentiate among different engineering disciplines.
- Measure forces and distances related to mechanisms.
- Distinguish between the six simple machines, their attributes, and components.
- Calculate mechanical advantage and drive ratios of mechanisms.
- Design, create, and test gear, pulley, and sprocket systems.
- Calculate work and power in mechanical systems.
- Determine efficiency in a mechanical system.
- Design, create, test, and evaluate a compound machine design.

Lesson 1.2 Energy Sources (11 days):

Concepts Addressed in Lesson:

1. Energy source classifications include nonrenewable, renewable, and inexhaustible.
2. Energy source processes include harnessing, storing, transporting, and converting.
3. Energy often needs to be converted from one form to another to meet the needs of a given system.
4. An understanding of work, energy, and power is required to determine system efficiency.
5. An understanding of the basics of electricity requires the understanding of three fundamental concepts of voltage, current, and resistance.
6. The atomic structure of a material determines whether it is a conductor, an insulator, or a semiconductor.

Performance Objectives Addressed in Lesson:

It is expected that students will:

- Identify and categorize energy sources as nonrenewable, renewable, or inexhaustible.
- Create and deliver a presentation to explain a specific energy source.
- Summarize and reflect upon information collected during a visit to a local utility company.

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- Define the possible types of power conversion.
- Calculate work and power.
- Demonstrate the correct use of a digital multimeter.
- Calculate power in a system that converts energy from electrical to mechanical.
- Determine efficiency of a system that converts an electrical input to a mechanical output.
- Calculate circuit resistance, current, and voltage using Ohm's law.
- Understand the advantages and disadvantages of parallel and series circuit design in an application.

### Lesson 1.3 Energy Applications (10 days):

#### Concepts Addressed in Lesson:

1. Energy management is focused on efficient and accessible energy use.
2. System energy requirements must be understood in order to select the proper energy source.
3. Energy systems can include multiple energy sources that can be combined to convert energy into useful forms.
4. Hydrogen fuel cells create electricity and heat through an electrochemical process that converts hydrogen and oxygen into water.
5. Solar cells convert light energy into electricity by using photons to create electron flow.
6. Thermodynamics is the study of the effects of work, thermo energy, and energy on a system.
7. Thermo energy can transfer via convection, conduction, or radiation.
8. Material conductivity, resistance, and energy transfer can be calculated.

#### Performance Objectives Addressed in Lesson:

It is expected that students will:

- Test and apply the relationship between voltage, current, and resistance relating to a photovoltaic cell and a hydrogen fuel cell.
- Experiment with a solar hydrogen system to produce mechanical power.
- Design, construct, and test recyclable insulation materials.
- Test and apply the relationship between R-values and recyclable insulation.
- Complete calculations for conduction, R-values, and radiation.

### Lesson 1.4 Design Problem Energy and Power (13 days):

#### Concepts Addressed in Lesson:

1. Design problems can be solved by individuals or in teams.
2. Engineers use a design process to create solutions to existing problems.
3. Design briefs are used to identify the problem specifications and to establish project constraints.
4. Teamwork requires constant communication to achieve the desired goal.
5. Design teams conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions.

#### Performance Objectives Addressed in Lesson:

It is expected that students will:

- Brainstorm and sketch possible solutions to an existing design problem.
- Create a decision-making matrix for a design problem.
- Select an approach that meets or satisfies the constraints provided in a design brief.
- Create a detailed pictorial sketch or use 3D modeling software to document the best choice, based upon the design team decision matrix.
- Present a workable solution to the design problem.

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Unit 2 Materials and Structures

Time Days: 40 days

Lesson 2.1 Statics (14 Days):

Concepts Addressed in Lesson:

1. Laws of motion describe the interaction of forces acting on a body.
2. Structural member properties including centroid location, moment of inertia, and modulus of elasticity are important considerations for structure design.
3. Static equilibrium occurs when the sum of all forces acting on a body are equal to zero.
4. Applied forces are vector quantities with a defined magnitude, direction, and sense, and can be broken into vector components.
5. Forces acting at a distance from an axis or point attempt or cause an object to rotate.
6. In a statically determinate truss, translational and rotational equilibrium equations can be used to calculate external and internal forces.
7. Free body diagrams are used to illustrate and calculate forces acting upon a given body.

Performance Objectives Addressed in Lesson:

It is expected that students will:

- Create free body diagrams of objects, identifying all forces acting on the object.
- Mathematically locate the centroid of structural members.
- Calculate moment of inertia of structural members.
- Differentiate between scalar and vector quantities.
- Identify magnitude, direction, and sense of a vector.
- Calculate the X and Y components given a vector.
- Calculate moment forces given a specified axis.
- Use equations of equilibrium to calculate unknown forces.
- Use the method of joints strategy to determine forces in the members of a statically determinate truss.

Lesson 2.2 Material Properties (11 Days):

Concepts Addressed in Lesson:

1. Materials are the substances with which all objects are made.
2. Materials are composed of elements and are categorized by physical and chemical properties.
3. Materials consist of pure elements, compounds and mixtures and are typically classified as metallic, ceramic, organic, polymeric, and composite.
4. Material properties including recyclability and cost are important considerations for engineers when choosing appropriate materials for a design.
5. Material selection is based upon mechanical, thermal, electromagnetic, and chemical properties.
6. Raw materials undergo various manufacturing processes in the production of consumer goods.

Performance Objectives Addressed in Lesson:

It is expected that students will:

- Investigate specific material properties related to a common household product.
  - Conduct investigative non-destructive material property tests on selected common household products.
- Property testing conducted to identify continuity, ferrous metal, hardness, and flexure.
- Calculate weight, volume, mass, density, and surface area of selected common household product
  - Identify the manufacturing processes used to create the selected common household product.

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- Identify the recycling codes.
- Promote recycling using current media trends.

### Lesson 2.3 Material Testing (10 Days):

#### Concepts Addressed in Lesson:

1. Engineers utilize a design process and mathematical formulas to solve and document design problems.
2. Material testing aids in determining a product reliability, safety, and predictability in function.
3. Engineers perform destructive and non-destructive tests on material specimens for the purpose of identifying and verifying the properties of various materials.
4. Material testing provides a reproducible evaluation of material properties.
5. Tensile testing data is used to create a test sample stress strain curve.
6. Stress strain data points are used to identify and calculate sample material properties including elastic range, proportional limit, modulus of elasticity, elastic limit, resilience, yield point, plastic deformation, ultimate strength, failure, and ductility.

#### Performance Objectives Addressed in Lesson:

It is expected that students will:

- Utilize a five-step technique to solve word problems.
- Obtain measurements of material samples.
- Tensile test a material test sample.
- Identify and calculate test sample material properties using a stress strain curve.

### Lesson 2.4 Design Problem Materials and Structures (5 Days):

#### Concepts Addressed in Lesson:

1. Design problems can be solved by individuals or in teams.
2. Engineers use a design process to create solutions to existing problems.
3. Design briefs are used to identify the problem specifications and establish project constraints.
4. Teamwork requires constant communication to achieve the desired goal.
5. Design teams conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions.

#### Performance Objectives Addressed in Lesson:

It is expected that students will:

- Brainstorm and sketch possible solutions to an existing design problem.
- Create a decision making matrix for the design problem.
- Select an approach that meets or satisfies the constraints given in a design brief.
- Create a detailed pictorial sketch or use 3D modeling software to document the best choice, based upon your team decision matrix.
- Present a workable design solution.

## Unit3 Control Systems

Time Days: 46 days

### Lesson 3.1 Machine Control (16 days):

#### Concepts Addressed in Lesson:

1. Flowcharts provide a step by step schematic representation of an algorithm or process.

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2. Control systems are designed to provide consistent process control and reliability.
3. Control system protocols are an established set of commands or functions typically created in a computer programming language.
4. Closed loop systems use digital and analog sensor feedback to make operational and process decisions.
5. Open loop systems use programming constants such as time to make operational and process decisions.

Performance Objectives Addressed in Lesson:

It is expected that students will:

- Create detailed flow charts utilizing a computer software application.
- Create control system operating programs utilizing computer software.
- Create system control programs that utilize flowchart logic.
- Choose appropriate inputs and output devices based on the need of a technological system.
- Differentiate between the characteristics of digital and analog devices.
- Judge between open and closed loop systems in order to choose the most appropriate system for a given technological problem.
- Design and create a control system based on given needs and constraints.

Lesson 3.2 Fluid Power (15 days):

Concepts Addressed in Lesson:

1. Fluid power systems are categorized as either pneumatic, which utilizes gas, or hydraulic, which utilizes liquid.
2. Fluid power is possible because in a system of confined fluid, pressure acts equally in all directions.
3. The most basic components of all fluid power systems include a reservoir or receiver, a pump or compressor, a valve, and a cylinder.
4. Fluid power systems are designed to transmit force over great distances, multiply an input force, and increase the distance that an output will move.
5. Laws about the behavior of fluid systems and standard conventions for calculating values within fluid systems aid in the design and understanding of such systems.
6. Standard schematic symbols and conventions are used to communicate fluid power designs.

Performance Objectives Addressed in Lesson:

It is expected that students will:

- Identify devices that utilize fluid power.
- Identify and explain basic components and functions of fluid power devices.
- Differentiate between the characteristics of pneumatic and hydraulic systems.
- Distinguish between hydrodynamic and hydrostatic systems.
- Design, create, and test a hydraulic device.
- Design, create, and test a pneumatic device.
- Calculate values in a fluid power system utilizing Pascal's Law.
- Distinguish between pressure and absolute pressure.
- Distinguish between temperature and absolute temperature.
- Calculate values in a pneumatic system, utilizing the perfect gas laws.
- Calculate flow rate, flow velocity, and mechanical advantage in a hydraulic system.

Lesson 3.3 Design Problem Control Systems (15 days):

Concepts Addressed in Lesson:

1. Design problems can be solved by individuals or in teams.



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2. Engineers use a design process to create solutions to existing problems.
3. Design briefs are used to identify the problem specifications and to establish project constraints.
4. Teamwork requires constant communication to achieve the desired goal.
5. Design teams conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions.

Performance Objectives Addressed in Lesson:

It is expected that students will:

- Brainstorm and sketch possible solutions to an existing design problem.
- Create a decision-making matrix for a design problem.
- Select an approach that meets or satisfies the constraints provided in a design brief.
- Create a detailed pictorial sketch or use 3D modeling software to document the best choice, based upon the design team decision matrix.
- Present a workable solution to the design problem.

Unit 4 Statistics and Kinematics

Time: 30 Days

Lesson 4.1 Statistics (5 Days):

Concepts Addressed in Lesson:

1. Engineers use statistics to make informed decisions based upon established principles.
2. Visual representations of data analyses allow for easy distribution and understanding of data.
3. Statistics is based upon both theoretical and experimental data analysis.

Performance Objectives Addressed in Lesson:

It is expected that students will:

- Calculate the theoretical probability that an event will occur.
- Calculate the experimental frequency distribution of an event occurring.
- Apply the Bernoulli process to events that only have two distinct possible outcomes.
- Apply AND, OR, and NOT logic to probability.
- Apply Bayes theorem to calculate the probability of multiple events occurring.
- Create a histogram to illustrate frequency distribution.
- Calculate the central tendency of a data array, including mean, median, and mode.
- Calculate data variation, including range, standard deviation, and variance.

Lesson 4.2 Kinematics (10 Days):

Concepts Addressed in Lesson:

1. When working with bodies in motion, engineers must be able to differentiate and calculate distance, displacement, speed, velocity, and acceleration.
2. When air resistance is not taken into account, released objects will experience acceleration due to gravity, also known as freefall.
3. Projectile motion can be predicted and controlled using kinematics equations.
4. When a projectile is launched, velocity in the x direction remains constant; whereas, with time, the velocity in the Y direction in magnitude and direction changes due to gravity.

Performance Objectives Addressed in Lesson:

It is expected that students will:

- Calculate distance, displacement, speed, velocity, and acceleration from data.
- Design, build, and test a vehicle that stores and releases potential energy for propulsion.
- Calculate acceleration due to gravity given data from a free fall device.

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- Calculate the X and Y components of a projectile motion.
- Determine the angle needed to launch a projectile a specific range given the projectile initial velocity.

### Lesson 4.3 Design Problem Statistics and Kinematics (15 Days):

#### Concepts Addressed in Lesson:

1. Design problems can be solved by individuals or in teams.
2. Engineers use a design process to create solutions to existing problems.
3. Design briefs are used to identify the problem specifications and establish project constraints.
4. Teamwork requires constant communication to achieve the desired goal.
5. Design teams conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions.

#### Performance Objectives Addressed in Lesson:

It is expected that students will:

- Brainstorm and sketch possible solutions to an existing design problem.
- Create a decision-making matrix for their design problem.
- Select an approach that meets or satisfies the constraints provided in a design brief.
- Create a detailed pictorial sketch or use 3D modeling software to document the best choice, based upon the design team decision matrix.
- Present a workable solution to the design problem.

Engaging Students work as a class or in small groups over an extended period of time because of the in-depth nature of the chosen project or problem. Like adults trying to solve a problem, students in Project Lead The Way curricula are not restricted to one discipline but rather students delve into mathematics, science, technology, and English Language Arts. In the process, they are learning to apply knowledge that they will retain beyond the test and integrating school learning and real life.

Project-based learning as used in the Project Lead The Way curriculum:

- Helps students develop skills for living in a knowledge-based, technological society. Solving highly complex problems requires that students have both basic skills (reading, writing, science, and mathematics) and foundation skills (teamwork, problem solving, research, time management, information synthesizing, and using technology tools).
- Adds relevance to the learning. By bringing real-life context and technology to the curriculum through projects and problems, teachers encourage students to become independent workers, critical thinkers, and lifelong learners. If students learn to take responsibility for their own learning, they will form the basis for working cooperatively and effectively with others in their adult life.
- Challenges students to high rigor. Complex, messy problems cannot be solved without the application of reading, writing, mathematics, and science. When working toward a solution to a problem, students often find themselves acquiring higher levels of academic skills and knowledge than if they were taught them in isolation.
- Promotes lifelong learning. Exposure to activities, projects, and problems teaches students to take control of their learning, their first step as lifelong learners. It promotes metacognition and self-knowledge. Students generate strategies for solving problems by gathering, analyzing, and testing their data, sharing their findings with peers, and determining their solutions. Thus, students develop the abilities to work with peers, work in teams, and develop group skills.

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- Meets the needs of students with varying learning styles. Students are expected to experience and to use multiple modalities in the process of researching and solving a problem and then communicating the solutions. This active learning takes advantage of student differences in interests and learning styles, giving each student a chance to excel in various learning activities.

### Unit 1

#### Lesson 1 Mechanisms

##### 1.1.1 Simple Machines Investigation

In this activity you will explore the function and characteristics of the lever, wheel and axle, and pulley systems. You will see firsthand how simple machines manipulate energy to create a desired output.

##### 1.1.2 Simple Machines Investigation

In this activity students explore the function and characteristics of inclined planes, wedges, and screws.  
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##### 1.1.3 Gears

In this activity students learn about gear ratios and how they affect speed and torque within a system. Students also construct simple and compound gear systems

##### 1.1.4 Pulley Drives and Sprockets

In this activity Students learn about belt and pulley systems and sprocket and chain systems. Students calculate ratios of examples of both systems in a lab environment.

##### 1.1.5 Compound Machine Design Project

Students will design a compound machine using 4 of the 6 simple machines. Students brainstorm ideas in their groups of three, test and record data onto their engineering notebook, then model their design with autodesk inventor.

#### Lesson 2 Energy Sources

##### 1.2.1 Energy Sources

Students work in groups of two and choose an energy source that interest them. They create two presentation slides about their energy source and compile it with the other teams slides to create a class presentation on PowerPoint.

##### 1.2.2 Energy Distribution

As a class visit a local utility company to observe, ask questions, and formulate opinions.

##### 1.2.3 Electrical Circuits

This activity will provides students with an introduction to voltage, current, resistance, series circuits, parallel circuits, and Ohms Law. Teams construct circuits using various fischertechnik components. They use a digital multimeter to measure properties within the circuit.

##### 1.2.4 Circuit Calculations

In this activity students will gain experience applying Ohms law and Kirchhoffs voltage and current laws to circuits in order to gain understanding of circuit requirements and relationships between voltage, current, and resistance.

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### 1.2.5 Mechanical System Efficiency

In this activity students investigate an energy conversion system designed to change electrical energy into mechanical energy. Students determine the efficiency of the system by collecting data regarding power input and output. Remembering units and precision when recording data

## Lesson 3 Energy Application

### 1.3.1 Solar Hydrogen Systems

In this activity students will use a solar module to produce electricity. They use the electricity from the solar module to separate hydrogen from oxygen, harness the hydrogen, and then use the hydrogen as fuel. Although teams will complete this activity, each student should individually complete this entire document.

### 1.3.2 Fuel Cell Technology

In this activity teams of two to three will design and create an airboat that will be powered by a fuel cell.

### 1.3.3 Thermodynamics

Students investigate the effects of work, thermos-energy, and energy on a system, as in the case of the room with the door left open.

### 1.3.4 Renewable Insulation

Students design a renewable composite insulation material.

Design Constraints:

- Composite insulation material must produce high R-value.
- Composite insulation material must have overall uniform thickness less than or equal to one inch.
- Composite insulation material must have consistent internal composition.
- Individual insulation material(s) must be environmentally friendly.
- Individual insulation material(s) must be recyclable.
- Individual insulation material(s) must be economical.
- Composite insulation material dimensions must not exceed the overall dimensions of Heat box apparatus top.

## Lesson 4 Design Problem: Energy and Power

### 1.4.1 Introduction to Design Briefs

Students:

1. Define a Problem
2. Brainstorm
3. Research and Generate Ideas
4. Identify Criteria and Specify Constraints
5. Explore Possibilities
6. Select an Approach
7. Develop a Design Proposal
8. Make a Model or Prototype
9. Test and Evaluate the Design using Specifications
10. Refine the Design
11. Create or Make Solutions
12. Communicate Processes and Results

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### 1.4.2 Design Problem

Students design and create a renewable electrical energy generating and distribution system that utilizes wind, solar electric, and fuel cell energy conversion systems. Successful system design will demonstrate strategic power generation and distribution to meet the demand of both residential and industrial consumers. System design effectiveness will be based on the total number of successfully supplied industrial and residential consumers during a simulated 24 hour electrical energy demand cycle.

## Unit 2

### Lesson 2.1 Statics

#### 2.1.1 Centroids

In this activity students identify the centroid location of common and complex shapes using object symmetry, mathematics, and MDSolids software.

#### 2.1.2 Beam Deflection

Students determine the weight of one of your classmates using nothing more than a standard 2x4 and a measuring device. This activity will provide students with a better understanding of Moment of Inertia and how it can be used to determine the strength of beams.

#### 2.1.3 Free Body Diagrams

Free body diagrams show all forces that act upon a body or part. The information identified in a free body diagram can be used to determine whether a part is adequate.

#### 2.1.4 Calculating Force Vectors

Students calculate force vectors

#### 2.1.5 Calculating Moments

Students explore firsthand the relationship between forces and distances as they are applied to a rigid object. In this activity students will be required to keep a meter stick level as varying moment forces are applied to the meter stick.

#### 2.1.7 Calculating Truss Force

In this activity students make changes to given trusses to make them statically determinate. They then solve for the outside forces and forces at each pinned connection of trusses.

#### 2.1.8 Truss Design

In this activity students fabricate two small trusses upon which to perform destructive tests. Students then use the information that the teams gathered during destructive testing to design an improved truss system.

### Lesson 2.2 Material Properties

#### 2.2.1 Product Analysis

Categorizing materials and identifying their properties is an essential skill in the everyday life of an engineer.

#### 2.2.2 Manufacturing Processes

1. Investigate the manufacturing process(es) used to create the component that you modeled in Activity

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### 2.2.1 Product Analysis.

2. Create an electronic illustration outlining the manufacturing processes used to create the product from raw material to finished product.
3. Cite the source(s) that assisted you in identifying the manufacturing process(es) for your modeled part.

### 2.2.3 Recycling

In this project students learn about some of the more common symbols and standards or codes that regulate recycling. These codes serve to protect the environment as well as all living things. Students complete the tasks listed below as a team unless noted otherwise.

1. Document information, as necessary, while your teacher discusses the Recycling Materials presentation. You will document the information in Activity 2.2.3a Recycling Facts.
2. Answer the questions below for each product selected in Activity 2.2.1 Product Analysis. Record the information In Activity 2.2.3a Recycling Facts.

- Can the entire product be recycled?
- What parts of the product can be recycled? What is the composition of the material(s) for these parts?
- What parts of the product cannot be recycled? What is the composition of the material(s) for these parts?

1. Create a Product Development Lifecycle for each product selected. You can use the example provided in the Recycling Materials presentation as a template, if necessary.

2. Individually, you will access the National Recycling Coalition at the following URL: <http://www.nrc-recycle.org/recyclingcalculator.aspx>. Select the Recycling Calculator and take the virtual tour for each product available. Take notes in your engineer notebook.

3. The Environmental Protection Agency (EPA) has asked your team to create a promotional medium to encourage a selected age group to recycle at least two different products. Provide your teacher with the following information to be pre-approved.

- Age group
- Medium Sign, cartoon, song, commercial, bumper sticker, t-shirt, or packaging (i.e., cereal box or bag, milk jug, covering of glass container, soda can, container for trash bag dispenser, newspaper stand)
- Recyclable products of focus (i.e., wood, plastic, metal, glass, shoes, jeans, etc.)

## Lesson 2.3 Material Testing

### 2.3.1 Engineering Calculations

Students learn about the different terms and points on a stress-strain curve related to strengths of materials.??

You will apply this information to solve common engineering problems

1. Axial Stress
2. Shear Stress
3. Elastic Region Modulus of Elasticity
4. Elastic Limit
5. Proportional Limit
6. Yield Point
7. Strain Hardening
8. Hooke Law
9. Prismatic Bars
10. Elongation

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### 2.3.2 Tensile Testing

Tensile testing provides engineers with the ability to verify and establish material properties related to a specific material. This verification process is critical in insures the selected material will meet design specifications. In this activity you will interpret and make sample specific calculations related to the material properties of a dog bone test sample.

### Lesson 2.4 Design Problems Materials and Structures2.4.1 Structural Design

Students will design and create a bridge utilizing West Point Bridge Designer software. West Point Bridge Designer is a simplified and scaled down computer-aided design tool developed by Colonel Stephen Ressler, Department of Civil and Mechanical Engineering, U.S. Military Academy, West Point, New York. The software will allow you to apply engineering design, material science, and statics to the design of a truss bridge carrying a two-lane highway that spans a river bed.

### Unit 3 Control Systems

#### 3.1.1 Inputs and Outputs

Students experiment with different inputs and outputs. They learn how digital and analog inputs behave in addition to normally open and normally closed inputs.

#### 3.1.2 Flowcharting

In this activity students create flowcharts using ISO and ANSI standards to document different processes.

#### 3.1.3 Basic Programming

In this activity students construct a flowchart that will turn a motor on and off. They will also check the system to see if the flowchart performs as written. Students will be introduced to four Function Blocks: Start, Motor, Time Delay, and End.

#### 3.1.4 Branch Functions

In this activity students create programs that control a lamp based on the input from digital and analog inputs.

#### 3.1.5 Variable Functions

In this activity students create a program that controls the number of times a light turns on and off.

The ability to use variables in your program is a powerful feature. Variables are intermediate storage spots for specific information. At specific spots in your program, you can query the variable and instruct the program to act on that information. This information can be whether a particular switch has been pressed, whether a predetermined number has been reached, or how often a specific event has occurred.

The variable expression can represent anything that has a value. The variable can equal another variable, an analog input, or a number. We can manipulate the variables to produce the output we desire.

#### 3.1.6 Open and Closed Loop Systems

In this activity students design an open loop program to control a motor driven on a track. Then they will design a closed loop system utilizing feedback from both analog and digital inputs to control the motor.

#### 3.1.7 Machine Control Design

Students will work in teams of two or three. The procedure detailed below must be repeated for each problem solved.

As a team read the problem and record the requirements, constraints, components, or programming that must be used in your engineering journal.

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With your team, discuss and brainstorm possible solutions in your engineering journal.

Sketch two potential physical solutions and two potential program solutions. Be sure to include labels, descriptions, signatures, and dates on all sketches.

Create a final physical solution as a detailed sketch. Be sure to include labels, descriptions, signatures, and dates.

Create and test your design, making necessary modifications. Include descriptions throughout the program for clarification of the process.

Prepare the following for documentation:

- Title, date, class, and team names
- Image of the final solution
- Two potential physical sketches
- Two potential program sketches
- Final physical sketch
- Final program sketch
- Final program with descriptions
- Answers to the conclusion questions

**Problem 1: Start / Finish Line (Hardware Level 1 Software Le**

The Olympic committee would like your team to invent a control system for use with track and field running events. They want this device to automatically record the time and beep when the first runner crosses the start / finish line.

**Problem 2: Soccer Goal Light (Hardware Level 2 Software Level 3)**

Your team has been asked to design a control system for the local soccer field that can detect when the ball has entered the goal. A light must blink for 10 seconds after a goal is scored. Remember, the goalie and others will also be crossing the goal frequently. You may need to modify the ball so that your device can differentiate between the soccer ball and other objects.

**Problem 3: Delivery Vehicle Control (Hardware Level 2 Software Level 4)**

An assembly plant would like for your team to design a vehicle to drive in a straight line back and forth to deliver batches of parts. The vehicle must travel back and forth based on input from a potentiometer. For safety reasons you must include an emergency shutoff in case the vehicle travels too far in either direction.

**Problem 4: Cable Winding Mechanism (Hardware Level 3 Software Level 3)**

A telecommunications contractor needs your team to design a device that can accurately wind up a specific length of cable. A gear with holes around its perimeter is attached to the winding shaft. Design a device that will count how many times light flashes through the holes. In this way an operator can watch as the number climbs in order to stop the device when the appropriate amount of cable is on the spool. You must include an option to reset the machine back to zero so that it will be ready for subsequent use. The device can be stopped and started by physical inputs or by the computer.

**Problem 5: Elevator (Hardware Level 4 Software Level 4)**

A company would like to begin producing residential elevators. Your team must design the control system and a prototype of an elevator that can go between three floors in any combination. The prototype must include a set of three switches to represent each floor inside the elevator. Each floor the elevator stops at must have a call button and a set of three lights to indicate where the elevator is currently located. A built-in safety mechanism requires that the elevator normally rest on the ground floor and return to the ground floor after a user-determined period of nonuse.



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### Problem 6: Central Air System (Hardware Level 2 Software Level 4)

A research center is testing disease-fighting bacteria. The bacteria will only grow within a small range of temperature. Your team must design and model an enclosed system that controls temperature based on a user setting. The device should use an NTC resistor to monitor temperature. It is expected that the fan or lamp will almost always be running at some capacity but is not required to run constantly at full capacity. The program must track how long the lamp and fan run as well as any time that neither is running. Since the bacteria will be in an enclosure, a control panel utilizing lights should indicate whether the fan or lamp is running at any given time.

### Problem 7: Chocolate Cookie Topper (Hardware Level 4 Software Level 2)

A cookie factory needs your team to design a device that will put a chocolate drop on top of their peanut butter cookies. The machine must position a cookie on a separate device that will then move it into position for a dropper to descend and dispense the chocolate drop. The cookie with the chocolate drop should then move to another position where it will be placed with other finished cookies to await inspection and packaging.

## Lesson 3.2 Fluid Power

### 3.2.1 Fluid Power Applications

In teams of two or three, students choose a fluid power device that possesses at least the four major components. Teams will research the device, take pictures of the device, and interview someone knowledgeable about the device. Teams will share your findings with the class.

### 3.2.3 Pneumatic Brake Design

Using pneumatic components, students will create a braking system utilizing friction. A pneumatic cylinder will be used to create friction and will be controlled by a switch. To accomplish this students will design and create two subsystems. One is the braking system. The other is an air compressor which will power the system.??

### 3.2.5 Hydraulic Lift Design

This activity will allow students to determine why the sizes of two hydraulic cylinders allow force to be increased while work remains the same. Students will design a system to take advantage of the force increase from the hydraulic system in addition to another mechanism of students' choice to further increase mechanical advantage.

## Lesson 3.3 Design Problem-Control Systems

### 3.3.1 Design Problem

This problem will provide students with the opportunity to work together in teams of two or three. Students will design a solution to the stated problem. Study the design brief located below. Using the steps in the design process, your team will create a solution to the design problem.

## Unit 4 Statics and Kinematics

### Lesson 4.1 Statics

#### 4.1.1 Data Exploration

The understanding and manipulation of data allows decision making to be based on outcomes and even predictions. Statistical calculations can be theory-based. Calculations can also be established through manipulation of data collection or experimentation. To better understand the advantages and limitations of both processes of probability, statisticians must have understanding and experience working with both theory and experimental data.

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### Lesson 4.2 Kinematics

#### 4.2.1 Self-Propelled Vehicle Design

In this activity students will design a self-powered car. They gather data to determine distance, displacement, speed, velocity, and acceleration.

#### 4.2.2 Acceleration Due to Gravity

In this activity students test a device designed to determine the acceleration due to gravity by timing how fast an object falls through a set of phototransistors.

#### 4.2.3 Projectile Motion

### Lesson 4.3 Design Problem Statistics and Kinematics

#### 4.3.1 Design Problem

This problem will provide students with the opportunity to work together in teams of two to three. Students will design a solution to the stated problem.

The following assessment methods may be used in a variety of combinations by teachers and students in order to gather information on student understanding and instruction. This information should be used in the preparation and designing of future lessons or related activities. Teachers and students should consider the various assessment methods as a means to improve instruction and learning.

Academic prompts- Open-ended statements are questions posed to students resulting in either a written or oral response. An example of an academic prompt may be: Why is this solution the best fit for your problem? Is that the only possible answer? What do you need to do next? Or, statements such as, How would you explain (topic) to someone who wants to learn how (topic) works? Sometimes academic prompts are used to trigger reflection writing in journals. For example, reflect on your work today and complete the following: I was surprised that I discovered that.....; The most important thing I learned today is.....; I still have trouble with.....;Something I would really like to know is.....; I usually give up when.....; Sometimes I don't know what to do when I start a project. (Fill in thoughts); and I would rather work alone than in a group because.....

Checklists are used in a variety of forms, such as a listing of expected outcomes during an activity or lesson to a formal checklist used to document work included in a portfolio or journal.

Computerized assessment: A computerized assessment may be commercially prepared or self-developed. It is used as a tool to collect student attitudes, ideas, and concerns about their understanding of a skill, procedure, product, or concept. For example, students may go through a specially designed tutorial that concludes with them completing a formal questionnaire. Sometimes a scale rating is provided and students are asked to assess themselves based on how well they think they are doing in learning the new material.

Put a mark on the scale of where you believe you are

Now, put a mark on the scale of where you believe you belong

Concept mapping This assessment method allows teachers to gather data on students misconceptions. This is sometimes referred to as webbing. Students are directed to create a map of their thinking, linking related topics and topics that may or may not seem related. Students use sentences to explain their thinking and linking of words. This type of map enables a teacher to begin to understand the thought patterns of students on a variety of topics and procedures.

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**Demonstrations/Presentations** Students explain and communicate their understanding of key ideas, concepts, and principles and abilities of processes, techniques, and skills.

**Informal observations/discussions/conferences** Quite observation of students either individually or in groups for the purpose of assessing and gathering information on their understanding of concepts, disposition to learning, abilities, and working in groups.

**Other evidence:** Other evidence may be in the form of observations, work samples, or dialogues for example.

**Student self-reflection/assessment:** Often academic prompts are used to encourage students to look closely at their learning. Ask students to write about their effectiveness in a small group with questions such as, When I worked with my group, I was pleased with After working with this group, I now can improve by or When we work together again, we need to

**Performance assessment:** This involves identifying the desired skills and abilities students will need and then checking for their level of performance.

**Performance tasks:** involves presenting students with a technological task or project and then observing, interviewing, and looking at their solutions and products to assess what they actually know and can do.

**Portfolios:** a formal or informal collection of student work. A portfolio may be in many forms from photographs depicting student growth and understanding to a specialized electronic journal showing work completed over a period of time.

**Project/Product(s):** these may take many forms and are limited by time, resources, and imagination.

**Individual and group work**

**Rubric:** a rubric is an evaluative device based on the identified criteria taken from the content standards. Points or words are assigned to each phrase or level of accomplishment. This method gives feedback to the students about their work in key categories, and it can be used to communicate student's performance to parents and administrators. A rubric is designed to assess what and how well students understand the standards addressed in an activity.

**Student Interviews:** a student interview includes a planned sequence of questions, similar to a job interview. In contrast, a student conference suggests that a discussion with both student and teacher sharing ideas takes place.