

---

# Principles Of Engineering Detailed Outline

---

## Unit 1 Energy and Power

**Time Days: 115 days**

### Lesson 1.0 Introduction to POE (15 days)

1. Introduction to classroom expectations, Engineering notebook, Pretest of Analytical skills and classroom expectations.
2. Note: This is the third of the STEM classes. Students were expected to have the first two stem classes as prerequisites. Due to revamping of the curriculum, most students will not have these prerequisites. As a result, all lessons have been extended.

#### **Lesson 1.1 Mechanisms** (35 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** (21 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.
- 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** (20 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** (23 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's decision matrix.
- Present a workable solution to the design problem.

## Unit 2 Materials and Structures

### Time Days: 55 days

#### Lesson 2.1 Statics (19 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** (16 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.
- Identify the recycling codes.
- Promote recycling using current media trends.

## **Lesson 2.3 Material Testing** (15 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's 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's decision matrix.
- Present a workable design solution.

## **Unit A Aerospace**

### **Time Days: 45 days**

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. Prototypes are created and tested.
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. Further analysis of prototypes are done and improvements made

**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's decision matrix.
- Present a workable design solution.

## **Unit 3 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.
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.
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's 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.

Project Lead The Way, Inc.

Copyright 2010

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