Course Description
This introductory course explores the wide variety of careers in engineering and technology and covers various technology systems and manufacturing processes. Using activities, projects, and problems, students learn firsthand how engineers and technicians use math, science, and technology in an engineering problem-solving process to benefit people. The course also addresses concerns about social and political consequences of technological change.

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Course Rationale
The Park Hill School District offers Project Lead the Way (PLTW) at both of the high schools. PLTW is a four year sequence of courses which, when combined with traditional mathematics and science courses in high school, introduces students to the scope rigor and discipline of engineering prior to entering college.

Enduring Understandings
Mechanisms are the basic components of most devices consisting of simple or compound machines.
Materials are composed of elements and area categorized by physical and chemical properties.
Control systems are designed to provide consistent process control and reliability.
Engineers use statistics to make informed decisions based upon established principles.

Key Resources
PLTW curriculum and resources downloaded from the PLTW Virtual Academy.

Board Approval Date
May 24, 2012

Course Details
Unit: Energy and Power
Duration: 25 Day(s)
Unit Overview
Students will gain an understanding of mechanisms through the application of theory-based calculations accompanied by lab experimentation.

Enduring Understandings
Mechanisms are used to redirect energy within a system by manipulating force, speed, and distance.

Energy often needs to be converted from one form to another to meet the needs of a given system.

Energy systems can include multiple energy sources that can be combined to convert energy into useful forms.

Teamwork requires constant communication to achieve the desired goal.

Essential Questions
Why are there trade-offs of mechanical advantages related to design?
Why must efficiency be calculated and understood during the design process?
Describe the emerging technologies are or may be on the horizon that will provide energy more efficiently?
What does consensus mean, and how do teams use consensus to make decisions?

Example Assessment Items
Given a simple machine investigation students will identify the mechanical advantage trade offs related to design.
Given a compound machine investigation students will calculate the efficiency of a mechanism.
Through a research project students will identify the emerging technologies.
Through a power and energy design problem students will model various roles within a team.

Academic Vocabulary
Mechanism
Energy
Product Development Lifecycle
Team

Topic: Mechanisms
Duration: 4 Day(s)

Description
Mechanisms are the basic components of most machines and consist of gears, sprockets, pulley systems, and simple machines. The effective use and understanding of mechanisms has contributed to the improvement and development of technology and society for thousands of years. The first uses of mechanisms can be seen in the development of paleolithic tools used for hunting, gathering, and shelter construction. Today mechanisms can be found in everyday life from the basic components of a bicycle to the high-tech equipment used in the medical industry.

Engineers and scientists use mechanisms to manipulate speed, distance, force, and function to meet a wide range of design and application requirements. Engineering design applications can range from large-scale manufacturing equipment to small-scale electrical equipment found in automobiles, homes, and offices. Due to the wide range of applications involving mechanisms, it is important that designers and end users understand the characteristics, applications, and limitations of mechanisms.

Learning Targets
The student will identify and differentiate among different engineering disciplines.

The student will distinguish between the six simple machines, their attributes, and components.

The student will calculate work and power in mechanical systems.

Topic: Energy Sources
Duration: 5 Day(s)

Description
Technological systems would not be possible without energy, work, and power. Although it is common to hear these terms used interchangeably in conversation, each is different and crucial to creating, using, or maintaining a technological system.

Most power used today is stored or made available when needed. In the past power that was created was often used immediately. A windmill might have been used to pump water or irrigate a field. A water wheel's rotary motion might have been used to ground grains into flour. These systems did not consist of many steps or processes between the energy source and its end use. Today's society demands that energy be stored and transported reliably and predictably to the end user. When energy and power changes form, some of it is lost along the way to elements like friction and heat. Engineers are being challenged to find creative ways to generate energy and to make systems more efficient.

In this lesson students will learn that as energy and power are converted, losses in the system will occur. Students will understand that such losses affect the overall efficiency of the system.

Learning Targets
The student will create and deliver a presentation to explain a specific energy source.

The student will demonstrate the correct use of a digital multimeter.

The student will calculate circuit resistance, current, and voltage using Ohm's law.
### HS Principles of Engineering

**Pre-Engineering**  
**Grade(s) 10th - 12th, 1 Credit**  
**Elective Course**

#### Topic: Energy Applications  
**Duration: 5 Day(s)**

**Description**  
Today's consumer demands effective energy management. Consumers rely on efficient and accessible energy to power automobiles, homes, appliances, and electronics. National trends regarding energy management include appliance and home energy star ratings and the development of alternative and renewable energy sources. Energy conservation states that energy cannot be gained or destroyed but instead transferred from one form to another. Understanding how energy is transferred from one form to another allows engineers to design efficient applications utilizing energy. We know that many sources of energy won't last forever and that many sources have negative consequences on the environment. In the past individuals were forced to harness power that humans or animals created from the energy stored in food. Power could also be harnessed from surrounding resources like wind, flowing water, heat from the sun, or from combustible materials like wood.

This lesson is designed to provide students with an opportunity to investigate thermo energy and alternative energy applications. Students will explore and gain experiences relating to solar hydrogen systems and thermo energy transfer through materials.

**Learning Targets**
- The student will test and apply the relationship between voltage, current, and resistance relating to a photovoltaic cell and a hydrogen fuel cell.
- The student will design, construct, and test recyclable insulation materials.
- The student will complete calculations for conduction, R-values, and radiation.

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#### Topic: Design Problem- Energy and Power  
**Duration: 7 Day(s)**

**Description**  
Problems exist everywhere, and they vary in their degree of complexity and importance. Regardless of how problems are identified or from where they come, engineers use the design process to creatively and efficiently solve problems.

Solution to problems are sometimes created by teams. These teams work together, constantly communicating with each other, to create the desired product. The team may receive a problem for which they are expected to create a solution with very few constraints. This allows the team to think creatively and use their ingenuity.

In this lesson students will work in teams to solve a design problem that focuses on energy and power. They will use their prior knowledge to create a solution to the problem. It is important for students to understand that an acceptable solution is one that fits the constraints and specifications of the design brief.

**Learning Targets**
- The student will brainstorm and sketch possible solutions to an existing design problem.
- The student will select an approach that meets or satisfies the constraints provided in a design brief.

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#### Unit: Materials and Structures  
**Duration: 20 Day(s)**

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Unit Overview
Students will explore and gain an understanding of mechanisms through the application of theory-based calculations accompanied by lab experimentation, energy and power system conversion and thermodynamics and alternative energy applications.

Enduring Understandings
Static equilibrium occurs when the sum of all forces acting on a body are equal to zero.
Materials are composed of elements and area categorized by physical and chemical properties.
Material testing aids in determining a product's reliability, safety, and predictability in function.
Teamwork requires constant communication to achieve the desired goal.

Essential Questions
Why must designers and engineers calculate forces acting on bodies and structures?
How can an existing product be changed to incorporate different processes to make it less expensive and provide better performance?
Why is it critical for engineers to document all calculation steps when solving problems?
What does consensus mean, and how do teams use consensus to make decisions?

Example Assessment Items
Through calculating truss force students will gain understanding of static equilibrium effects on an object.
Using the research gathered the students will create a presentation on the product lifecycle.
The student engineers' notebooks check will provide a location and format for product documentation.
Through the structural design project the students will utilize team work to problem solve.

Academic Vocabulary
Consensus
Quality control
Material Properties
Static Equilibrium

Topic: Statics  Duration: 7 Day(s)

Description
Statics is the basis for the study of engineering mechanics and specifically rigid-body mechanics. Statics is concerned with the equilibrium of bodies that are at rest or that move at a constant velocity. Using measurements of geometry and force, Archimedes studied statics concepts in ancient Greece. Most of his work centered on simple machines for construction of buildings.

In this lesson students will learn how to identify and calculate forces acting on a body when it is in static equilibrium. Students will calculate internal and external forces of a truss. They will use this knowledge to design, build, and test their own truss designs.

Learning Targets
The student will create free body diagrams of objects, identifying all forces acting on the object.
The student will identify magnitude, direction, and sense of a vector.
The student will calculate the X and Y components given a vector.

Topic: Material Properties  Duration: 5 Day(s)

Description
Material properties are an important piece of information that engineers rely on when selecting the best material for a design solution. For instance in the 1988 Challenger space shuttle disaster, an o-ring seal failed, causing the death of seven astronauts. A misunderstanding about the limits of a material led to this accident.

Engineers often deal with the design of useful products that require materials with certain characteristics or properties. Complexity is increased when we consider that new materials are constantly being developed, and their application in new products drives economic growth. Engineers, therefore, must know how to make sense of the multitude of different materials available. When existing materials don't provide the desired properties, engineers create new materials called synthetics. Synthetic materials allow engineers to be extremely innovative when designing solutions to society's needs.

Sometimes the focus isn't on the creation of a new material, but on the creation of advanced recycling technology. Nike is one of several corporations assisting engineers with innovative recycling technology. For instance, Nike has worked with engineers to develop a method of recycling athletic shoes. The recycled shoes are ground up and used for the production of basketball courts, tracks, playgrounds, etc.

This lesson is designed to provide students with an opportunity to investigate the basic categories and properties of materials. Students will discover how products are made and how they are recycled once they are no longer useful.

Learning Targets
The student will conduct investigative non-destructive material property tests on selected common household product including testing for continuity, ferrous metal, hardness, and flexure.
The student will calculate weight, volume, mass, density, and surface area of selected common household product.
The student will identify the manufacturing processes used to create the selected common household product.
Material Testing

Material Testing is a critical process that determines whether a product is reliable, safe, and predictable in function. Material testing is basically divided into two major categories: destructive testing and nondestructive testing. Destructive testing is defined as a process where a material is subjected to a load in a manner that will ultimately cause the material to fail. Machines have been developed specifically to conduct destructive testing. These machines exert force on the sample and record information such as resulting deformation, the amount of stress that builds up inside the sample, elastic behavior, strength, etc. When non-destructive testing is performed on a material, the part is not permanently affected by the test. The part is usually still serviceable. The purpose of non-destructive testing is to determine whether the material contains imperfections.

Over many years, tests have been developed for measuring the common properties of engineering materials, including acoustical, electrical, magnetic, physical, optical, and thermal properties. But why is material testing so significant?

Learning Targets
- The student will utilize a five-step technique to solve word problems.
- The student will tensile test a material test sample.
- The student will identify and calculate test sample material properties using a stress strain curve.

Design Problem- Materials and Structures

Students have been exposed to the different types and properties of materials in previous lessons. They have also tested and been made aware of the importance of choosing the right material in regards to safety and environmental impacts. Students will now apply what they have learned to a design problem using the design process as their guide.

Problems exist everywhere, and they vary in their degree of complexity and importance. Regardless of how problems are identified or from where they come, engineers use the design process to creatively and efficiently solve problems.

Problems are sometimes solved by teams. These teams work together, constantly communicating with each other, to create the desired product. The team may receive a problem for which they are expected to create a solution with very few constraints, with allows them to be quite creative.

In this lesson students will work in teams to solve a materials design problem. They will use their prior knowledge to solve the problem. It is important for students to understand that an acceptable solution is one that fits the constraints and specifications of the design brief.

Learning Targets
- The student will select an approach that meets or satisfies the constraints given in a design brief.
- The student will present a workable design solution.

Control Systems

Unit: Control Systems

Duration: 23 Day(s)
HS Principles of Engineering
Pre-Engineering

Unit Overview
Students will explore and gain an understanding of mechanical process control using computer software and hardware, pneumatic and hydraulic power components related to the manipulation of work and power and design problems related to control systems.

Enduring Understandings
Control systems are designed to provide consistent process control and reliability.

Fluid power systems are designed to transmit force over great distances, multiply an input force, and increase the distance that an output will move.

Design teams conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions.

Essential Questions
What are the advantages and disadvantages of using programmable logic to control machines versus monitoring and adjusting processes manually?
Can you identify devices or systems that do not use fluid power that might be improved with the use of fluid power?
Why are Pascal's Law, the perfect gas laws, Bernoulli's Principle, and other similar rules important to engineers and designers of fluid power systems?

Example Assessment Items
Through basic input and output programming the students will understand programmable logic machine controlling.
Upon completion of the fluid power practice problems students' will comprehend Pascal's law and Bernoulli's Principle's effect on fluid power systems.
Using the design problem students' will demonstrate the utilization of fluid power as a problem solving mechanism.

Academic Vocabulary
Algorithm
Fluid Power
Solid Modeling

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<th>Topic: Machine Control</th>
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<td>Description</td>
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<td>From iPods to automobiles, we use computers every day. Computers are sometimes so small and hidden that we don't even realize we're using a computer. Many of us never think about automobiles containing computers; however, today's vehicles are packed with tiny computers that regulate and monitor systems such as air bags and cruise control. How much more control will computers take from drivers in the future? What will drivers be willing to let their cars do for them? With GPS systems that provide routes and track speed, what are the barriers for autonomous cars?</td>
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In this lesson students will learn how to control mechanical processes using computer software and hardware. The software communicates through a hardware interface with different inputs and outputs.

Learning Targets
The student will create control system operating programs utilizing computer software.
The student will create system control programs that utilize flowchart logic.
The Students will differentiate between the characteristics of digital and analog devices.

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<th>Topic: Fluid Power</th>
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<td>The primary components and principles of fluid power systems allow industry and machinery to achieve a multitude of tasks. Although fluid power has been used throughout history, it is far from obsolete. In fact fluid power provides exceptional power advantages. Fluid power technologies impact areas from commercial farm machinery to respirator equipment used to provide oxygen to medical patients. Fluid power possesses some very important characteristics. Fluid power has a large amount of power per unit volume or mass. This is generally referred to as power density. Systems are able to multiply force. Another advantage is that fluid can change direction quickly without damaging a system. This allows engineers and designers to utilize flexible piping and hoses to transfer fluid in a variety of directions.</td>
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In this lesson students will be introduced to both pneumatic and hydraulic power. They will learn the basic components of each system and how they are designed to manipulate work and power. Students will see a clear connection to the previous lesson applications regarding manipulating work and power.

Learning Targets
The student will differentiate between the characteristics of pneumatic and hydraulic systems.
The student will calculate values in a fluid power system utilizing Pascal's Law.
The student will calculate flow rate, flow velocity, and mechanical advantage in a hydraulic system.

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<th>Topic: Design Problem-Control Systems</th>
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Learning Targets
The student will differentiate between the characteristics of pneumatic and hydraulic systems.
The student will calculate values in a fluid power system utilizing Pascal's Law.
The student will calculate flow rate, flow velocity, and mechanical advantage in a hydraulic system.
Description
In previous lessons students were introduced to a variety of ways to transfer energy through mechanical systems. Some of those systems included simple machines, gear systems, pulley systems, sprocket systems, and fluid power. They also learned how to control different mechanisms by writing programs utilizing control software.

Students will now apply what they have learned to a design problem using the design process as their guide.

Problems exist everywhere, and they vary in their degree of complexity and importance. Regardless of how problems are identified or from where they come, engineers use the design process to creatively and efficiently solve problems.

Solutions to problems are sometimes created by teams. These teams work together, constantly communicating with each other, to create the desired product. The team may receive a problem for which they are expected to create a solution with very few constraints. This allows the team to think creatively and use their ingenuity.

In this lesson students will work in teams to solve a design problem that focuses on control systems. They will use their prior knowledge to create a solution to the problem. It is important for students to understand that an acceptable solution is one that fits the constraints and specifications of the design brief.

Learning Targets
The student will create a detailed pictorial sketch or use 3D modeling software to document the best choice, based upon the design team's decision matrix.

The student will present a workable solution to the design problem.

Unit: Statistics and Kinematics
Duration: 15 Day(s)

Unit Overview
Students will explore and gain an understanding of the processes of gathering, organizing, interpreting, and formulating an understanding of data.

Enduring Understandings
Statistics is based upon both theoretical and experimental data analysis. When working with bodies in motion, engineers must be able to differentiate and calculate distance, displacement, speed, velocity, and acceleration.

Essential Questions
Why is it crucial for designers and engineers to utilize statistics throughout the design process? Why is process control a necessary statistical process for ensuring product success?
How are the relationships between distance, displacement, speed, velocity, and acceleration valuable used in the study of Kinematics?

Example Assessment Items
Reliability
Acceleration

Academic Vocabulary
Reliability
Acceleration

Topic: Statistics
Duration: 3 Day(s)

Description
Statistics allow for informative decision-making formulated from theoretical and experimental data analysis. Data analysis has become so integrated into today's modern lifestyles that most individuals are unaware of its role in their daily lives. This can be seen in reality shows that base results upon contestants' national popularity and voting results. Box office movie rankings are based on weekend ticket sales. At an individual level, people use statistics for calculating gas mileage, green calculations such as average energy consumption, insurance rates, and calculating class rank and GPA.

In this lesson students will learn the processes of gathering, organizing, interpreting, and formulating an understanding of data.

Learning Targets
The student will calculate the experimental frequency distribution of an event occurring.

The student will create a histogram to illustrate frequency distribution.

The student will calculate the central tendency of a data array, including mean, median, and mode.

Topic: Kinematics
Duration: 5 Day(s)
Description
While statics is concerned with bodies at rest or moving at a constant acceleration, dynamics is concerned with the accelerated motion of bodies. The study of dynamics developed much later than statics because of the need for accurate measurement of time. Galileo Galilei was a major early contributor, performing experiments with pendulums and falling bodies. Newton's development of the three fundamental laws of motion was the springboard for increased understanding and work by other scientists. The two major braches of dynamics are kinematics, which is concerned with the geometric aspects of motion, and kinetics, which is concerned with the forces causing the motion.

In this lesson students will create a vehicle to learn important aspects of motion and freefall. Students will perform an activity that will help them to understand the kinematics concepts involved in projectile motion.

Learning Targets
The student will design, build, and test a vehicle that stores and releases potential energy for propulsion.

The student will calculate the X and Y components of a projectile motion.

The student will determine the needed angle to launch a projectile a specific range given the projectile's initial velocity.

Topic: Design Problem-Statistics and Kinematics

Description
In previous lessons students were introduced to statics and forces on structures. They were also exposed to kinematic equations regarding projectiles. Students created different devices that they used to apply the knowledge using real-world situations.

Problems exist everywhere, and they vary in their degree of complexity and importance. Regardless of how problems are identified or from where they come, engineers use the design process to creatively and efficiently solve problems.

Solutions to problems are sometimes created by teams. These teams work together, constantly communicating with each other, to create the desired product. The team may receive a problem for which they are expected to create a solution with very few constraints. This allows the team to think creatively and use their ingenuity.

In this lesson students will work in teams to solve a design problem that will require them to use their prior knowledge to create a solution to the problem. It is important for students to understand that an acceptable solution is one that fits the constraints and specifications of the design brief.