PLTW Engineering
Engineering Essentials | Course Outline

Learn how you can improve the world with Engineering Essentials!

Explore how engineers make a difference and improve lives, while using modern engineering tools, such as geographic information systems, 3-D solid modeling software, and prototyping equipment. Work on your own and as part of a team to develop solutions to community and global challenges that the next generation of engineers will face.

Engineering Essentials is a full-year course designed to be a high school student's first exposure to the PLTW Engineering program and is appropriate for students in grades 9-12. In Engineering Essentials, students explore the work of engineers and their role in the design and development of solutions to real-world problems.

The course introduces students to engineering concepts that are applicable across multiple engineering disciplines and empowers them to build technical skills through the use of a variety of engineering tools, such as geographic information systems (GIS), 3-D solid modeling software, and prototyping equipment. Students learn and apply the engineering design process to develop mechanical, electronic, process, and logistical solutions to relevant problems across a variety of industry sectors, including health care, public service, and product development and manufacturing.

Using PLTW's activity-, project-, problem-based (APB) instructional approach, students advance from completing structured activities to solving open-ended projects and problems that provide opportunities to develop planning and technical documentation skills, as well as in-demand, transportable skills, such as problem solving, critical and creative thinking, collaboration, communication, and ethical reasoning. The last is particularly important as the course encourages students to consider the impacts of engineering decisions.

Through both individual and collaborative team activities, projects, and problems, students create solutions to problems as they practice common engineering design and development protocols, such as experimental design, testing, project management, and peer review. In addition, the course emphasizes statistical analysis and mathematical modeling – computational methods that are commonly used in engineering problem-solving.

The following is a summary of the units of study that are included in the course. The course requires a rigorous pace, and it is likely to contain more material than a skilled teacher new to the course will be able to complete in the first iteration. Building enthusiasm for and a real understanding of role, impact, and practice of engineering is a primary goal of the course.

Engineering Essentials Unit Summary

Unit 1 Inclined to Design
Unit 2 Make it Move
Unit 3 Power it Up
Unit 4 Make a Plan

Unit 1: Inclined to Design

Unit 1 introduces students to foundational cross-disciplinary engineering concepts, empowers them to develop and strengthen their transportable skills, and exposes them to global engineering challenges that the next generation will face. Throughout the unit, students will imagine themselves as engineers and envision a future in which they can make a difference in the world.

Students learn the engineering design process and have the opportunity to apply that process to multiple projects and problems throughout the unit as they improve their communication and collaboration skills. They reflect on design problems and solutions from a systems perspective and investigate ethics as they consider the impact of engineering decisions. Students also learn basic skills associated with project management, including developing a project schedule and critical path analysis to help them plan and track progress during larger projects. They use a geographic information system as a tool to help identify, define, and solve problems using spatial information.

Inclined to Design

Lesson 1.1 Engineers and Engineering
Lesson 1.2 Systems and the Engineering Design Process
Lesson 1.3 Product Design
Lesson 1.4 Natural Disaster Relief Center

Lesson 1.1 Engineers and Engineering
In Lesson 1.1, students consider their perception of engineers and engineering. They learn brainstorming techniques, define mindset characteristics that are important to success in engineering, and identify their own personal traits that align with engineering. Using their personal engineering perspective, students reflect individually and within a team on global engineering challenges, choose a challenge that they feel is the most important challenge facing their generation, and gather evidence to make a persuasive presentation to convince an audience of its importance.

Lesson 1.2 Systems and the Engineering Design Process
Students are introduced to the concepts of systems and systems thinking as a mindset used to consider the interconnectedness of our world and the far-reaching impacts of engineering decisions. Students use geographic information systems to investigate natural and man-made systems to inform design decisions.

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Lesson 1.3 Product Design
In this lesson, students explore a variety of ethical perspectives, then analyze a scientific experiment and learn to design experiments in order to gain specific knowledge and understanding. The lesson also introduces the concept of sustainability as students consider the impacts and trade-offs necessary in engineering decision-making, and discuss the ethical implications of those decisions.

Lesson 1.4 Natural Disaster Relief Center
In the final lesson of Unit 1, students develop basic skills necessary to create maps and layers in a geographic information system in order to address the unit problem. Students work independently and as part of a team to apply the knowledge and skills developed throughout the unit to design a relief center system to serve a community devastated by a natural disaster.

Unit 2: Make it Move

In Unit 2, students apply mechanical and mathematical concepts to design solutions to engineering problems. They develop multiple types of models to represent aspects of real objects/phenomena, including conceptual models, graphic models (drawings), 3-D solid computer models, physical models, and mathematical models, and begin to understand the inherent limitations of each. These models are used to define, test, and communicate design ideas and mechanical solutions.

Students build on skills and knowledge gained from Unit 1 and have additional opportunities to apply the design process, experimental design, systems thinking, and project management to design and test mechanical solutions to improve people's lives. Students continue to develop their collaboration and communication skills and consider the impact of their solution on people and society.

Make it Move

Lesson 2.1 Statics
Lesson 2.2 Mechanical Advantage
Lesson 2.3 Mechanical Systems

Lesson 2.1 Machines
In this lesson, students review simple and compound machines as they develop and use models to represent objects and systems. Students employ experimental design to inform development of a model that represents important aspects of a phenomenon, and develop a protocol to test the function of a compound machine compared to design criteria. Students continue to develop skills in using 3-D design software to model objects. Finally, students work collaboratively using a design process to develop a working mechanical model that incorporates a 3D printed part.

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Lesson 2.2 Mechanical Motion
Students are introduced to – and practice determining – quantities related to mechanical systems, including gear ratio, and mechanical advantage. They explore various types of motion and methods to convert one type of motion to another (e.g., linear motion to rotation). Students apply a design process and employ the use of conceptual, computer, mathematical, and physical models and the concept mechanical advantage to reduce the amount of work we do.

Lesson 2.3 Mechanical Systems
Students apply prior learning and technical skills, a design process, experimental design, systems thinking, and project management to design and test a mechanical solution to improve people's lives. In the process, students continue to improve their collaboration and communication skills.

Unit 3: Power it Up

In Unit 3, students discover the foundation of all modern electronic devices, such as cellular phones, MP3 players, and high-definition televisions. Students learn how to use digital circuits to develop electronic solutions that improve people's lives.

Students review energy forms and the transfer of energy into the form of electricity. They investigate the fundamental circuit components, concepts, equipment, and skill set associated with circuit design. Students use graphical, computer, and physical models to represent and investigate analog circuits. Students design experiments to determine the relationship among voltage, current, and resistance in circuits. They are then introduced to the basics of digital signals, starting with truth tables and logic expressions, then apply the design process to design, simulate, and breadboard a circuit to accomplish a goal. Finally, students collaborate and work with other teams as they apply skills and knowledge learned in prior units to develop a proof of concept prototype for an electromechanical system.

Power it Up

Lesson 3.1 Energy Conversion
Lesson 3.2 Logic
Lesson 3.3 Electromechanical Systems

Lesson 3.1 Energy Conversion
This lesson begins by examining the importance of energy and electricity in our lives. Students view a video timeline of the impact of electricity on society and learn about how energy is converted to electricity and transferred to our homes and businesses – where it is transformed into other forms of energy for our use. Students examine local and global electrical usage. In addition, students are introduced to electrical circuits and various models used to represent electrical circuits, including physical models, schematics, and computer simulations. Students use technology to measure voltage, current, and resistance, and experiment to determine a mathematical model to represent the relationship among those quantities in a circuit.

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Lesson 3.2 Logic
In this lesson, students gain knowledge and skills necessary to design and build circuits – starting with truth tables and logic expressions – used to represent the input and output of a logic gate, the basic building block of digital circuits. Students investigate how circuits work, learn to represent circuits with truth tables and logic expressions, and build physical models using integrated chips. Students also learn the basics of programming a microcontroller to electronically control products and devices through data collection, sensing, and actuation of physical components. Using a microcontroller to gather data from multiple sensors, students collaboratively design an electromechanical device to perform a function.

Lesson 3.3 Electromechanical Systems
Students work in teams to develop a proof of concept design and prototype of an electromechanical system to perform specific functions. This problem provides opportunities for students to continue building skills in communication, collaboration, and ethical engineering practice.

Unit 4: Make a Plan

In Unit 4, students investigate issues related to population growth and development, and use geographic information systems as tools to define, model, and solve engineering challenges that result from development.

Make a Plan

Lesson 4.1 Urban Design
Lesson 4.2 Maps as Models
Lesson 4.3 The Sustainable Urban Environment
Lesson 4.4 A Better Place

Lesson 4.1 Urban Design
In Lesson 4.1, students predict global population growth and investigate impacts and challenges of population growth and urbanization. They investigate urban subsystems that allow high-density population centers to function and are introduced to the concept of urban planning. The ideas of risk and trade-offs in engineering design are discussed, and students consider risks and rewards related to potential solutions to urban infrastructure problems. In collaborative teams, students apply their learning as they design a city redevelopment plan and consider the environmental, social, and economic impacts of their design.

Lesson 4.2 Maps as Models
This lesson provides opportunities to investigate a variety of online geographic information system tools that support urban planning and engineering design (e.g., determining flood probabilities, locating traffic controls, conducting feasibility studies for new waste disposal facilities). Students practice geospatial data collection strategies and produce maps to model geospatial information.

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Lesson 4.3 The Sustainable Urban Environment
In Lesson 4.3 students learn additional geographic information systems development skills and use GIS to consider sustainable solutions to modern challenges, investigate population density, and apply low-impact development controls to reduce stormwater runoff at their school.

Lesson 4.4 A Better Place
In this lesson students apply the engineering design process and prior learning related to systems thinking, modeling, and project management. Students work in collaborative teams to develop a solution to improve the safety and well-being of the citizens of a local community.