

Unit 3: Energy in Action (6 Weeks)

Content Area: **STEM**
Course(s):
Time Period: **Full Year**
Length: **6 Weeks**
Status: **Published**

Unit 3: Energy in Action (6 Weeks)

Unit Rationale

In this unit students explore energy more deeply and useful applications of it through electrical circuits, fluids, and kinematics. They begin the unit by exploring the relationships between circuit components, derive formulas, and apply their understanding to solve problems. Students then move into the world of fluids, the deep mathematical principles that govern them, and apply their knowledge to design their own fluid power system. They end the unit implementing their understanding of energy in motion through kinematics. Students also continue their career exploration journey by examining the financial aspects of attending a postsecondary institution.

Essential Questions

- 3.1 - 1 How do you differentiate between circuit types?
- 3.1 - 2 How do you model electrical circuits?
- 3.1 - 3 How do you test circuit parameters?
- 3.1 - 4 What are the mathematical relationships between circuit parameters?
- 3.1 - 5 Why are Kirchhoff's Laws important to engineers and designers of electrical circuits?
- 3.2 - 1 What impact does fluid power have on our everyday lives?
- 3.2 - 2 What devices or systems might be improved with the use of fluid power?
- 3.2 - 3 What are the similarities and differences of mechanical advantage in simple machines?
- 3.2 - 4 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?
- 3.3 - 1 How do we graph and analyze motion?
- 3.3 - 2 What equations govern how objects move?
- 3.3 - 3 How do we predict where projectiles will land?

Pre-Assessments

Catapult design using given materials and measuring out mass using a gram scale and rice.

Instructional Plan

MODULE 1

LESSON 3.1

Electrical Circuits In Lesson 3.1, students explore the basic components of electrical circuits and model them through a hands-on introduction. They then explore the basic elements of electricity and electrical circuits and build simple circuits with breadboards and online simulations. Students collect data to derive the formula for Ohm's Law then apply their understanding of Ohm's Law to solve problems. They then move into a comparison between series and parallel circuits and explore their similarities and differences. Students continue hands-on breadboarding and simulations to derive Kirchhoff's voltage and current laws. They end the lesson with a final project that applies all the skills acquired to design and build their own functional safe.

Activity 3.1.1

Illumination Creation: In this activity, you'll explore a simple electrical circuit using an incandescent bulb similar to the design Edison patented more than 100 years ago.

Student Learning Intentions (SLI) WALT: (We are learning to...)

- Explore the relationships between various circuit components.
- Draw diagrams that show proposed electrical configurations.
- Generate explanations about correct and incorrect electrical configurations.
- Contribute to the efforts of a team.

Student Learning Strategies

Journaling
Collaboration
Cooperative Learning
APB Approach (Activities, Projects, Problems)
Class Discussions
- Working Circuit

Success Criteria

Formative Assessment (drives instructional decisions)

- Properly Labeled Circuit Diagram

Activities and Resources

- See Above

Activity 3.1.2

Ohm's Law Lab: Throughout this activity, you will construct circuits using a breadboard, and you will model circuits using Autodesk® Tinkercad®. Reference the Tinkercad Basics video along with [Tinkercad Circuit Tips](#) and [Breadboards](#) topics as needed.

Student Learning Intentions (SLI) WALT: (We are learning to...)

- Build functioning electrical circuits.
- Model functioning electrical circuits using Autodesk® Tinkercad®.
- Test circuit parameters using a digital multimeter.
- Determine the mathematical relationship between voltage, current, and resistance (Ohm's Law).

Student Learning Strategies

Journaling
Collaboration
Cooperative Learning
APB Approach (Activities, Projects, Problems)
Class Discussions

Success Criteria

- Working Circuit

Formative Assessment (drives instructional decisions)

- 3D Circuit

- Properly labeled Circuit Diagram

Activities and Resources

- OHM's Law Measurements

- See Above

Suggested Modifications

See Activity 1.1.1

Activity 3.1.3

Series vs. Parallel Circuits: In this activity, you will use Autodesk® Tinkercad® to model both series and parallel circuits and determine whether the mathematical relationships you identified in Activity 3.1.2 Ohm's Law Lab still apply.

Student Learning Intentions (SLI) WALT: (We are learning to...)

- Differentiate between series and parallel circuits.
- Solve for voltage, current, and/or resistance in series and parallel circuits.

Student Learning Strategies

Journaling
Collaboration
Cooperative Learning
APB Approach (Activities, Projects, Problems)
Class Discussions
- Working Circuit

Success Criteria

- 3D Circuit
- Properly Labeled Circuit Diagram
- OHM's Law Measurements

Formative Assessment (drives instructional decisions)

- See above

Activities and Resources

Suggested Modifications

See Activity 1.1.1

Activity 3.1.4

Equivalent Resistance: In this activity, you'll model more circuits to determine these mathematical relationships.

Student Learning Intentions (SLI) WALT: (We are learning to...)

- Solve for equivalent resistance in series and parallel circuits.

Student Learning Strategies

Journaling
Collaboration
Cooperative Learning
APB Approach (Activities, Projects, Problems)

Success Criteria	Class Discussions - Working Circuit - 3D Circuit
Formative Assessment (drives instructional decisions)	- OHM's Law Measurements
Activities and Resources	- See above
Suggested Modifications	See Activity 1.1.1

Activity 3.1.5

Kirchhoff's Law Lab: In this activity, you'll walk in the footsteps of Gustav Kirchhoff and design, test, and analyze a complex circuit to develop rules that govern current and voltage. So, are you ready to embark on this electrifying journey of discovery?

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none"> • Experimentally validate Kirchhoff's laws.
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions - Working Circuit
Success Criteria	- 3D Circuit
Formative Assessment (drives instructional decisions)	- Kirchoff's Law Meaurements
Activities and Resources	See above.
Suggested Modifications	See Activity 1.1.1

Activity 3.1.6

Volt Vaults: In this project, you and your team will submit a prototype to Volt Vaults. The physical prototype

vault should be fabricated using common consumables (like cardboard and tape), but all the electronics must be fully functional. Your design will require a combination circuit to satisfy all requirements from Volt Vaults.

Student Learning Intentions (SLI) WALT: (We are learning to...)

- Apply knowledge of electrical circuits to solve an authentic design problem.

Student Learning Strategies

Journaling
 Collaboration
 Cooperative Learning
 APB Approach (Activities, Projects, Problems)
 Class Discussions

Success Criteria

- Working Circuit

Formative Assessment (drives instructional decisions)

- 3D Circuit

- Working Prototype

Activities and Resources

See above.

Suggested Modifications

See Activity 1.1.1

LESSON 3.2

Fluid Power In this lesson, students learn the fundamentals of hydraulic and pneumatic fluid power. They begin by exploring the differences between hydraulic and pneumatic systems as well as common mathematical formulas that support fluid power engineering. Students then apply these concepts to complete a problem set surrounding fluid power mathematics. This lesson concludes with students designing and building their own working hydraulic system.

Activity 3.2.1

Under Pressure: In this activity, you will learn about the physics of fluid power by studying hydraulic and pneumatic systems. Then, in Activity 3.2.2 Mathematics of Pressure, you will use these concepts and mathematical approaches to solve authentic engineering problems.

Student Learning Intentions (SLI) WALT: (We are learning to...)

- Identify devices that use fluid power.
- Explain the basic components and functions of

fluid power devices.

- Differentiate between hydraulic and pneumatic systems.
- Apply flow rate, pressure, and fluid power equations to engineering problems.

Student Learning Strategies

Journaling
Collaboration
Cooperative Learning
APB Approach (Activities, Projects, Problems)
Class Discussions

Success Criteria

- Properly setup scenario
- Proper measurement tool alignment

Formative Assessment (drives instructional decisions)

- Properly formatted Data

Activities and Resources

- See Above

Suggested Modifications

See Activity 1.1.1

Activity 3.2.2

Mathematics of Pressure: In Activity 3.2.1 Under Pressure, you learned several calculations related to pneumatic and hydraulic fluid power. In Activity 3.2.2, you will complete several practice problems to help you gauge your current level of knowledge. For assistance at any point, you can refer to the previous activity, the [PLTW Engineering Formula Sheet](#), and your PLTW Engineering Notebook.

Student Learning Intentions (SLI) WALT: (We are learning to...)

- Practice problem-solving skills and logical reasoning.
- Apply fluid power equations to engineering problems.

Student Learning Strategies

Journaling
Collaboration
Cooperative Learning
APB Approach (Activities, Projects, Problems)
Class Discussions

Success Criteria

- Properly setup scenario
- Proper measurement tool alignment

Formative Assessment (drives instructional decisions)	- Properly formatted Data
Activities and Resources	- See Above
Suggested Modifications	See Activity 1.1.1

Activity 3.2.3

Pressurized Power: In this project, you and a partner will design and build a hydraulic fluid power device using plastic syringes, plastic flex tubing, water, and various consumable items. During this activity, you will gain a better understanding of how fluid power systems work.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none"> • Apply knowledge of fluid power to solve an engineering design problem.
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions - 3D Model
Success Criteria	- Working Prototype
Formative Assessment (drives instructional decisions)	- Properly formatted Data
Activities and Resources	- See Above
Suggested Modifications	See Activity 1.1.1

LESSON 3.3

Kinematics In Lesson 3.3, students explore the physics of moving objects. They begin by experimentally measuring the gravitational constant. Then, students consider motion vertical and horizontal directions and derive the equations that govern horizontal projectile motion. This lesson culminates with an engineering design challenge where students are challenged to design and build a zipline and calculate where an object will land when dropped.

Activity 3.3.1

Gravitate to Greatness: In this activity, you'll conduct an experiment to unveil one of the most fundamental concepts on Earth, the gravitational constant known as "g." This single letter represents acceleration due to the unrelenting force that keeps us firmly grounded and pulls objects toward the Earth.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none">• Analyze Position-Time and Velocity-Time graphs.• Experimentally determine Earth's gravitational constant.
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions - Google Sheet of Recorded Data
Success Criteria	- Properly formatted equations
Formative Assessment (drives instructional decisions)	- Calculations of G
Activities and Resources	- See Above
Suggested Modifications	See Activity 1.1.1

Activity 3.3.2

Horizontal Projectile Motion: In this activity, you will develop equations that govern objects undergoing projectile motion. While these equations were developed centuries ago by Italian astronomer Galileo Galilei, they are still used today to calculate things like the trajectory of meteors through Earth's atmosphere and fireworks displays.

Student Learning Intentions (SLI) WALT: (We are learning to...)

- Determine the equations that govern projectile motion.
- Use the projectile motion equations to predict where a projectile will land.

Student Learning Strategies

Journaling
Collaboration
Cooperative Learning
APB Approach (Activities, Projects, Problems)
Class Discussions
Game

Success Criteria

- Working Throwing Device

Formative Assessment (drives instructional decisions)

- Properly setup equations

Activities and Resources

- Properly formatted Prediction

Suggested Modifications

- See Above.

See Activity 1.1.1

Activity 3.3.3

Application of Kinematics: Your teacher has set up a zipline made of fishing line to simulate the cargo plane's flight path. Design and construct a device that safely carries survival supplies (represented by a golf ball) down the zipline. As the device travels down the zipline, it must collide with an obstacle attached to the fishing line designed to stop the device's motion. Upon collision, the device must eject the supplies (golf ball). Design and construct this obstacle to work with your device.

Student Learning Intentions (SLI) WALT: (We are learning to...)

- Apply your knowledge of kinematics to solve an authentic design problem.

Student Learning Strategies

Journaling
Collaboration
Cooperative Learning
APB Approach (Activities, Projects, Problems)
Class Discussions

Success Criteria

- Properly assembled Prototype

Formative Assessment (drives instructional decisions)

- Properly Formatted Data

Activities and Resources

- See Above.

Suggested Modifications

See Activity 1.1.1

LESSON 3.4

Integration of Circuits, Fluid Power, and Kinematics In this unit problem, students will combine their knowledge of electrical circuits and kinematics to design and build an automated golfer and a golf course. Students will also create two targets that trigger an LED to illuminate and another to produce a sound. This problem requires deep understanding of series and parallel circuits, fluid power, as well as horizontal and vertical motion.

Activity 3.4.1

Auto Golf: You and your team are tasked to develop equipment for an Auto Golf game. Specifically, you'll use the engineering design process to develop a player and two targets. The player must be constructed using VEX® V5 parts, household consumables, and fluid power components to reliably launch a projectile no fewer than three distances (think drive, chip, putt, or other type shots). The distance at each position is up to you, and will depend upon the type of device you design.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none">• Apply knowledge of electrical circuits, fluid power, and kinematics to solve an authentic design problem.
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	- 3D Model - V5 Code - Working Prototype
Formative Assessment (drives instructional decisions)	- Properly formatted Data
Activities and Resources	- See Above
Suggested Modifications	See Activity 1.1.1

Modifications and/or Accommodations

Suggested Modifications (ELL, Sp. Ed, Gifted, At-risk of Failure)

English Language Learners

Native language support: The teacher provides auditory or written content to students in their native language.

Adjusted Speech: The teacher changes speech patterns to increase student comprehension. This could include facing the students, paraphrasing, clearly indicating the most important ideas, and speaking more slowly.

Visuals: The teacher uses graphics, pictures, visuals, and manipulatives. This helps ELL students better understand and comprehend the subjects at hand.

Front-Loading Vocabulary: The teacher front loads vocabulary. This means providing students with a list of important vocabulary words they will need to know for a book, lesson, etc. prior to the lesson being taught. Including pictures to go with the vocabulary words is also very beneficial for the students.

Special Education Students

Chunking: The teacher presents information in a way that makes it easy for students to understand and remember. Chunking is based on the presumption that our working memory is easily overloaded by excessive detail. The best way to deliver information is to organize it into meaningful units. Because students with special needs get overloaded easily, chunking is an effective strategy to use with them.

Checking for Understanding: It is important to constantly check for understanding, especially for students who have accommodations. Teachers want to make sure students understand the concepts being covered in a way that makes sense to them.

Extra time: The teacher provides students with special needs extra time to complete work or answer questions. It is important to give students enough time to process their thoughts.

Oral Reading: The teacher will read work orally to students. Class work such as tests and literature circles may need to be read aloud to the student.

Timers: The teacher will use timers as an instructional tool. The use of timers is beneficial for students who have trouble completing tasks. Timers can be helpful so the student is aware of how much time they have to complete an assignment.

Students with 504 Plans

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Extra time: The teacher provides students with special needs extra time to complete work or answer questions. It is important to give students enough time to process their thoughts.

Gifted & Talented Strategies

Extensions/Enrichments: Teachers will provide gifted and talented students with extension/enrichment projects. Students will be challenged to further their understanding, to apply acquired knowledge, and/or to produce something in reference to acquired knowledge.

Modify/Change Activities: Teachers will monitor and modify activities to accommodate those students who need to be challenged further. Additional reading, problem-solving, writing, or project work is necessary for those students who are ready to move on at a rate more accelerated than their peers. In this way, G & T students are provided the same opportunity for support as special needs students.

Students at Risk of School Failure

Directions or Instructions: Make sure directions and/or instructions are given in limited numbers. Give directions/instructions verbally and in simple written format. Ask students to repeat the instructions or directions to ensure understanding occurs. Check back with the student to ensure he/she hasn't forgotten.

Peer Support: Peers can help build confidence in other students by assisting in peer learning. Many teachers use the 'ask 3 before me' approach. This is fine, however, a student at risk may have to have a specific student or two to ask. Set this up for the student so he/she knows who to ask for

clarification before going to you.

Alternate or Modified Assignments: Always ask yourself, "How can I modify this assignment to ensure the students at risk are able to complete it?" Sometimes you'll simplify the task, reduce the length of the assignment or allow for a different mode of delivery. For instance, many students may hand something in, the at-risk student may jot notes and give you the information verbally. Or, it just may be that you will need to assign an alternate assignment.

Increase One to One Time: When other students are working, always touch base with your students at risk and find out if they're on track or needing some additional support. A few minutes here and there will go a long way to intervene as the need presents itself.

Contracts: It helps to have a working contract between you and your students at risk. This helps prioritize the tasks that need to be done and ensure completion happens. Each day write down what needs to be completed, as the tasks are done, provide a checkmark or happy face. The goal of using contracts is to eventually have the student come to you for completion sign-offs.

Hands On: As much as possible, think in concrete terms and provide hands-on tasks. This means a child doing math may require a calculator or counters. The child may need to tape record comprehension activities instead of writing them. A child may have to listen to a story being read instead of reading it him/herself.

Tests/Assessments: Tests can be done orally if need be. Break tests down in smaller increments by having a portion of the test in the morning, another portion after lunch and the final part the next day.

Seating: Seat students near a helping peer or with quick access to the teacher. Those with hearing or sight issues need to be close to the instruction which often means near the front.

Integration of Diversity, Equity and Inclusion, Climate Change, Informational and Media Literacy

New Jersey Student Learning Standards: Content Area

New Jersey Core Curriculum - Grade 10 - Technology

8.1.12.A.4

Construct a spreadsheet workbook with multiple worksheets, rename tabs to reflect the data on the worksheet, and use mathematical or logical functions, charts and data from all worksheets to convey the results.

8.1.12.D.1

Demonstrate appropriate application of copyright, fair use and/or Creative Commons to an original work.

8.2.12.C.5

Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled.

TECH.8.1.12.A.4	Construct a spreadsheet workbook with multiple worksheets, rename tabs to reflect the data on the worksheet, and use mathematical or logical functions, charts and data from all worksheets to convey the results.
TECH.8.1.12.D.1	Demonstrate appropriate application of copyright, fair use and/or Creative Commons to an original work.
TECH.8.2.12.C.5	Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled.

Integration of Career Readiness, Life Literacies and Key Skills

TECH.9.4.12.CI.1	Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a).
TECH.9.4.12.CI.2	Identify career pathways that highlight personal talents, skills, and abilities (e.g., 1.4.12prof.CR2b, 2.2.12.LF.8).
TECH.9.4.12.CI.3	Investigate new challenges and opportunities for personal growth, advancement, and transition (e.g., 2.1.12.PGD.1).

Integration of Computer Science and Design Thinking

CS.9-12.8.1.12.DA.6	Create and refine computational models to better represent the relationships among different elements of data collected from a phenomenon or process.
CS.9-12.8.2.12.ED.1	Use research to design and create a product or system that addresses a problem and make modifications based on input from potential consumers.
CS.9-12.8.2.12.ED.2	Create scaled engineering drawings for a new product or system and make modification to increase optimization based on feedback.

Interdisciplinary Connections: NJSLs for ELA, Social Studies, Science and/or Math

CCSS.Math.Content.HSF-IF.B.4	For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship.
CCSS.Math.Content.HSG-MG.A.1	Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
CCSS.Math.Content.HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.
CCSS.Math.Content.HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

CCSS.Math.Content.HSS-ID.A.1

Represent data with plots on the real number line (dot plots, histograms, and box plots).

21st Century Life and Career

CRP.K-12.CRP2.1

Career-ready individuals readily access and use the knowledge and skills acquired through experience and education to be more productive. They make connections between abstract concepts with real-world applications, and they make correct insights about when it is appropriate to apply the use of an academic skill in a workplace situation.

CRP.K-12.CRP5.1

Career-ready individuals understand the interrelated nature of their actions and regularly make decisions that positively impact and/or mitigate negative impact on other people, organization, and the environment. They are aware of and utilize new technologies, understandings, procedures, materials, and regulations affecting the nature of their work as it relates to the impact on the social condition, the environment and the profitability of the organization.

CRP.K-12.CRP11.1

Career-ready individuals find and maximize the productive value of existing and new technology to accomplish workplace tasks and solve workplace problems. They are flexible and adaptive in acquiring new technology. They are proficient with ubiquitous technology applications. They understand the inherent risks-personal and organizational-of technology applications, and they take actions to prevent or mitigate these risks.

CRP.K-12.CRP12.1

Career-ready individuals positively contribute to every team, whether formal or informal. They apply an awareness of cultural difference to avoid barriers to productive and positive interaction. They find ways to increase the engagement and contribution of all team members. They plan and facilitate effective team meetings.