Energy: Conversion Teacher Resources

Related Documents

See “Files” section in the LMS.

Preface

Energy, and the conversion of energy to different forms, is all around you. Many of the devices we use every day convert electricity to usable forms of energy such as light and heat. Students will learn about this conversion of energy as well as the conversion of a variety of fuel sources from stored energy to usable electrical energy.

First, students review concepts of potential and kinetic energy. Next, students learn about forms of energy including thermal, light, nuclear, chemical, electrical, and mechanical. Students then learn about the conversion of energy between forms and the energy transfer required to move energy from place to place.

After students have explored energy conversion and transfer, they are presented with a design problem involving moving large amounts of donated food from a truck to a food pantry.

Transfer

Students will be able to independently use their learning to …

1. Evaluate a problem in a novel situation.
2. Apply a step by step design process to solve a problem.
3. Identify energy conversion in everyday situations.

Understandings

Students will understand that:

1. Engineers have a step by step approach of looking at and solving a problem called the design process.
2. Engineers and designers create new products and technology to meet a need or want that meets specific criteria for success, including constraints on materials, time, and cost.
3. Engineers generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
4. Engineers propose a solution to a design problem to develop after evaluating multiple possible designs.
5. Prototypes can be evaluated and improved upon using a series of fair and controlled tests to identify a product’s strengths and limitations.
6. Engineers write down everything they do to document their work, organize their thoughts, and show their steps in an engineering notebook.

7. Engineers share their work with and get feedback from others at many points throughout the design process.
8. Energy is the capacity to do work.
9. Energy has the ability to cause motion or create change.
10. Two types of energy exist: potential (stored energy) and kinetic (energy in motion).
11. Six main forms of energy include light, thermal, electrical, mechanical, chemical, and nuclear.
12. Energy can be converted from one form to another to meet a human need or want.
13. Energy can be transferred from place to place by sound, light, heat, and electric current.

Knowledge

It is expected that students will:

- Explain what happens at each step of the design process.
- State questions engineers may ask when gathering information about a situation people want to change.
- Identify the differences between invention and innovation.
- List examples in which energy is converted between potential and kinetic energy.
- Describe six main forms of energy, including light, thermal, electrical, mechanical, chemical, and nuclear.
- List ways in which energy may be converted from one form to another.
- Describe how sound, light, heat, and electric current can transfer energy.

Skills

It is expected that students will:

- Follow a step by step approach to solving a problem.
- Identify specific constraints such as materials, time, or cost that engineers and designers must take into account given a specific design problem.
- Brainstorm and evaluate existing solutions to a design problem.
- Generate multiple solutions to a design problem, taking into account criteria and constraints.
- Use a decision matrix to compare multiple possible solutions to a design problem and select one to develop, taking into account how well each solution meets the criteria and constraints of the problem.

- Plan fair tests in which variables are controlled to identify a product's strengths and limitations.
- Perform fair tests in which variables are controlled to identify a product's strengths and limitations.
- Organize and maintain an engineering notebook to document work.
- Share findings and conclusions with an audience.
- Differentiate between potential and kinetic energy.
- Explain how energy can be converted to meet a human need or want.
- Compare and contrast the transfer and conversion of energy.
- Apply scientific ideas about the conversion of energy to solve a simple design problem.
- Design a system that is able to store energy and then convert the energy to a usable form as it is released.

Essential Questions

Students will keep considering:

1. How are energy conversion and transfer related?
2. How can humans use energy conversion and transfer to meet needs and wants?
3. How is usable energy converted from resources in your area?
4. What are some energy conversions that take place to create usable energy in a community?

Day-by-Day Plans

Time: 10 instructional hours

***NOTE:** In preparation for teaching this module, it is strongly recommended that the teacher read the Energy: Conversion Teacher Resources document, including the Understandings, Knowledge, and Skills addressed in the module. In preparation for Part 2, the teacher will need to build two electrical generators with the VEX IQ® equipment and additional supplies as described in Part 2.*

To prepare for Parts 1, 2, and 4, the teacher should ensure that all Autodesk® Inventor® Publisher files for Activity 2.1, 2.2, and Project 2.4 have been downloaded and installed in the Autodesk® Inventor® Publisher app on the tablet. A demonstration of how to install and use the app is provided for the teacher in the Energy, Collisions and Conversion Core Training course. If you prefer not to use iTunes to update your iPad® tablets, you can use an alternative technique via the Canvas App.

Part 1: What Is Energy Conversion?

120 minutes

- The teacher introduces students to the Canvas app and assists students with the login process. For the remainder of the module, the students will access the assignments in the Canvas app.
- The students read the document Energy: Conversion Introduction about the three fictional characters and the food pantry unloading problem.
- The students discuss what the problem is and how it relates both to the fictional story and the concept of energy.
- The teacher leads a class discussion around the question of where to start when facing a challenge. The teacher reviews the design process and explains that the Launch Log will be used to record all work for this module, including brainstorming ideas, sketches, and other written work as assigned.
- In Part 1 students review potential and kinetic energy by searching the classroom for examples and documenting and sharing with the class.
- Part 2 may be completed as a demonstration or as a student activity. The teacher and/or the students build a KinetiCan to demonstrate the conversion between kinetic energy to potential energy and back. KinetiCan preparation instructions can be found in the Energy, Collisions and Conversion Core Training course.
- If the KinetiCan is to be built by the students, the teacher will need to collect a can for each student or pair of students to use for the construction.
- In Part 3 students reflect on human energy sources and how energy from food is converted to usable energy. The energy in food is stored as potential energy and is released as kinetic energy when converted for uses such as contracting muscles or generating heat.
- In Part 4 students construct a stationary bike model using the VEX IQ® equipment. Students will use the Autodesk® Inventor® Publisher app to view instructions on how to construct the bike.
- If this is the first time students will work with the VEX IQ equipment, the teacher may wish to allow students time to explore how the pieces fit together and how the kit is organized. The PLTW VEX IQ construction kit contents can be found in the Dashboard of this module.
- Students respond to questions in step 8 either as a discussion or in their Launch Logs.
- The bike assemblies will be used later in Project 2.4 and should remain intact to save time during that project if possible.

Part 2: Energy Conversion in Action

120 minutes

- In Activity 2.2 Energy Conversion in Action, students experience several types of energy conversion. As they work through the activity, they will be exposed to vocabulary that can be used in the final part of the activity.
- This activity is broken into three parts including a digital presentation created by the students. Part 1 of the activity will take approximately 30 to 40 minutes to complete.
- The teacher assists students in accessing the Energy: Conversion module in the Canvas app and leads a brief review of the design challenge faced by the three fictional students involving the food pantry design problem.
- Prior to students beginning Part 1 Energy Conversion Observations, the teacher will prepare two sets of three stations for the students to observe energy conversion. Students will observe each station for approximately 5-10 minutes.
- The generator station requires significant setup time by the teacher to build two hand crank generators as described below.
- Student instructions for each station are located in Activity 2.2 Energy Conversion in Action.
- Specific station setup instructions are below:
    - Hand Warmers
        - As student groups rotate through the station, they will open a hand warmer package, remove the hand warmer, and shake.
        - The station requires one hand warmer for each group. If all six stations are running at one time, both hand warmer stations will require three packages for a total of six in the classroom.
        - The hand warmers will begin to warm up as soon as they are exposed to air. To ensure students feel the change in temperature, each group will need to open a new package.
    - Glow Sticks
        - All students will receive a glow stick at this station. Each station should have fifteen glow sticks for a class of thirty.
        - The students will be asked to bend the glow stick to break the glass tube in the middle.
        - If desired, the teacher may allow the students to take home the glow sticks.
    - Generator
        - Prior to this activity, the teacher will construct two identical generators to be used in the stations.
        - The generators are assembled from VEX IQ® equipment, a motor, wire, leads, motor, tape, and LED.
        - A typical LED illuminates when current flows in one direction and blocks current in the opposite direction, resulting in no illumination. The LED used in PLTW Launch is a specialized

model known as a Bipolar LED or back-to-back LED. The LED is actually a combination of two LEDs with opposite polarity. Current in a direction results in the illumination of a green LED, while current in the opposite direction results in a red illumination. This is important to know if you acquire an LED from a source other than the PLTW kits or if a student recreates this activity outside of the classroom.

  - Use the Autodesk® Inventor® Publisher instructions to construct a generator
    - EC2_Gen_Step01_Base.ipm
    - EC2_Gen_Step02_Stabilizer.ipm
    - EC2_Gen_Step03_Supports.ipm
    - EC2_Gen_Step04_Shafts.ipm
    - EC2_Gen_Step05_Handle.ipm
    - EC2_Gen_Step06_Electrical.ipm
    - EC2_Gen_Step07_Final.ipm
  - If students cannot turn the generator handle fast enough to cause the LED to illuminate the generator, output can be increased by removing the 36 Tooth Gear and replacing it with a 60 Tooth Gear. This requires that the shaft be moved to the set of holes immediately above where it is shown in the Autodesk® Inventor® Publisher instructions. The increased power output from the generator increases the risk of damaging the LED, so modify only if needed.

- After the students complete their observations, they are prompted to reflect on the following questions:
  - What were some similarities between the stations?
    Possible responses include the following: glow stick and generator both created light; students had to do something to the glow stick and hand warmer for a change to occur.
  - What were some differences between the stations?
    Possible response includes the following: students needed to keep turning the generator, while the glow stick and hand warmer stayed lit and warm.
  - What do you think caused the changes you observed?
    Students may know that chemicals combine to make the glow sticks illuminate, and they may suggest that they made the LED illuminate when they turned the hand crank on the generator. The generator is an example of energy conversion from kinetic energy into electrical energy and then into light energy.
- The teacher will decide if the students record their answers in their Launch Logs or if they discuss the questions with a partner or small group. The teacher may also lead a class discussion using the questions.
- In Part 2 of the activity, students learn about six different forms of energy and review energy conversion. Part 2 of the activity will take approximately 20

minutes to complete. Students may view the presentation individually, in pairs, or in small groups depending on the number of available tablets.

- In Part 3 of the activity, students work in small groups to create a brief presentation describing the energy conversion in one of the stations. Part 3 of the activity will take approximately 60 minutes to complete. The student digital presentations should be simple. The teacher may decide how the information on energy conversion will be shared.
- The teacher decides if students will be assigned one of the three stations or if they will be allowed to pick a station of their choice.
- The students will use an app on the tablet either assigned by the teacher or chosen by the students to present their work. Possible apps include Popplet Lite, Stage™, and Educreations™.
- Expected answers:
    - Hand Warmer: The energy conversion observed is chemical energy to thermal energy. This energy conversion meets a human need or want by providing heat for people in a cold setting.
    - Glow Stick: The energy conversion observed is chemical energy to light energy. This energy conversion meets a human need or want by providing a source of light that can be turned on when desired.
    - Generator: The energy conversion observed is mechanical energy from the person turning the hand crank to electric energy in the motor to light energy in the LED.
- Additional information on how each of the energy conversions occur is listed for teacher reference. Students do not need to understand the chemical reactions or electricity generation for the purposes of the activity. However, the teacher may wish to discuss the details of each conversion.
    - Hand Warmer: The stored chemical energy is released as heat in an exothermic reaction that creates rust. A typical pouch will contain iron powder, salt, water, an absorbent material, and activated carbon. When the pouch is removed from the plastic packaging, the iron powder in the pouch reacts with oxygen in the air to form iron oxide.
    - Glow Stick: There are two separate chemicals in the glow stick; one is inside a glass tube to keep the chemicals separated. When the glass inside breaks, the two chemicals can mix and a chemical reaction occurs. The chemicals in the glass are diphenyl oxalate plus a chemiluminescent dye. The chemical in the plastic tube is hydrogen peroxide. The chemical reaction that occurs results in chemiluminescence, or light created by a chemical reaction.
    - Generator: The hand crank generator converts mechanical energy from the person turning the crank into electrical energy by spinning a coil of wire around a magnet. This electricity is then transferred to the LED and converted to light energy as the electricity passes through the LED.

- The students complete Activity 2.2 and answer conclusion questions either through the Canvas app or in their Launch Logs.

Part 3: Light Up Your World

80 minutes

- This activity is designed to provide context for students learning about the sources of energy, its conversion into electrical energy, transporting energy to our homes and industry, and ultimately its conversion into forms of energy that benefit us, including light, thermal, and mechanical energy.
- The teacher assists the students in navigating to Activity 2.3 Light Up Your World in the Canvas app.
- In Part 1 of the activity, students will use a coin battery and LED to construct an electrical circuit. This will allow students to see an example of energy conversion from chemical energy into electrical energy then into light energy. The LED is the same LED used in the construction of the generator. Details about a bipolar, or back-to-back LED are in the section above. Students will use the knowledge gained by constructing a simple circuit to take apart a flashlight while documenting the energy conversions.
- In Part 2 of the activity, students apply what they learned from the previous circuits to learn about energy sources that generate large amounts of electricity for homes and businesses.
- Students work in pairs, small groups, or individually to research an energy source such as oil, natural gas, coal, or wind. Students organize and summarize this research by creating a mind map using Popplet Lite.
- If desired, students may complete the Going Further section of the activity and research the primary source of electricity in their community. Students may document their research using an app such as Educreations or Popplet Lite, or they may create a resource to teach younger students about local energy production.
- Students answer conclusion questions either through the Canvas app or in their Launch Logs.

Part 4: Harnessing Energy

80 minutes

- In this project students will use two devices built with VEX IQ® equipment to work toward a solution to a fictional tree house problem as presented in the Project 2.4 Introduction.
- The teacher assists the students in navigating to Project 2.4 Harnessing Energy in the Canvas app.
- The teacher reads through the introduction with the class and leads a short discussion on the tree house problem.
- In Part 1 students follow directions using the Autodesk® Inventor® Publisher app to build a pulley system using the VEX IQ® equipment.

- In Part 2 students develop a solution for lifting objects into a tree house. Students will use the steps of the design process as outlined in the project and may choose to use the pulley and/or the bike from Activity 2.1 as part of their solution.
- Students document work in their Launch Logs, including all brainstorming, sketching, and testing information.
- The students complete Project 2.4 Harnessing Energy and answer the conclusion questions either through the Canvas app or in their Launch Log.

Part 5: Food Pantry Design Problem

200 minutes

- In this design challenge, students will design and model a system to unload boxes of food at a community food pantry.
- The teacher reads the fictional story of the friends from the Energy: Conversions Introduction document and reminds students of the original design problem.
- The students access the Problem 2.5 Food Pantry assignment on the Canvas app.
- Design Process

  Ask

  - The teacher guides a discussion asking the students to again consider the problem.
  - The students review the criteria and constraints of the design problem by reading through step 3 in the procedure as shown below:

Student document:

3. 

   a. ***The first step is Ask***
   b. ***Respond to the following questions in your Launch Log:***
      - ***What is the need or want that we are trying to fulfill?***
      - ***What will make the design solution successful?***
   c. ***Review the criteria and constraints for the design problem below and add this information to the Ask section of the Launch Log.***

Criteria ***Criteria are guidelines or rules for your design.***	***Constraints*** ***Constraints are the limitations or restrictions on your design.***
• ***The group will design, build, and test a system to unload boxes of food at a***	• ***Your teacher will determine the amount of time you have to design, sketch, and build your***

community food pantry. • ***The system must move boxes of food a minimum of 12 feet.*** • ***The model may be scaled down to a scale of 1 inch = 1 foot. If you choose to use this scale, the model must be able to move boxes of food a minimum distance of 12 inches.*** • ***The system must convert energy from one form to another to solve the problem.***	***model.*** • ***You are limited to the following materials:*** o ***VEX IQ® equipment*** o ***String*** o ***Other materials as determined by your teacher***

d. Follow your teacher's directions to complete the self-assessment at the end of the Ask section.

- The teacher leads a discussion on the criteria and constraints of the design problem.
- The students respond to the following questions in their Launch Logs:
  - What is the need or want that we are trying to fulfill?
  - What will make the design solution successful?
- The teacher guides the students as they complete the self-assessment at the end of each section. The students circle one statement in each row.

Explore

- The teacher leads the students through this step of the design process and encourages students to brainstorm several ideas before developing a single solution.
- The teacher determines specific materials that may be used in the solution, including quantity of VEX IQ® parts used and any additional materials as determined by the teacher.
- The teacher guides the students through step 4 of the procedure as shown below:

Student document:

4. 

a. ***The second step is Explore***

b. ***Write or sketch in the Explore section of your Launch Log how others have tried to solve the same problem.***

c. ***You may use the skills and knowledge your team gained from the activities and project in this module as well as any outside information you have to help your group design the best solution.***

d. ***Brainstorm several ideas that may solve the problem and write or sketch them in the Explore section.***

e. ***Talk to your team and share ideas. Add any additional ideas by writing or sketching in your Launch Log.***

f. ***Follow your teacher's directions to complete the self-assessment at the end of the Explore section.***

Model

- The students design and model a system to unload boxes of food at a community food pantry.
- The teacher guides the students through the use of a decision matrix to compare possible design solutions. The decision matrix for students may be found on the document entitled Problem 2.5 Decision Matrix and may be printed for each student group.
- Specific step-by-step instructions on how to use the Decision Matrix can be found in step 5 of the procedure as shown below:

Student document:

5. 

a. ***The third step is Model***

b. ***In this step you will compare the solutions that your team generated during the Explore step.***

c. ***Use a decision matrix to choose one design or develop a new design that combines the best features of all designs.***

d. ***Detailed instructions on how to use the decision matrix are below:***

   - ***The first step in using the decision matrix and analyzing a design is for each team member to present their design and explain how it is supposed to work as well as any special features it may include.***
   - ***After each presentation team members will ask questions in order to fully understand your design concepts. They will also make suggestions that might improve your design.***

- ***The second step of this activity is to use the decision matrix to guide the team's selection of the best solution to the design process.***
    - ***In the left-hand column, list each of the designs that are being rated. Example: Mylo's design #1, Mylo's design #2, Suzi's design #1…***
    - ***Rate each design against each criterion using the scale found below the matrix. This can be completed together by the group, or each group member can rate the criteria separately and the total score can be entered. Example: Mylo thinks the criteria for moving the boxes for the first design rates at 3, while Suzi and Angelina only rate them at 2 – the total of 7 should be entered under the first column.***
    - ***Tally the scores to determine the best designs. Add the scores located in the row to the right for each design. The design with the highest score in the total column will indicate the best design.***
- ***Remember, it is okay to go back in the design process to see if there are any other improvements that could be made to your team's best design. Go back to the decision matrix and see if any of the components could be improved, and then brainstorm to try to find solutions. It is okay to combine ideas and add features from other designs on your team. Once your team has tweaked the final design to include ideas that provided the best score, you should be sure you identify the best design in your Launch Log.***

e. Follow your teacher's directions to build a model of your design.

f. Document your design by sketching the final model or taking photographs of the completed model.

g. ***Follow your teacher's directions to complete the self-assessment at the end of the Model section.***

- The teacher guides the students as they complete the self-assessment at the end of each section. The students circle one statement in each row.

Evaluate

- The students collect and evaluate test data.
- The teacher may choose to have the student record a video of the test on a tablet.
- Students record how well their system moved boxes of food a minimum of 12 inches.

- Students may wish to build model food boxes using VEX IQ® equipment or other materials.
- Step 6 of the procedure is shown below:

Student document:

6. 

a. ***The fourth step is Evaluate***
b. ***Follow your teacher's directions to test your food box unloading system.***
c. ***Record the results of your test in your Launch Log.***
d. ***Follow your teacher's directions to complete the self-assessment at the end of the Evaluate section.***

- The teacher guides the students as they complete the self-assessment at the end of each section. The students circle one statement in each row.

Explain

- The students present their design, evaluation, and suggestions for improving their food box unloading system.
- The students may use iPad apps such as Educreations or Popplet to present their design, an explanation of results, and suggestions for improvement.
- Step 7 of the procedure is shown below:

Student document:

7. 

a. ***The fifth step is Explain***
b. ***In this step you will present your design, evaluation, and suggestions for improvement for your prototype of the food box unloading system.***
c. ***Complete the Explain section of your Launch Log.***
d. ***Follow your teacher's directions to complete the self-assessment at the end of the Explain section.***

- The teacher guides the students as they complete the self-assessment at the end of each section. The students circle one statement in each row.

- At the conclusion of the module, the students complete the Energy: Conversion Check for Understanding.

National and State Standards Alignment

Next Generation Science Standards

- 4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
- 4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
- 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Common Core ELA

- RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.
- RI.3.3 Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect.
- RI.3.8 Describe the logical connection between particular sentences and paragraphs in a text (e.g., comparison, cause/effect, first/second/third in a sequence).
- W.3.7 Conduct short research projects that build knowledge about a topic.
- W.3.8 Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories.
- SL.3.3 Ask and answer questions about information from a speaker, offering appropriate elaboration and detail.

Common Core Math

- MP.4 Model with mathematics.
- MP.5 Use appropriate tools strategically.