Energy: Collisions Teacher Resources

Related Documents

See “Files” section in the LMS.

Preface

This module begins with three fictional characters at an amusement park observing bumper cars. Through the example of the bumper cars, students are introduced to energy transfer and conversion in collisions. The students will apply new skills and knowledge to solve a design problem where they are asked to design and build a restraint system to protect a passenger in a vehicle collision. The passenger will be represented by an egg. The vehicle will roll down an inclined plane and collide with a solid object such as a wall.

Students explore how mechanisms change energy by transferring direction, speed, type of movement, and force. Students discover a variety of ways that potential energy can be stored and released as kinetic energy. Citing evidence, students explain the relationship between the speed of an object and the energy of that object. They also predict the transfer of energy as a result of a collision between two objects. As students solve the problem for this module, they will apply their knowledge and skills related to energy transfer in collisions to develop a vehicle restraint system.

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. Predict the effects of a collision.

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 by 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 ability to do work.
9. Engineers design mechanisms to change energy by transferring direction, speed, type of movement, and force.
10. Potential energy can be stored in many ways and is released as kinetic energy.
11. The faster a given object is moving, the more energy it possesses.
12. Contact forces transfer energy during a collision, resulting in a change in the object's motion.

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 ways in which energy can be transferred.

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.
- Classify energy in a system as potential or kinetic energy.
- Explain, citing evidence, the relationship between the speed of an object and the energy of that object.
- Predict the transfer of energy as a result of a collision between two objects.
- Solve a simple design problem involving the transfer of energy and collisions between two objects.

Essential Questions

Students will keep considering:

1. How are potential and kinetic energy related?
2. What happens to energy during a collision?

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: Collisions Teacher Resources document, including the Understandings, Knowledge, and Skills addressed in the module. VEX IQ® equipment will also need to be prepared for this module, including the vehicle for the teacher demonstration in Part 1. Student tablets will need the most up to date version of the following apps: Canvas by Instructure, Autodesk® Inventor® Publisher, Popplet Lite, and Educreations™ applications.*

In preparation for the module, the teacher should ensure that all Inventor Publisher files for Activity 1.3, including the Vehicle and Pendulum, have been downloaded and installed in the Inventor Publisher app on the tablet. A demonstration of how to use the app and how to install the files 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, an alternative technique is available via the Canvas App.

Part 1: Energy and an Introduction to the Design Problem

120 minutes

- In preparation for the vehicle demonstration, the teacher will assemble the vehicle following the instructions found on the Autodesk Inventor Publisher application.
- The teacher begins the module with a demonstration involving an egg sitting on the basic car design and rolling down the metal ramp to hit a wall. The egg should break or at least crack. It is fine if the egg falls out of the vehicle part way down and cracks on the ramp. If the egg does not break, you may need to increase the angle of the ramp and repeat the demonstration. During pilot testing organic eggs were found to have thicker shells and were more difficult to break at the standard angle of the ramp.
- During the demonstration the teacher may wish to record the collision with the camera feature or a slow motion app such as Ubersense on a tablet.
- After the demonstration the teacher leads a discussion about what happened and encourages the students to propose questions they have about the demonstration.
- The teacher explains that at the conclusion of the module, students will be asked to build the same car, only they must transfer their egg successfully down the ramp and hit the wall without breaking the egg.

- The teacher distributes the Launch Log. In the “Ask” section beginning on page 14, the students answer the two prompts below:
    - What is the need or want that we are trying to fulfill?
    - What will make the design solution successful?
    - Note: the question about constraints will be answered in Part 5.
- The teacher leads a class discussion around the question of where to start when facing a challenge. The teacher describes the design process and explains that the Launch Log will be used to document all of their work related to the vehicle restraint design problem. The Launch Log will also be used to document student work throughout the Energy: Collisions module.
- The teacher introduces students to the Canvas Learning Management System (LMS) and assists students with the login process. For the remainder of the module, the students will access assignments in the LMS.
- The teacher assists students in accessing the Energy: Collisions module in the Learning Management System.
- The students read the document EC.1 Introduction about the three fictional characters and the bumper car ride at the amusement park.
- The students discuss what the problem is and how it relates both to the fictional story and to the vehicle restraint system they are asked to design in this module.
- The teacher guides the students to Activity 1.1 Energy and reads the introduction with the students.
- In this activity the students read an article on seatbelt safety and discuss the reading with a classmate. The teacher may choose to print the article on page 2 of the activity if students are not comfortable reading on the tablet or if several students are sharing a tablet at one time.
- The teacher leads a class discussion on what the students learned and if they have any ideas on how to protect their egg passenger in the final design problem.
- The students complete Activity 1.1 Energy and answer conclusion questions. The students may complete all work on the Launch Log or use the LMS to submit their work.

Part 2: Potential and Kinetic Energy

80 minutes

- The teacher assists the students in navigating to Activity 1.2 Potential and Kinetic Energy in the LMS.
- The teacher presents the PowerPoint presentation titled Potential and Kinetic Energy, which includes a simulation on slide 4. The simulation will not work on a tablet, and the computer used for viewing must have an updated version of Java. The teacher should test the link and simulation prior to presenting to students.
- The teacher demonstrates potential and kinetic energy with the ramp and car, identifying where the car has the most potential energy (at the top of the ramp) and where the car has the most kinetic energy (when it is rolling the fastest).
- The teacher will direct students to one of the following tablet apps and give an introduction of the app or apps to the class.
    - Monster Physics™ Lite
    - TinkerBox™
    - Autodesk® Digital STEAM Applied Mechanics

- The students work through the app and answer conclusion questions through Activity 1.2 Potential and Kinetic Energy in the LMS.
- The teacher may choose to have students take screen shots of the app they are using and insert the images into the Canvas assignment using the text entry box.
- The teacher assists students in submitting work through the LMS.
- Alternatively, teachers may direct students to take screen shots of the app and create an Educreations™ presentation that answers the conclusion questions with an image they are describing.

Part 3: Speed and Energy

100 minutes

- In this activity students explore the relationship between speed and energy of an object by assembling a simple model of a pendulum and vehicle and documenting the changes to the system that can increase or decrease the speed of the objects. Changes to the system will include varying the amount of potential energy by altering the mass or initial height of the objects.
- 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.
- The teacher assists the students in navigating to Activity 1.3 Speed and Energy in the LMS.
- In Part 1 the students build the pendulum and document the effect of raising the pendulum to different heights prior to release.
- The teacher may have the students complete the assignment on paper or record a video of the pendulum movement along with student responses to upload through Canvas.
- In Part 2 the students build the car as described in the Car Assembly document. Each VEX IQ kit has enough parts for two cars.
- The poster board is taped to a wall or chair and the ground to create a ramp for the car assembly. Students will roll the cars down the ramp and make observations related to speed and energy.
- The students record videos of the cars as they travel down the ramp and describe the relationship between speed and energy. Specifically, students consider the relationship between speed and kinetic energy and speed and initial potential energy.
- The students complete Activity 1.3 and conclusion questions.
- The vehicles will be used throughout the remainder of the module and should remain assembled.

Part 4: Energy Transfer in Collisions

100 minutes

- In this project students will describe elastic and inelastic collisions in systems they construct using VEX IQ equipment. Students will also describe how energy is conserved and transferred in a collision, including changes in motion and the production of heat and sound.

- The teacher will guide the students in discussing the sound created by a car accident and relating that sound production to the sound created by clapping hands.
- The teacher assists the students in navigating to Project 1.4 Energy Transfer in Collisions in the LMS.
- The students use the vehicles they assembled in the previous activity. Each group will require 2 cars, 2 pieces of poster board, masking tape, and the additional VEX IQ parts as described in Project 1.4.
- The teacher reads through the introduction with the students and reviews the new key terms. The informational text in the introduction may be used to demonstrate close reading.
- To complete Project 1.4, the students will need to record their observations on a chart in their Launch Logs. They may copy the chart provided in Project 1.4 from the LMS, or the teacher may wish to print pages 3 and 5 and have students tape or glue the charts into their Launch Logs.
- The students complete Project 1.4 Energy Transfer in Collisions and answer the conclusion questions.
- At the conclusion of the testing, the teacher shows the Potential and Kinetic Energy simulation at **http://phet.colorado.edu/en/simulation/energy-skate-park** to review concepts and discuss results from the collision testing.
- Students may capture collisions using a tablet app that allows playback in slow motion. A possible app to record the collisions is Ubersense Coach: Slow Motion Video Analysis.

Part 5: Vehicle Restraint Design

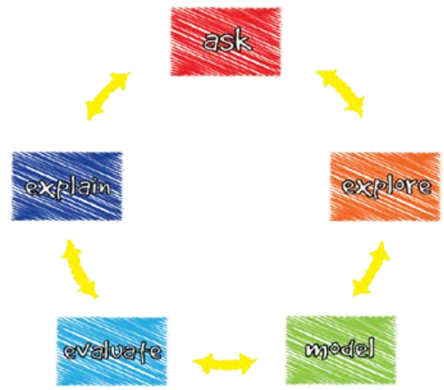
200 minutes

- In this design challenge, students will design a restraint system or alter the vehicle design to protect a passenger in a car during a collision. Students will prototype their design using the VEX IQ vehicle they constructed in Activity 1.3 and an egg as a passenger. The solution will be tested by rolling the vehicle down an inclined plane at varying slopes to evaluate the effectiveness of the design. Students will use technology to present their design solution, test outcomes, and provide suggestions for improvement.
- The teacher reads the fictional story of the friends from the Energy: Collisions Introduction document and reminds students of the original design problem. Alternately, student may read the introduction individually or in pairs.
- The students access the Problem 1.5 Vehicle Restraint Design assignment in the LMS.
- **Ask**
    - The teacher guides a discussion asking the students to again consider the problem.
    - The teacher reviews the design process and the role of engineers by reviewing step 2 of the procedure with the students as shown below:

Student document:

2. You will use an engineering design process as you work to develop a solution to the vehicle restraint problem.

- ***The design process is a step by step way to solve problems.***
- ***An engineer is a person who is trained to use technology, mathematics, and science to solve problems.***
- ***Engineers use the design process to develop many possible solutions to a problem.***



- The teacher reads through the criteria and constraints of the design problem as detailed in step 3 of the procedure as shown below:

Student document:

3. 

a. The first step is Ask

b. In this step you will:

- ***Explain how the design problem addresses a need or want.***
- ***Describe the criteria that will lead to a successful outcome.***
- ***Explain how the constraints will impact the design.***

c. Review your responses in your Launch Log to the following:

What is the need or want that we are trying to fulfill?

What will make the design solution successful?

d. Review the criteria and constraints for the design problem below and add this information to the Ask section of the Launch Log.

Criteria	***Constraints***
A raw egg will travel on a vehicle down an inclined plane and collide with a solid object. ***After the collision the egg should not be broken or cracked in any way.***	***None of the base parts of the car may be removed.*** ***Additional VEX IQ parts may be added.*** ***A list of additional materials will be provided.***

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

    - The students review their entries in their Launch Logs and add information regarding the criteria and constraints.
    - The teacher guides the students how to complete the self-assessment at the end of the Ask section. The students circle one statement in each row.
- **Explore**
    - The teacher leads the students through this step by following the directions found in step 4 of the procedure as shown below:

Student document:

4. 

a. The second step is Explore

b. In this step you will:

- ***Research how others have tried to solve this problem.***
- ***Brainstorm several ideas that may solve the problem.***

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

d. You may find more information by researching restraint systems using the Internet as directed by your teacher.

e. Brainstorm several ideas that may solve the problem and write or sketch them in the same section.

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

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

    - The teacher determines specific materials that may be used in the solution, including quantity of materials added to the vehicle and number of additional VEX IQ parts used. It is possible to create an effective design using only VEX IQ parts. Additional materials allowed are at the teacher's discretion.
    - The teacher determines whether the students may research vehicle restraint systems on the Internet. The design challenge may be completed successfully without additional research.
- **Model**
    - The students design and model a system to protect a passenger in a car during a collision.
    - The teacher leads the students through this step by following the directions found in step 5 of the procedure as shown below:

Student document:

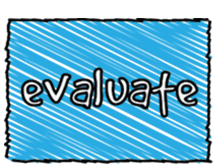
5. 

a. ***The third step is Model***
b. ***In this step you will:***
    - ***Compare multiple solutions to see how well each one meets the criteria and constraints.***
    - ***Sketch, model, and write about the best solution.***
c. ***In this step you will compare the solutions that your team has generated from the Explore step.***
d. ***To compare multiple solutions and determine how well each one meets the criteria and constraints, you will use a decision matrix.***
    - ***A decision matrix is used to compare design solutions against one another, using specific criteria that are often based on project requirements.***
e. ***Use a decision matrix to choose one design and sketch the final design in your Launch Log in the Model section. Label your sketch with materials and other details. An example decision matrix for this problem may be viewed in Problem 1.5 in the LMS.***
f. ***Follow your teacher's directions to build a prototype, or testable version, of your design.***
g. ***Document your prototype by sketching the final design or taking photographs before you begin testing.***
h. ***Follow your teacher's directions to complete the self-assessment at the end of the Model section.***

    - A decision matrix is used to compare possible design solutions. The decision matrix for students may be found on the document titled EC.1.5.B Decision Matrix.

- **Evaluate**
    - The students collect and evaluate test data from the prototype vehicle restraint system. Step 6 of the procedure details how to test the prototypes as shown below:

Student document:

6. 

    a. ***The fourth step is Evaluate***
    b. ***In this step you will:***
        - ***Plan a controlled test.***
        - ***Conduct and document a controlled test.***
        - ***Use data to identify aspects of your design that can be improved.***
    c. ***Follow your teacher's directions to test your vehicle restraint system. Your vehicle will roll down an inclined plane and collide with a solid object at the bottom.***
    d. ***Record the results of your test in your Launch Log.***
    e. ***Follow your teacher's directions to complete the self-assessment at the end of the Evaluate section.***

    - If desired, the teacher may choose to increase the angle of the ramp by placing books or other objects under the top of the ramp. The teacher may then ask students to predict the resulting collision.
    - The students may use tablets to record a video of the collision with the camera feature or a slow motion app such as Ubersense.
- **Explain**
    - The students may use tablet apps such as Educreations or Popplet Lite to present their design, an explanation of results, and suggestions for improvement.
    - An overview of this step is described in step 7 of the procedure as shown below:

Student document:

7. 

    a. ***The last step is Explain***
    b. ***In this step you will:***
        - ***Explain how the prototype solved (or did not solve) the problem.***
        - ***Suggest ways to improve your model.***
        - ***Predict how the improvements will make your model a better solution to the problem.***
        - ***Communicate your solution to others.***
    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.***

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

National and State Standards Alignment

Next Generation Science Standards

- 4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.
- 4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide.
- 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.4.1 Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.
- RI.4.3 Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.
- RI.4.9 Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably.
- W.4.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
- W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic.
- W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.
- W.4.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.

Common Core Math

- 4.OA.A.3 Solve multistep word problems posed with whole numbers and having whole-number answers using the four operations, including problems in which remainders must be interpreted. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding.
- MP.4 Model with mathematics.
- MP.5 Use appropriate tools strategically.