CRASH TESTS
ENERGY AND COLLISIONS
4TH GRADE  |  MODULE 3
Teacher Notes:

Use this space to keep notes on the module as you work through the lesson. This space will also contain helpful links and information for you to use throughout the module.

What is STEAM Fundamentals?

STEAM Fundamentals is a phenomenon-based, hands-on curriculum designed to engage elementary students in real-world applications. Each module is centered around an anchor phenomenon, which encourages students to ask questions about the natural world. As they seek answers to their questions, students make observations, gather information, and design investigations to test their ideas. Students learn to work in teams, engage in critical reflection, develop models, and share their ideas through speaking and writing. The modules introduce the engineering design process to help students apply concepts and design solutions.

STEAM Fundamentals' modular approach provides ultimate flexibility to schools. Teachers can implement the curricula as stand-alone units or to insert specific modules into an existing lesson plan. Each module connects to key math, writing, cyber, and arts concepts, and has been mapped to national academic standards. Alignment guides are available in Canvas under additional resources.

NICERC is asking that you please provide feedback as you implement the modules. STEAM Fundamentals is still under development and will be edited throughout the year as feedback is received. This is a wonderful opportunity for you to take part in new cutting edge materials and to help us make the modules even better.

Most of the supplies needed for STEAM Fundamentals are common household items and are easy to source. NICERC has preassembled kits available for schools that are interested.

Our Approach: Phenomenon-Based Learning

Step 1. Phenomenon
Explore the world around you.
Ask a question.

Step 2. Gather Information
Make observations.
Conduct research.
Design investigations.

Step 3. Draw conclusions
Make a claim.
Use evidence and reasoning to support your claim.

Each module supports the development of 21st-century skills such as team building, communication, problem solving, critical thinking, leadership, and creativity.
Teacher Notes:

**Materials List**

**Per Group**
- 1 - Ruler
- 1 - Book
- 1 - Foam board/cardboard
- 5 - Pennies
- Various objects of different sizes
- Scissors

**Per Class**
- Tape
- Block car kit
- Yarn or string

1 - Rubberband
1 - Empty tissue box
Module Components

The STEAM Fundamentals Curriculum includes the following components:

- **Teacher Manual**: Guides teachers through all course content and includes instructions for conducting investigations, helpful notes for classroom use, and supplemental activities and resources.

- **Student Portfolio**: Digital or printable pages that students can use to take notes, complete problems, and practice both scientific and creative writing skills.

- **Standards Alignment Guide**: Maps each activity to the appropriate science, math, ELA, computer science, and arts standards (located under Additional Resources).

- **Additional Resources**: A growing library of resources, such as Phenomenon Posters and technology lessons, to accompany the curriculum (located under Additional Resources).

The OWL icon indicates a moment when students should return to their Research Log and complete the corresponding section of the OWL chart as discoveries about the phenomena occur. The Research Log (page 3) features a focus question that ties all the learning from the unit together. In the Teacher Guide, the OWL chart is completely filled in, as it will be for students at the end of the module. However, they will only ever fill out one or two cells at a time.

Cyber Pop Outs connect the STEAM topic to the cyber world.

**Bold, italicized Text**

Bold, italicized text indicates suggested vocabulary words. Each time a vocabulary word is presented, the teacher can call attention to the word by placing the corresponding vocabulary card on a “Science Terms Wall” so that it will be visible to students for the rest of the module.

**Orange Text**

Orange text indicates solutions that are only visible in the Teacher Manual.
COLLISIONS

MODULE OVERVIEW

Through this module, your students will discover why safety devices like seat belts and car seats are an important part of high speed travel.

Optional Anchor Phenomenon details: Brittany and Sierra are going for a car ride. Brittany wonders why there are laws about using seat belts and car seats for kids.

**Standards**

4-PS3-1, 4-PS3-3, 3-5-ETS1-3

- **= Science and Engineering Practices** - Constructing explanations and designing solutions, asking questions and defining problems, planning and carrying out investigations
- **= Disciplinary Core Ideas** - Definitions of energy, conservation of energy and energy transfer, relationship between energy and forces, developing possible solutions, optimizing the design solution
- **= Crosscutting Concepts** - Energy and matter

**Learning Progression**

<table>
<thead>
<tr>
<th>Previous</th>
<th>Current</th>
<th>In the Next Module</th>
<th>Not</th>
</tr>
</thead>
<tbody>
<tr>
<td>In kindergarten students made observations to determine the effect of sunlight on Earth’s surface using words like warmer and cooler. (K-PS3-1)</td>
<td>Students will use evidence to construct an explanation relating the speed of an object to the energy of that object. (4-PS3-1)</td>
<td>In Module 4 students will look at the energy contained in waves. (PS4-1)</td>
<td>We are not teaching how to calculate the speed of an object. We are not trying to measure the exact force or amount of energy.</td>
</tr>
<tr>
<td>PS3-3 is not covered until 4th grade.</td>
<td>Students will ask questions and predict outcomes about the changes in energy that occur when objects collide. (4-PS3-3)</td>
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</tr>
<tr>
<td>In Module 2 students looked at the energy in sound waves. They also explored the energy needed to move objects and send information. (4-PS3-2 and 4-PS3-4)</td>
<td>Students will plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model that can be improved. (3-5-ETS1-3)</td>
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</tbody>
</table>
**Safety**

Always use caution when demonstrating any type of collision. For the toy car activities throughout the module, always roll the car on the floor instead of on top of your desk. Clear the area near the ramp and make sure the toy car will not run into anything that is not part of the investigation. If the wooden car falls from the top of a desk, the wheels may break off.

**Misconceptions**

Be on the lookout for these possible preconceived notions or misunderstandings.

- Students may think that energy can be created or destroyed. Explain that energy is not destroyed in a collision and does not disappear when the car stops. Instead, when the car collides with another car or a barrier, the energy is transferred to another object or the air.

- The word force is often used in many different contexts. (Examples: A force of nature, the Armed Forces, etc. My sister forced me to do that. May the Force be with you.) Clarify the scientific meaning used in this context as a push or pull.

**Differentiation**

Each module contains activities that can be adjusted and leveled based on learner needs.

- Links and videos are provided to help all learning styles. If several resources are provided for the same topic, have students use the presentation type that helps them learn best in their own way.

- For more information, extension videos and activities, and discussion questions, visit the Insurance Institute for Highway Safety at [https://classroom.iihs.org/](https://classroom.iihs.org/)
PHENOMENON

What do you notice or observe?

Students may say, “The girl is sitting in a booster seat. She looks older. They are both wearing seat belts.”

What questions do you have?

Students may say, “Why is an older girl sitting in a baby seat? How old are they? Why do we have to wear seat belts? Why do kids have to sit in a booster seat?”

What question has your class decided to answer?

Suggested question: “Why are there car seat and seatbelt guidelines?”

DEVELOPING A CLASS FOCUS QUESTION

1) After students record their own observations and questions in their Learning Portfolio, invite them to share their responses with each other. They can share verbally or post their questions to a central space.

2) Add additional questions and observations to guide students into developing a consensus about the focus question for the module: “Why are there car seat and seatbelt guidelines?”

3) Record this focus question at the top of the Research Log (p. 3) and on the phenomenon poster (available for download on Canvas under additional resources).
Focus Question:
Suggested question: “Why are there car seat and seatbelt guidelines?”

<table>
<thead>
<tr>
<th>Discovery 1: What is the relationship between speed and energy?</th>
<th>Observe</th>
<th>Wonder</th>
<th>Learn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students may say, “The race car is moving. It is going fast. The driver is wearing a helmet.”</td>
<td>Students may say, “How fast is the car going? What is its speed? Is it on a race track?”</td>
<td>Students may say, “My car driving on the highway has more energy than a parked car because it is moving. The faster it goes, the more energy it has. Since it has lots of energy, we have to make sure we keep ourselves safe while riding.”</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Discovery 2: What happens when objects collide?</th>
<th>Observe</th>
<th>Wonder</th>
<th>Learn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students may say, “The two cars are about to hit each other. The cars are in motion. It looks dark outside.”</td>
<td>Students may say, “What will happen? Is anyone going to get hurt? How many people are in the car? What caused the car crash?”</td>
<td>Students may say, “Collisions result in a change in motion and a transfer of energy to the surrounding air as heat and sound.”</td>
<td></td>
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<tr>
<th>Discovery 3: How can we reduce the impacts of collisions?</th>
<th>Observe</th>
<th>Wonder</th>
<th>Learn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students may say, “There is a yellow crash test dummy. It has black markings and circle on his head. It is sitting in a seat with a seatbelt on. There is metal on its neck.”</td>
<td>Students may say, “Why do we need a crash test dummy? Why is the car crash dummy yellow? Do they always look like this one? Why does it have a yellow and black circle on the side of his head?”</td>
<td>Students may say, “Crash dummies help scientists design safer cars. Seat belts reduce the impact of collisions. All safety devices, like car seats, booster seats, and seat belts, need to be used properly and worn correctly to be effective and keep children safe.”</td>
<td></td>
</tr>
</tbody>
</table>

Focus Question Results:
Students may say, “There are car seat and seat belt guidelines because cars in motion have energy and passengers need to be kept safe in case there is a collision. When two objects collide, energy is transferred through a change in motion, a change in speed, and a transfer of energy as sound and heat. When a passenger is properly wearing a seatbelt, the energy is transferred to the safety belt instead of the rider. Scientists use crash test dummies to test different designs, and they collect data to determine the most effective seat belt as well as how to properly wear it. States establish laws and car seat guidelines to keep people safe in collisions.”
CRASH TESTS
DISCOVERY 1 OVERVIEW

The investigative phenomenon picture is of a race car in motion.

Students will look at different examples of things with more or less energy. They will also experiment with cars and two different ramps.

Standards

4-PS3-1

= Science and Engineering Practices - Constructing Explanations and Designing Solutions

= Disciplinary Core Ideas - Definitions of Energy

= Crosscutting Concepts - Energy and Matter

Learning Progression

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<td>Remind students what they learned in the last module, &quot;Sending Information, through their exploration with the micro:bit about how energy can be transferred to a different place by light, heat, sound, and electricity. (4-PS3-2)</td>
<td>Students will use evidence to construct an explanation relating the speed of an object to the energy of that object. (4-PS3-1)</td>
<td>In Module 4 students will look at the energy contained in waves. (PS4-1)</td>
<td>We are not teaching how to calculate the speed of an object. We are not trying to measure the exact force or amount of energy.</td>
</tr>
<tr>
<td>In kindergarten students made observations to determine the effect of sunlight on Earth’s surface using words like warmer and cooler. (K-PS3-1)</td>
<td>In middle school, students will construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. (MS-PS3-1)</td>
<td>The word kinetic energy is used in the video but students are not memorizing the definition or trying to understand the difference between types of energy.</td>
<td></td>
</tr>
</tbody>
</table>
Safety

In the experiment of page 6, roll the toy car on the floor instead of on top of your desk. Clear out the area near the ramp and make sure the toy car will not run into anything that is not part of the experiment. If the wooden car falls from the top of a desk, the wheels may break off.

For the "Get Moving" activity, have students spread out more than an arms length apart, so they will not accidentally hit another student.

Misconceptions

Be on the lookout for these possible preconceived notions or misunderstandings.

- Energy does not specifically cause things to happen. Energy is needed to cause an action, but other factors are also necessary, including a force.

- Focus on the speed of the car increasing, not the force caused by the hand releasing it. Students should simply place the car at the top of the ramp and release it, allowing it to roll without pushing it. This will help keep the force more constant.

Differentiation

Each module contains activities that can be adjusted and leveled based on learner needs.

- Links and videos are provided to help all learning styles. If several resources are provided for the same topic, have students use the presentation type that best helps them learn in their own way.

- When an article with a higher reading level is provided as an option, there are also other articles or videos that can be used to gain the same knowledge for students who are unable to read at that level.

Activity Tips

- Gather materials in advance. Find toy cars or order one of the following block car kits early to make sure it arrives in time before you the module begins:
  
  https://www.activepowersports.com/pine-pro-10051-block-kits-bulk-10-10051


- Have extra cardboard on hand in case you need to replace the ramp after several tests.
Teacher Notes:

Another example for comparison: Have students think about how we use the word energy in the morning after we slept well. Ex: When I have a good night’s sleep, I wake up in the morning and I have lots of energy. That means I feel awake and ready to go for the day.

Remember to add the energy vocabulary card to the wall.

Remind students what they learned in the last module, "Sending Information," through their exploration with the micro:bit about how energy can be transferred to a different place by light, heat, sound, and electricity.

GATHER INFORMATION

Discovery 1: What is the relationship between speed and energy?

Have you ever heard something or someone described as having a lot of energy? When have you heard the word energy being used? What do you think the person meant when they said it? Students may say, "My mom says our puppy has a lot of energy when he is running around. She means he can’t sit still. At the end of the day, my dad says he has no energy to throw the baseball in the yard. He means he is tired and wants to sit down."

Find out about the scientific meaning of energy:

Energy and Work (stop at 1:15)
https://classroom.ihs.org/camtasia/5HhNEl227y9IHnGuQ7Q6DZTb51NBw/Energy_Explained_wQ.mp4

Energy Explained https://www.solarschools.net/knowledge-bank/energy

Why is it so difficult to define energy? Students may say, "Energy is all around us, so it is tough to understand. Energy exists in many different forms."

What is energy? Students may say, "Energy is the ability to do work." or "Energy is the ability to cause change."

What kind of energy does a car traveling down the highway have? Students may say, "Cars in motion have kinetic energy."

Make a hypothesis: On a scale of 1-5, circle how much energy you think the race car has in the picture above.

1 2 3 4 5

Explain your answer. Students may say, "I chose 5 because I predict that the car has a lot of energy because it looks like it’s going very fast." or "I chose 3 because I predict the car has some energy because it is moving, while 1 on the scale would be stopped or not moving."
If something can change or if it moves, then some type of energy is present. In each pair of photos, which picture shows objects that possess more energy? Look for objects that are moving faster than others and mark the box beside the photo.

1. ![Image](image1.png)
2. ![Image](image2.png)
3. ![Image](image3.png)
4. ![Image](image4.png)

Get Moving! Stand up behind your desk and show a few examples of different kinds of movement. Think about the difference in energy as you complete each action.

<table>
<thead>
<tr>
<th>Walk in place.</th>
<th>Wave your arms.</th>
<th>Stand still.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hop behind your desk.</td>
<td>Jump faster.</td>
<td>Sit in your chair.</td>
</tr>
<tr>
<td>Run in place.</td>
<td>Walk slowly.</td>
<td>Pretend to be asleep.</td>
</tr>
<tr>
<td>Make arm circles.</td>
<td>Pat your head.</td>
<td>Do jumping jacks.</td>
</tr>
</tbody>
</table>

Which movements were fast?

*Students may say, "Run in place, jump faster, jumping jacks."*

How can you explain your movements based on what you know so far about *speed* and *energy*?

*Students may say, "When I speed up, I have more energy. The faster I move, the more energy I use or the more energy I have or possess."*
Teacher Notes:

It is suggested that students work in groups for this activity. Have them complete 3 fair tests for the low ramp first. Measure the height of the low ramp and record it above the chart. After the car stops, measure the distance that the car travels and record. A fair test is an experiment where you only change one variable and keep all other parts the same or controlled.

Materials note: Depending on the sturdiness of your cardboard, you may need to replace it after several uses if it bends after a few trials.

Extension: Complete the activity on different surfaces to compare results. (smooth floor, carpet, wax paper, etc.) Discuss the effect of friction and refer back to module 2.

Remember to add the stationary and fair test vocabulary card to the wall.

Race Car Experiment

Try This

1. Create a ramp, or inclined plane: Tape one end of a half of a sheet of cardboard to the floor. (to keep the board from sliding and be the base of your ramp.) Place an object such as a textbook under the opposite end of the board to create an inclined surface.

2. Put an object at the bottom at the end of the ramp, such as a block of wood. (For a smaller toy car, use a smaller item like dice.) Place the toy car at the top of the ramp. Release the car, without pushing it, and allow it to roll until all movement stops.

3. Using the ruler, measure how far the object moved from the bottom of the ramp and record in the chart below.

4. Increase the slope of the cardboard by adding more or different objects under the board. Repeat steps 2-3 for the higher ramp.

Materials

Cardboard/Foamboard Wooden car/Toy Car Ruler Tape Various objects of different size

Low ramp height: ________________ High ramp height: ________________

Low Ramp Trial Results (distance moved) High Ramp Trial Results (distance moved)

1

2

3

1

2

3

Students may say, “The car travels faster or has more speed on the high one. The car reached the bottom first on the higher ramp. The car traveled farther on the higher one.”
How does changing the height of the ramp affect the speed of the car?

Students may say, “The car consistently travels faster on the higher ramp.”

What happened to the stationary object at the base of the ramp?

Students may say, “The car collided with it and pushed it forward.”

What was the independent variable in this experiment?

Students may say, “The independent variable was the height of the ramp.”

What was the dependent variable in this experiment?

Students may say, “The dependent variable was how far the object at the base of the ramp moved.”

The word “energy” comes from the Greek word “energeia” meaning activity.

What does this activity demonstrate about speed and energy transfer?

Students may say, “The faster an object is moving, the more impact it has on the stationary object it hits and moves it a longer distance.”

How you think the height of the ramp affects the distance the car traveled? What do you think would happen if you decreased the slope of the low ramp?

Students may say, “The car has more speed, so it travels faster on the higher ramp. If we lowered the ramp even more than the first time, the car would move the slowest and barely move the stationary object or possibly not at all.”

How else could you investigate that the faster an object is moving, the more energy it possesses?

Students may say, “We could roll marbles at different speeds toward a piece of foil and see how much it indents the foil. We could investigate on playground with a baseball and bat. If we move the bat slowly to hit the ball, how far does the ball go? Then try to swing the bat fast and see how much farther the ball would travel.”

If students are still struggling with the concept of energy and speed, relate it to the idea of how dangerous something is. Ex: What do you do before you cross the street? (Look both ways for cars because if a car is coming and hits me I will get hurt badly.) Well what about if I look and see a parked car? Can I cross and why? (That car is not dangerous because it is not in motion. It has no speed and no energy, so it cannot hurt me.)

Reiterate that a car going slowly would cause less harm than a car going faster because a slower car has less speed and therefore less energy.

Consider the reason for school zones, reduced speed limits in construction zones and neighborhoods, etc.
Teacher Notes:

This activity is called a Claim/Evidence/Reasoning writing task. The accompanying rubric follows on the next page.

**Phenomenon:**

What was the Discovery question you attempted to answer in this lesson?

*Suggested question: “What is the relationship between speed and energy?”*

**Claim:**

In your own words, state what speed has to do with energy.

Students may say, "The speed of an object is related to the energy of the object. If an object is moving quickly, it has more energy than an object that is moving slowly."

**Evidence:**

What facts did you learn from your research and investigations about your claims?

Students may say, "I learned that energy is the ability to do work or cause change. In my race car experiment, when the car hit the block of wood from the low ramp, it did not travel very far. When the car hit the block of wood from the high ramp, it moved farther than when it was hit from the low ramp."

**Reasoning:**

Explain how your evidence supports the claim you have made about the phenomenon.

Students may say, "The higher ramp caused the car to move faster (more energy) and the car was able to move the block of wood farther. The energy from the car was transferred to the block of wood, causing the block of wood to move. This taught me that the faster an object is moving, the more energy it possesses."

Return to your Research Log and fill in the Learn section for Discovery 1: What is the relationship between speed and energy?
Fill in the rubric to assess students’ learning through the “Claim, Evidence, Reasoning” (CER) task on the previous page.

<table>
<thead>
<tr>
<th>CER Rubric</th>
<th>YES (____ points)</th>
<th>NO (____ points)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student’s response correctly explains one or more ways speed is related to energy.</td>
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<tr>
<td>Student’s response uses evidence to support the claim. Student explains what happened in the experiment that was conducted.</td>
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<td></td>
</tr>
<tr>
<td>Student’s reasoning correctly explains the transfer of energy.</td>
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