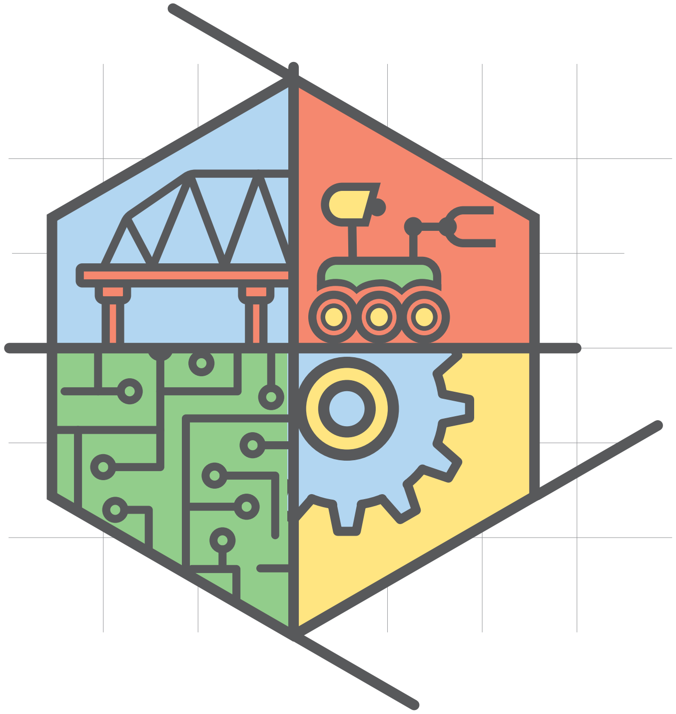

Forces & Interactions

3rd Grade Physical Science Unit

A digital copy of this document is available on the STEM Materials Center website at:
https://www.stemmaterials.org/forces_and_interactions/

STEM
Science
Technology
Engineering
Math

A program of Educational Service District 112 supporting Next Generation Science Standards

Background on the Core Scientific Ideas in this Unit

WHAT WILL STUDENTS KNOW AT THE END OF THIS UNIT?

This 3rd Grade Physical Science Unit accompanies the kit for **Forces and Interactions**, and weaves together various FOSS investigations from the Models and Designs, Variables, and Electricity and Magnetism kits in order to align with Next Generation Science Standards for 3rd Grade. Students embark on a mission to create a campaign which promotes seat belt use for a teenage audience. In the context of this project, students investigate the effects of balanced and unbalanced forces acting on an object and collect evidence to write a claim based on evidence for why seatbelts are important.

Throughout the unit, students engage in several engineering tasks which help them to understand the effects of force on a moving object and to explore how devices can be used to increase passenger safety during driving. STEM-related career connections are embedded throughout specific parts of the unit where students are engaging in the practices and building of the competencies that are used by STEM professionals in the field.

UNIT OVERVIEW

Lesson No.	Duration	Standards	Materials Needed	Focus	Assessment Options
1 page 6	5-6 sessions	3-PS2-1	Computers, apple, teddy bear, balloons, straws, scissors, masking tape, pennies, clear plastic cup, Index card, string	**Engage: Who needs seat belts?!** • Engage with topic by thinking about car safety and seatbelts. • Construct explanations and create an initial model of interaction between car, passenger and seat belt. • Explore balanced and unbalanced forces through inquiry lab stations. • Create before/during/after and force diagrams to show balanced and unbalanced forces? • Modify initial models after inquiry stations.	Formative Assessments: Initial models, BDA diagrams, free body diagrams, revised initial models after inquiry
2 page 12	4-6 sessions	3-PS2-2	Strings (50 cm), paper clips, pennies, pencils, meter tapes, playdoh	**Explore: Pendulum Predictions** • Study the phenomenon of a pendulum and create a diagram to illustrate the patterns they observe. • Investigate how different variables effect the swing of the pendulum and identify observable patterns. • Draw a before/during/after diagram to illustrate pendulum movement. • Create a model that uses patterns and evidence to predict future movement of pendulum. • Investigate how height of drop affects force of impact.	BDA Diagrams, model illustrating pendulum movement, Pendulum Probe.
3 page 17	5-6 sessions	3-PS2-1 3-PS2-2	Sticks (long medium, and short), wooden boards, cardboard, binder clips (small), wooden hubs, washers, Recyclable materials: empty juice/milk cartons, paper towel rolls, plastic, etc.	**Explain: Engineering Go-Carts** • Engineer a cart that rolls down a ramp. • Plan and conduct an investigation to show how balanced and unbalanced forces affect the movement of the car. • Construct an argument based on evidence for the effects of net force on motion of car. • Create a model to show direction and magnitude of forces acting on car. • Communicate findings and CER argument with other classmates.	Presentation communicating findings to class

UNIT OVERVIEW (cont.)

Lesson No.	Duration	Standards	Materials Needed	Focus	Assessment Options
4 **page 22**	4-5 sessions	3-PS2-1 3-5-ETS1-1	Students' carts, other materials from previous investigations, empty milk/juice boxes, paper tower rolls, rubber bands, tape, and misc. building materials.	**Elaborate** • Engineer a device that can keep a play-doh person safe from getting injured in a crash. • Write a scientific CER argument to connect observations of device to the importance of seat belts in real-life.	Diagram of safety device, CER argument
5 **page 26**	5 sessions	3-PS2-3 3-PS2-4	**FOSS Kit Materials for Electricity and Magnetism** Investigation 1: Magnets, iron filings, test object sets, washers, paperclips, other misc. objects for students to test.	**Elaborate (cont.)** • Engage by studying several magnetic phenomena and create a KLEWS chart about magnets. • Create a drawing showing the interactions between magnets. • Investigate the interactions between magnets and magnetic vs non-magnetic objects. • Imagine and engineer a prototype drawing of a device that uses magnetic properties to increase driving safety.	KLEWS Chart, drawings of magnetic interactions, prototype drawing of device with explanations.
6 **page 30**	5-6 sessions	3-PS2-1 3-PS2-2	Computers with internet access, posters, markers	**Evaluate** • Create memes to campaign the importance of seat belts for safe driving. • Write a CER argument that explains why seatbelts are important for safe driving.	Memes and presentations Summative assessment: CER Argument

LESSON 1: Who needs seat belts?!

Strategy: Engage

Engage students by presenting a driving question that connects to real-life phenomenon.

In this Unit, students will study the importance of seat belts and safe driving practices in preventing injury during a car collision. Their investigations of balanced and unbalanced forces will be anchored in the context of their Unit project, which involves creating a campaign to help teenagers understand the importance of wearing seat belts while driving. Students will use science and engineering practices to investigate this phenomenon, develop their understanding, and collect evidence about the forces and interactions involved in the process of driving and safety.

All ESD-created Teacher Resources and materials are in this Google Drive folder

Setting the stage and thinking about the question (2-3 days):

Are seat belts important for safe driving? Present students with these slides with statistics about teenagers and seat belt use. Then, facilitate a discussion where students share their thoughts on the topic. How do they feel about wearing a seat belt? Have they ever not wore a seat belt for some reason? Why might a teenager choose not to wear a seat belt? Extend the conversation by asking students: what other laws and rules do we have that try to protect people from getting hurt during a car collision (ex. speed limits, stop lights, other traffic rules)? Read article and facilitate discussion using this readworks article about seatbelts and safety.

Creating an initial model:

Present students with this video of a car collision. Have students think about the forces acting in this situation. What forces have they felt while driving in a car? What happens when you are driving in the car and brakes slam really hard? Have students create a model of the dummy in the car during a collision. Can they use arrows to represent these forces? Hint: How does the dummy move? How can we choose arrows to show the movement? How might the seatbelt help keep the person (dummy) safe? What other driving practices are important in keeping a driver safe? These are just initial thoughts and ideas and do not need to be completely coherent at this point, as students will continue to deepen and refine their understanding throughout the Unit.

Materials Needed

- computers
- apple
- teddy bear
- balloons
- straws
- scissors
- masking tape
- pennies
- clear plastic cup
- index card
- string

Social Studies connection:

Ask students if they have traveled to other parts of the world where people did not wear seat belts? Do people in other parts of the world wear seatbelts? Facilitate a discussion where students can share their experiences. Next, have students look at data from around the world. Which countries have a higher percentage of people using seat belts? Which countries do you observe that have the lowest rates? Why do they think that there is there such a difference in seat belt use? Graph of data from different countries. Original Data Source

Math connection:

Have students analyze and interpret the bar graph. Students in 3rd grade may have only an emerging understanding of percentages. Present the bar graph in scaled form. Ex. ask students if the bars for different countries are showing "almost all," "almost half," "a quarter," "most," "some," or "almost none" of the population wearing the seatbelt. Students are practicing using precision of language to analyze the graph and express their thinking. This bar graph can also be presented first without any labels so students can try to come up with ideas about what the bars might be showing. Then labels on different axes and names for countries can be revealed one by one, with the U.S. being presented last. Quantities can also be changed to fractions to help students understand the relationship between the numbers.

Exploring Balanced and Unbalanced forces (3 days)

- Ask students to think about the investigative question for these lab stations: Why does an object move or why doesn't an object move? Students will be interacting with several simple investigations and will study the forces (whether balanced or unbalanced) acting on different objects. As described in PS2.A: Forces and Motion, students should be able to describe that forces have both strength and direction. Students will demonstrate their understanding of this DCI by creating free-body diagrams to represent the forces acting on objects using arrows with varying direction and magnitude.

Teacher Demonstration:

- Place an object (ex. apple) on a desk. Ask students to identify if there are any forces acting on the apple. If students are not able to identify forces, as the following questions: Is there a force that keeps the apple on the table and keeps it from floating away? Is there a force that keeps us on the ground instead of floating around in space? (Gravity) If gravity is so strong, why don't we just fall to the middle of the earth? Is there force that keeps us up? Yes, the force of the ground (called "normal force" in Science). If something is sitting on a table, then the force of the table is pushing up.
- Build a free-body diagram of an object at rest together with students. Then, give students the example of a skydiver who is falling in the sky using this video of skydivers. What are the forces acting on him? Which force is strongest? How do you know? How can we show that the force of gravity is higher than the force of the air pushing up? (Draw a longer arrow in the downward direction).
- Have students create a simple diagram of the forces acting on the skydiver before and after pulling the chute. Use these questions to prompt students' thinking: how are the skydivers moving before they pull the chute? What are the forces acting on them? How are the skydivers moving after they pull the chute? What forces are acting on them now?

LESSON 1 (cont.)

Teacher Demonstration continued:

- **Introduce students to the free-body diagrams (force diagrams).** A free body diagram is a way to show the forces that are acting on an object and what direction they are acting in (please view ***teacher resources*** below). NGSS asks that students to identify the direction and strength of a force acting on an object in relation to other forces, free-body diagrams are one way to have students think about the strength (magnitude) and direction of a force using a visual representation. Introduce students to the idea of a free-body diagram and ask: What do the arrows in a free body diagram mean (the forces acting on the object and the direction they are pushing or pulling the object)? How can you tell what direction an object is moving based on the free body diagrams (biggest arrow represents strongest force, so object will move in that direction)? How about an object that isn't moving, are there any forces acting on it (yes, but the forces are balanced)? Give students the freedom to represent forces however they make most sense to them (ex. some students may choose to use thickness of an arrow to show magnitude while others may choose to use length/size). Examples of free-body diagrams

FORCE LAB STATIONS:

Teacher Resource Guide
Force Lab Station Signs
Have students rotate amongst various inquiry-based force stations where they observe various phenomena and create a BDA Diagram or free-body diagram for each station. Labs can also be conducted as demos or stand-alone lab activities.

Connect with the storyline:

Now that students have started exploring balanced and unbalanced forces, have them revisit the phenomenon of a car collision. Revisit the collision-test video. How was the test dummy moving during the collision? (Ask students to act out the movement or use their arms to wave direction of movement). Can you use an arrow to represent the direction of movement in your model? Was there a time when forces were balanced? Was there a time when forces were unbalanced? How did the airbag and the seatbelt help the test dummy stay safe? How can they modify their initial model to include arrows showing the forces acting during a collision? Ask students to use the SEP of developing models to create BDA Diagram showing how forces were acting in the collision. This scaffolded BDA diagram template can be used to help students visualize the event: example of a completed BDA diagram.

LESSON 1 (cont.)

Then, reconnect to the driving question by having students think about how they will use what they learned to convince teenagers to wear seatbelts. In their Campaign Log, have students begin to discuss and jot down at least a few pieces of evidence that the retrieved from this lesson to use as evidence to support their claim about why seatbelts are important in safe driving. What evidence did they find in their mini-labs that they can use to convince teenagers that seatbelts are important? How are the scientific ideas of balanced and unbalanced forces being observed during a car collision.

Teacher Resources:

Physics Classroom Lesson on Drawing Free Body Diagrams

Introduction to Free Body Diagrams or Force Diagrams

Free Body Diagrams Lesson

How Lesson 1 Supports Next Generation Science Standards

3-PS2 Forces & Interactions

The materials/lessons/activities outlined in this activity are just one step toward reaching the Performance Expectations listed below. Additional supporting materials/lessons/ activities will be required.

https://www.nextgenscience.org/dci-arrangement/3-ps2-motion-and-stability-forces-and-interactions

Peformance Expectation	**Connections to Classroom Activity,** *Students:*
3-PS2-1 Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.	• Students explore a series of investigations and describe the interactions between forces in these investigations. • Students describe the strength and direction of forces acting on an object. • Students create diagrams to illustrate the strength and direction of forces acting on an object. • Students identify and illustrate the source of the forces on objects during an investigation. • Students identify and illustrate the impact of the force of gravity on an object. • Students describe the cause and effect connection between balanced and unbalanced forces and the movement of an object. • Students analyze and illustrate the forces acting on an object before, during, and after an event.
SCIENCE & ENGINEERING PRACTICES	
Asking Questions Developing and Using Models	• Students carry out various investigations at inquiry stations to identify how balanced and unbalanced forces can affect movement. • Students create and modify a model to illustrate the forces acting in various events including a car crash.
DISCIPLINARY CORE IDEAS	
PS2.A: Forces and Motion	• Forces have both strength and direction and can be represented using arrows of different lengths. • When the forces acting on an object are balanced, the net force equals zero, and there is no movement. • When the forces acting on an object are unbalanced, change in magnitude or direction occurs in the direction of the greatest force.

How Lesson 1 Supports Next Generation Science Standards (cont.)

CROSSCUTTING CONCEPTS	
Cause and Effect	• When there are balanced forces acting on an object, there is no change in speed or direction. • Unbalanced forces cause movement. • Gravity causes an object to be pulled down towards the earth.

LESSON 2: Pendulum Predictions

Strategy: Explore

Students will explore how different variables affect observable patterns through the use of pendulums.

Present students with the following investigative phenomenon using this video of pendulums to think about before the lesson. What seemed to be happening in this video of pendulums? What patterns did they observe? Why don't all the pendulums move the same way? Why is each one moving differently? Ask students to share their thinking and work in teams to create a drawing/model to explain the patterns they observed.

Here are some additional pendulum videos for students to explore.
Ask students, "What evidence of patterns can you see in these videos?"
Sand pendulum
Paint dripping pendulum

FOSS kit variables: Investigation 1 Swingers (3-4 sessions)

In this investigation, students will create a pendulum and will study how different variables affect the movement of the pendulum. In NGSS, the DCI focus is on students *identifying patterns to predict future movement* instead of focusing on the scientific method and manipulation of variables.

Swingers Part 1: Have students engage in the FOSS investigation. Extend investigation to address the DCI by bringing students' attention to the variable of string length. How can they plan an investigation to test how the length of the string affects the swing? What variables can they look at? Ask students to identify different data that they will collect to answer the question. What happens to the number of swings in 15 seconds when the string is shorter vs longer? What patterns are they observing? Is there a difference in the number of swings based on length of string? Ask them to work in their teams to write a statement that explains the pattern they observed. Use a sentence frame to help students create the statement (ex. A ______ string results in _________ number of swings). Why might that be? Ask students to think of why the length of the string affects the number of swings. Have students log their ideas.

Swingers Part 2 & 3: This investigation expands on the idea that string length relates to the number of swings in 15 seconds by having students create a physical representation of the data on a number line.

Materials Needed

FOSS Kit Materials for Investigation 1: Swingers

- 2 strings (50 cm)
- 2 paper clips
- pennies
- 2 pencils
- 1 meter tape
- masking tape

Additional materials for storyline extension activity:

- Playdoh

LESSON 2: Pendulum Predictions (cont.)

Swingers extension using phET simulation:

Ask students to investigate the variable of height. How does the height of the drop affect how far up the pendulum will travel? Students will have to set up two measuring tapes to measure the height of the drop and the height it travels. Here is an online printable measuring tape. Have students write a statement explaining the relationship they found using a sentence frame: "The higher we drop the pendulum from, the ________ it will go. The lower we drop the pendulum from, the ________ it will go." Students can then test and refine their models using the phet simulation. Use the evidence from the phet simulation to test and see if their model is accurate.

Other potential discussion prompts that connect to ideas in Lesson 1:

- Ask students to remember, "how can we tell if the forces acting on an object are balanced or unbalanced?" (forces are balanced when an object is not moving and unbalanced when an object is in motion). When is the pendulum moving? Is it ever still?
- What are the forces acting on the pendulum? What made the pendulum move back and forth in the first place? Have students draw a BDA diagram. Where in the swing are forces acting on the pendulum balanced? Where are they unbalanced? How can you tell?
- How many times is the pendulum able to swing? What happens to the swing after some time? Why do you think that is? Why does it slow down?
-

FORMATIVE ASSESSMENT POSSIBILITY:

Have students engage in this Paige-Keeley-style probe to assess their understanding of the pendulum investigations.

LESSON 2: Pendulum Predictions (cont.)

Investigation Extension: Play-doh Pendulums (1-2 sessions)

In order to engage students in learning within the context of the storyline and to help students deepen their understanding of balanced and unbalanced forces, present students with this investigation extension:

Have students use their pendulums from the previous investigations and attach a playdoh ball around the paperclip. Essentially, they will now have a pendulum with a playdoh ball at the bottom. Have students hang their pendulum near a wall (or hard surface) so that they will be able to collide their playdoh pendulum to this surface. Provide students with a question to investigate: "How does the height at which you drop the pendulum affect the amount of force when the playdoh ball hits the wall? What happens when you change the variable of how high it is dropped?" Ask students to plan how they will collect data (ex. measuring the height at which the pendulum is dropped and the observed damage to the playdoh ball). Also, ask students what variables need to be controlled (ex. make sure that the ball is not being swung with force or results will not be valid!) Ask students to analyze their data, and identify patterns. Then, students can use their observations to craft a prediction: "The higher we drop the pendulum from, the ________ the force of collision. The lower we drop the pendulum from, the ________ the force of collision."

This student sheet can be modified to accompany this investigation

If teams finish early, they can also study the relationship between size of the playdoh ball (mass) and the force of impact (how does the size of the ball affect the amount of damage it experiences when dropped from a certain height).

Math connection:

Ask students to attend to the precision of their measurements. Ask them to measure the length of string and height of drop using rulers and a meter stich marked with halves and fourths of an inch. Students may require a mini-lesson on how to use a ruler to measure to fourths of an inch.

Reconnect to the Campaign:

What did we learn about what happens when there's more force in a collision? What evidence from our Swingers and Playdoh Pendulums Investigations can we use to help teenagers understand the importance of safe driving practices (such as seat belts and following speed limits)? Have students revisit their Campaign logs and cite specific pieces of evidence that they think would be helpful. Since the focus of this lesson was not as much on seat belts, gives students the freedom to talk about how general traffic rules such as speed limits might prevent damage during a collision.

How Lesson 2 Supports Next Generation Science Standards

The materials/lessons/activities outlined in this activity are just one step toward reaching the Performance Expectations listed below. Additional supporting materials/lessons/ activities will be required.

https://www.nextgenscience.org/dci-arrangement/3-ps2-motion-and-stability-forces-and-interactions

3-PS2 Forces & Interactions

Peformance Expectation	**Connections to Classroom Activity,** *Students:*
3-PS2-2 Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. .	• Students observe the pattern of movement of a pendulum and collect data. • Students analyze data about movement of pendulum and identify patterns in the length of the string and the number of swings. • Students collect and analyze data about the height at which the pendulum is dropped and the height at which it travels. • Students use their observable patterns to make a statement that predicts the motion of the pendulum. • Students study how height of drop and mass affect force of a collision.
SCIENCE & ENGINEERING PRACTICES	
Analyzing and interpreting data Using Mathematics and computational thinking	• Students conduct an investigation to collect data about the swing of pendulums. • Students analyze data and identify patterns. • Students construct explanations to describe the movement of the pendulum and to make predictions about its movement. • Students investigate how the variables of drop-height and pendulum mass affect the force of impact.

How Lesson 2 Supports Next Generation Science Standards (cont.)

DISCIPLINARY CORE IDEAS	
PS2.A Forces and Motion	• The patterns of an objects movement can be observed and measured. Students observe the movement of a pendulum and collect data. • Patterns can allow us to predict future motion of an object. Students make predictions of the movement of the pendulum based on patterns that they identified. • Students study how force of a collision is affected by variables such as height of drop and mass of ball.
CROSSCUTTING CONCEPTS	
Patterns	• Students observe the phenomenon of a swinging pendulum and collect data in order to identify patterns. Students then use these patterns to predict future movement based on variables. • Students identify patterns relating the drop-height and mass of pendulum to the amount of force resulting from a collision.

LESSON 3: Engineering Go-Carts

Strategy: Explain

Students will be studying and explaining the effects of balanced and unbalanced forces by creating and experimenting with go-carts.

First, students will engage in the engineering design process to create carts that can effectively carry a "play-doh person." This engineering process may take several class sessions. Try to provide them with a variety of materials to experiment with.

Adaptation of FOSS Investigation 3.1: Free Rolling Go-Carts (3 sessions):

This investigation was originally in the 5-6 grade kit. Please see scaled changes in the lesson framework below. The following lesson is an attempt to provide 3rd graders with more support in order to successful engineering a go cart.

Engineering connection: **Engineering Carts:**

This slide presentation can be used to teach this lesson. It includes guidelines to support students during the engineering design process. Discuss the design challenge with the students: The goal of the cart is to roll down the ramp. What design features will be important in helping the cart roll down nicely? What are some barriers that may prevent that from happening? Have students work in teams to build their free rolling go-carts using materials provided and guide them through the engineering process. *Note: Give students the option of using the wooden hubs as wheels (they will be sturdier).*

Guide students through the Engineering Design process, giving time and feedback for students to plan, design, check, optimize, and share with the class. Slides to scaffold the design process:

1. **Brainstorm and Plan:** What are important parts of the car? What should the car be able to do? What materials will you use?
2. **Design:** Build the car and test out different materials to see what works best.
3. **Check:** Does your car perform everything it is supposed to (roll down a ramp, roll when pushed, can carry a p lay-doh person).
4. **Share:** Talk with the class about how your team build the car and the challenges that you had.

Creating free-body diagrams: Why does the cart move when it's on the ramp but not really when it is lying flat? Ask students to work in teams to make two different free-body diagrams, one of cart lying flat on a table, and the other of the cart moving down the ramp. What are the forces acting on the cart in both situations? In which situation are the forces balanced? In which are the forces unbalanced? Make predictions about what will happen. (Boundary: the focus is simply on the strength and direction of the force, and students can focus on only 2 forces). Sample force diagrams

Materials

FOSS Kit Materials for Investigation 3: Free Rolling Go-Carts:

- Sticks (long medium, and short)
- wooden boards
- cardboard
- binder clips (small)
- wooden hubs
- washers

Other recyclable materials:

- empty juice/milk cartons
- paper towel rolls
- plastic

LESSON 3: Engineering Go-Carts (cont.)

TEACHERS RESOURCES:

- Sample video of design challenge with early elementary
- Sample video of design challenge with upper elementary

Supplemental TeachEngineering.org Lessons:

- Form vs. Function
- Cars: Engineering for Efficiency: This lesson can also be taught in conjunction with or as an extension of students engineering their carts.

Planning and conducting an investigation on Balanced and Unbalanced forces (2 sessions):

Utilize the SEP of planning and carrying out investigations in the context of DCI PS2.A, to answer the question: how do balanced and unbalanced forces affect an object's movement? Ask students to think about their car: how can they tell when forces are balanced? How about when forces are unbalanced?

- **Planning and Testing:** How can they investigate the effects of balanced and unbalanced forces on their car? When they were experiences balanced and unbalanced forces in their stations, or observing patterns with pendulums, how could they tell when forces were balanced or unbalanced? How can this be tested? Examples of variables that can be manipulated during investigation (varying strength of push, pushing car on different surfaces like tile, carpet and grass, forces and counter forces being applied in different directions). Have students come up with a method they will use to collect data. How will their data help them to answer the guiding question?
- **Analyzing and Interpreting Data:** After students have started collecting data to answer the guiding question, they will engage in the SEP analyzing and interpreting data: what are some patterns they observed? What happened when the forces acting on the object were balanced? What happened an unbalanced amount of force was applied? How did the strength of a force affect whether or not it moved? How did the direction of the force affect how the object moved? Ask students to identify patterns and have teams share their findings as a class.
- **Constructing an Argument from Evidence:** Have students use their patterns to construct an argument from evidence. Does the pattern in your data support the conclusion that the movement of your object is related to the forces acting on it? Why or why not? Have students construct a model to explain their argument. Students can use sentence frames to construct their argument ("If forces are_________, then the cart will __________. If forces are __________, then the cart will __________.) Graphic Organizer for creating a CER argument.
- **Creating a Model:** Ask students to draw a model and use arrows to show the direction of forces acting on their car and the resulting motion (or lack of motion). Students can also add an arrow to show the direction the object is moving.
- **Communicating Findings:** Facilitate a gallery walk where students can share their models with other groups. Have students make sure that the presenters for their groups know how to explain the model to other classmates. One (or two) team member/s will stay with the model while other team members circulate the classroom.

LESSON 3: Engineering Go-Carts (cont.)

FOSS Investigations 3.2 and 3.3 (Optional extension): Self-propelled Go-Carts

This investigation is optional. The teacher can perform this lesson as a demo (building self-propelled carts may be too challenging for many 3rd graders based on their developmental age). Build the self-propelled cart and demonstrate it for students. Have several trial runs and have students create diagrams to explain the forces that are acting in order to make the cart move.

Create a BDA diagram with drawings to show:

1. What was happening to the cart before we let it go? If you used rubber-bands to "charge" your cart, how did that create a force? Before we released the car, were forces balanced or unbalanced?
   What happened when we released the car?
2. What was happening while your cart was moving forward? Were forces balanced or unbalanced?
   How do you know?
3. What happened after your cart stopped moving. Were forces balanced or unbalanced, how do you know?

Connect with the storyline:

Ask students to shift gears to reconnect with the storyline. Now, instead of thinking about the outside of the car, ask students to think about what is happening on the inside of the car. Have students re-watch the crash-test dummy video and talk about what is happening in the hangar of the car. Ask students to work in teams to revise or recreate their initial a BDA diagram for the event. Are forces balanced or unbalanced during different parts of the event? How can you tell? Then, students can revisit their Campaign Log for teenagers and write down any information they think may be useful and convincing for their campaign.

How Lesson 3 Supports Next Generation Science Standards

The materials/lessons/activities outlined in this activity are just one step toward reaching the Performance Expectations listed below. Additional supporting materials/lessons/ activities will be required.

https://www.nextgenscience.org/dci-arrangement/3-ps2-motion-and-stability-forces-and-interactions

3-PS2 Forces & Interactions

Peformance Expectation	**Connections to Classroom Activity,** *Students:*
3-PS2-1 Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.	• Students plan an investigation using their go-cart to study the effects of balanced and unbalanced forces on their car. • Students identify the type of data they will collect. • Students conduct the investigation and interpret their data to identify patterns in their findings. • Students construct a model to explain their findings and support an argument based on evidence on how balanced an unbalanced forces affected the movement of their car.
SCIENCE & ENGINEERING PRACTICES	
Planning and Carrying out Investigations Analyzing and interpreting data Engaging in Argument from Evidence Communicating information	• Students plan and conduct their investigation. Students identify which variables they will manipulating and how their data will help them answer the guiding question. • Students analyze their data, find patterns, and construct an argument based on their data to answer the guiding question. • Students create a model to show their findings and support their argument. • Students present their findings and their arguments to their classmates.

How Lesson 3 Supports Next Generation Science Standards (cont.)

DISCIPLINARY CORE IDEAS	
PS2.A Forces and Motion	• Students conduct an investigation to study the impact of balanced and unbalanced forces on an object. • An object that has no net force acting on it will be at rest, while an object that has a net force acting on it will be moving in the direction of the net force. • Each force acting on an object has both strength and direction.

CROSSCUTTING CONCEPTS	
Cause and Effect Patterns	• Students study how the application of forces that vary in magnitude and direction have an effect on an object's movement. • Students identify patterns in how balanced and unbalanced forces affect movement.

LESSON 4: Be Safe!

Strategy: Elaborate

Part 1: Creating a safety device that restrains (4-5 sessions)

Seatbelts for all vehicles, or not? Have students watch this video of professional biker, Matt Jones doing tricks on his bike. Why wouldn't Matt want to have a seat belt? Facilitate a discussion where students can talk about the CCCs of Cause and Effect.

Connect with the storyline:

Now that students have created go-carts, they will serve as models for us to experiment about driving safety. Revisit the investigative question with students: "Can seat belts prevent injury during a car crash?" Ask students to share what they have learned throughout previous experiments about how forces can affect movement. What happens to a person when a car crashes? What forces are acting? Have students work in teams to look at their initial models from Lesson 1. What knowledge have they acquired that can help them improve their model?

Career connections:

Introduce students to Georg Mueller using this video, Johnson Control's Engineer of Safety Testing. What types of things is Georg doing in his job? How is his job an important one in the world?

Engineering connection: **Engineering Design Challenge**

In this part of the lesson, students will engineer a device that can keep a play-doh person from getting injured during a cart crash. This slides presentation can be used to help scaffold the process.

- Creating the passenger: Ask students to create a play-doh (or clay) person that will be able to ride on their cart. What are the important parts of the person that should be included (head, arms, legs, torso, neck)? Ask students to place the person on the cart and to do a 2 meter test. What happened to the play-doh person? Ask students to do at least three runs, and to catalog their findings.
- Then, ask students to put their play-doh person back on their go-cart and then crash their cart into a book (the crash has to be a little forceful if you would like students to see the passenger fly off). What happened to the play-doh person? Ask students to repeat the test at least 3 times and to identify patterns of movement of both the car and the passenger during the collision. What happened to the car when it hit the book? What happened to the play-doh person when the car hit the book? What patterns do you see? Ask students to discuss and write down a pattern that they observed.

Materials Needed

- Carts and other materials from previous investigations,
- empty milk/juice boxes
- paper tower rolls
- rubber bands
- tape
- misc. building materials

LESSON 4: Be Safe! (cont.)

Career connections:

Show students this video about the evolution of crash-test dummies and ask them why this is such an important career when studying the safety of cars. What are some things that are important when creating a crash-test dummy, and why?

1. **Plan:** What is the problem we are trying to solve? What are our requirements? What are our limitations? What ideas do we have?
2. **Design:** create a device or structure to keep your play-doh person safe. What are the parts of the device? What are the functions of each part? What materials will you use to build it? What are your best options? How are you using each team member's ideas to make the best possible prototype?
3. **Check:** How can you *test* it? How do you know that your device is working? *Test* the device. Do several trial runs and write down your observations in your Science notebooks. How can you make adjustments to make the prototype even better?
4. **Share your results with the class**. What were special features of your device that helped it protect the passenger? What are ways you might be able to improve it? What were some challenges your team faced?

Connect with the storyline:

Ask students to collect evidence that you found in this investigation can be used to support why seat-belts are important and to convince a teenage target audience. Have students log their findings in their Campaign Logs.
You can also link to this "how stuff works" page for additional information.

Here are questions to prompt thinking:

5. What forces were acting on your car? What forces were acting on your person?
6. Were forces balanced or unbalanced?
7. What happened to your play-doh person when they were not secured to the cart?
8. Did your device exert any force on the person? How did your device help to keep your play-doh person safe? How did your prototype help to keep your person from flying off the car? *(Note: students should be able to explain that the safety belt exerts a force in the opposite direction that the person is moving, creating balance, and preventing the passenger from flying out of the vehicle).*
9. How is your device similar to a seatbelt? How is your device different from a seatbelt?

Teacher resources:

Video about design challenge

How Lesson 4 Supports Next Generation Science Standards

The materials/lessons/activities outlined in this activity are just one step toward reaching the Performance Expectations listed below. Additional supporting materials/lessons/activities will be required.

https://www.nextgenscience.org/dci-arrangement/3-ps2-motion-and-stability-forces-and-interactions

3-PS2 Forces & Interactions

Peformance Expectation	Connections to Classroom Activity, *Students:*
3-PS2-1 Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. 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.	• Students describe the motion of the car and the play-doh person and the forces they exert on each other. • Students collect data to identify forces acting on the play-doh person and to minimize the forces that can cause injury. • Students describe how unbalanced forces acting on a person can cause injury in the case of a car crash. • Students design a device to reduce net force acting on a person caused by impact of the vehicle. • Students test and refine their devices. • Students explain how the concepts studied were used to design and improve their safety device.
SCIENCE & ENGINEERING PRACTICES	
Designing Solutions Engaging in an Argument from Evidence Communicating information	• Students use their conceptual understanding of balanced and unbalanced forces to construct a device that reduces net forces acting on the play-doh person. • An object that has no net force acting on it will be at rest, while an object that has a net force acting on it will be moving in the direction of the net force. • Each force acting on an object has both strength and direction. • Injury during a car crash is caused by an unbalanced force acting on a passenger. The goal of the safety device is to apply a counterforce that will balance out the net force due to a collision.

How Lesson 4 Supports Next Generation Science Standards (cont.)

DISCIPLINARY CORE IDEAS	
PS2.A Forces and Motion	• Students use their conceptual understanding of balanced and unbalanced forces to construct a device that reduces net forces acting on the play-doh person. • An object that has no net force acting on it will be at rest, while an object that has a net force acting on it will be moving in the direction of the net force. • Each force acting on an object has both strength and direction. • Injury during a car crash is caused by an unbalanced force acting on a passenger. The goal of the safety device is to apply a counterforce that will balance out the net force due to a collision.
CROSSCUTTING CONCEPTS	
Cause and Effect Patterns	• Students study how impact can cause forces acting on a passenger to become unbalanced. • Students identify patterns in how balanced and unbalanced forces affect movement of a person driving inside a vehicle.

LESSON 5: Magnets

Strategy: Elaborate

In this lesson, students will be studying the effects of magnetic forces on the interaction between objects. Students will then imagine and design a driving safety device that uses concepts of magnetism to prevent car crashes or reduce injury.

Engage students by showing the following videos of this investigative phenomenon:

- Neodymium magnet
- Dropping a neodymium magnet through a thick copper pipe

Ask students to make observations and ask questions. What do they observe is happening? What questions arise from their observations of magnets? Work with students to create a KLEWS chart about magnets.

Materials

FOSS Kit Materials for Electricity and Magnetism Investigation 1:

- magnets
- iron filings
- test object sets
- washers
- paperclips
- other misc. objects for students to test.

FOSS Investigation 1: The Force (3 sessions)

Before starting the FOSS investigations, it may be helpful to re-frame the context for learning to align with the DCI PS2.B: Types of Interactions which discusses how magnetic forces cause objects to interact even though there is no physical contact. Mix the iron filings provided in your kit with some type of small-grained material (like rice, wheat, quinoa, etc.). Provide students with magnets and ask them to separate the iron filings from the grains. Let students explore, then ask them what they observed.

- What direction were the iron filings going?
- Is there evidence that there was a force acting on the iron filings (yes, because they moved!)?
- What evidence showed that there was a force present?

LESSON 5: Magnets (cont.)

FOSS Investigation 1: The Force (3 sessions) cont...

- What happened to the force as you moved the magnet away from the filings, versus when you move the magnet closer?
- Ask students to create a drawing showing the interaction between the magnet and the iron filings. Can they draw arrows to represent the direction of the force that was *causing* the pull? What was the *effect* of that pull?

Part 1: Investigating magnets and materials.

Allow students to test various objects in their test bag and explore other objects in the classroom.
Re-direct students' attention to not only look at whether objects are magnetic or not, but to ask questions and observe how distance (between objects), and feel of material has an impact on the magnetic force between the magnet and different objects. When students are debriefing in their groups, ask them to come up with questions that highlight certain things they observed in the way the magnetic (or non-magnetic) objects interacted with the magnets.

- What is cause and effect relationship between the magnets and the objects that are magnetic?
- When students explore the attractive and repulsive forces between the magnets, ask students to come up with questions describing what they observe.
- How was the repulsive force different than the attractive force that they just observed?
- What determines whether the magnets exhibit a repulsive or attractive force?
- How can they manipulate this?

Have students watch this video about 9 cool magnetic gadgets and identify whether there is an attractive or repulsive force (or both) acting on the objects that are interacting. You can pause the video after each gadget is presented so students can discuss in pairs before sharing their thoughts with the class for discussion. Have students work in teams to add to their KLEWS charts.

Part 2: Investigating more magnetic properties. Have students continue through Part 2 of this investigation.

- Ask students to write down any additional observations.
- The DCI PS2.B asks students to make connections with the distance between objects and the strength of the magnetic force between.
- Ask students to make observations about distance and magnitude of force. Have students work in teams to revisit and add to their KLEWS chart.

Part 3: Detecting the force of Magnetism. Have students create mystery magnet boxes and play the magnet detecting game.

- Ask students to talk with their teams about the strategies that worked to help figure out where the magnets were located. What are the properties of magnets?

LESSON 5: Magnets (cont.)

Part 4: Detecting the force of Magnetism continued...

Connect with the storyline:

Connect with the storyline and present Imagination/Innovation Challenge (1-2 sessions):

Present students with the following challenge: using what you learned about magnets, and what you know about balanced and unbalanced forces, create a device that will reduce the negative impacts of a car crash. The device can either be something inside the vehicle that protects the passenger during and after impact, OR something that is a part of the outside structure of the car that can prevent a car crash from happening.

Students should:

1. Create a detailed diagram of the device from at least 3 perspectives (front, back, and side view). Include arrows showing force direction and magnitude.
2. Describe the property of magnets that is being used in the device (repulsion or attraction)
3. Explain how this device prevents injury in the case of an accident?

How Lesson 5 Supports Next Generation Science Standards

3-PS2 Forces & Interactions

The materials/lessons/activities outlined in this activity are just one step toward reaching the Performance Expectations listed below. Additional supporting materials/lessons/activities will be required.

https://www.nextgenscience.org/dci-arrangement/3-ps2-motion-and-stability-forces-and-interactions

Peformance Expectation	**Connections to Classroom Activity,** *Students:*
3-PS2-3 Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other. 3-PS2-4 Define a simple design problem that can be solved by applying scientific ideas about magnets.	• Students explore magnets and magnetic properties. • Students ask questions about the interactions they observe between magnets and the objects that they are (or are not) attracted to. • Students ask questions and identify patterns in the behavior or magnets when they interact with each other.
SCIENCE & ENGINEERING PRACTICES	
Asking Questions and Defining Problems Designing Solutions	• Students ask questions after observing different magnetic phenomena (interactions between magnets and objects, and between magnets themselves). • Students use concepts of magnetism to create a device that can reduce negative consequences of impact during a car crash, or prevent the impact before it happens.
DISCIPLINARY CORE IDEAS	
PS2.A Types of Interactions	• Electric and magnetic forces are acting even when two objects are not in contact. • The strength and direction of magnetic forces depends on the distance between and orientation of objects.
CROSSCUTTING CONCEPTS	
Cause and Effect Interdependence of Science, Engineering, and Technology	• The distance between objects will affect the strength of the magnetic force between them. • Objects that are magnetic (iron, nickel, certain types of steel) will be attracted to magnets. • Opposite poles of a magnet will create an attractive force, while like poles will create a repulsive force. • Magnets and magnetic properties can be used to create devices to improve safety for people during driving.

LESSON 6: Getting the message out!

Strategy: Evaluate

- Students have conducted several investigations exploring the effects of balanced and unbalanced forces on the movement of an object, and have connected this to movement of a car and passenger sitting in a car.
- Students have also constructed a safety device to restrain their passenger and have studied how a safety belt exerts a force that helps bring balance to the forces acting on a passenger during a car crash.
- Throughout the Unit, students have logged all the evidence they found that would help them convince a teenage audience about the importance of seatbelts. Now, students will engage in argumentation based on evidence to create a meme series (5 memes) that emphasizes the importance of seatbelts in safe driving.

Materials Needed

- computers with internet access
- posters
- markers

Students will create a digital media campaign to target teenage drivers and will use their safety device as a model.

The campaign will include two parts:

1. A meme
2. A written argument

Part 1 (3-4 sessions)

A meme is a form of digital media that includes a picture with a witty caption. The creator of the meme has to use the computational skill of *abstraction*, or removing unnecessary detail and condensing a message into a sentence. Ask students to come up with one powerful sentence that can summarize their investigations about force and how seatbelts are important. Ask each team to create at least 5 memes. The memes can be printed and presented around the school to increase public awareness of the importance of seat belts.

Teacher Resources on use of memes in the classroom: It may be helpful to expose students to the idea of memes by including memes in instruction for at least a few weeks before the meme project. For the actual meme project, it may be useful to save some blank meme images that you think will be appropriate to use at the 3rd grade level and provide students with several options of images they can chose for the meme. After students have created their memes, have them submit their memes for approval. Pick at least one meme create by each team to be printed and posted around a partnering high school.

- Intro to using memes in the classroom.
- Simple and funny teacher memes to present to students several weeks before meme creation.
- General info about memes in instruction
- Creating memes on google.
- Blank memes on google.

LESSON 6: Getting the message out! (cont.)

Materials Needed

- Computers with internet access
- posters
- markers

Career connections:

Social Media Manager
A social media manager is a person who works for a company or organization and manages the way that they are represented on social media. It is a career did not exist a decade ago, but now, companies are constantly looking for individuals to help create a positive public image that can be widely shared with a public audience. Ask students if they have siblings (or parents) that engage on social media. How do people use social media? Have you seen companies using social media (yes, for advertising)?

Some of the skills of a social media manager include:

- being able to study a population to identify needs and perceptions of the audience,
- designing, creating and managing promotions,
- looking at data and adjusting strategies,
- working with other team members in various departments,
- developing strategies to get a message out to a large audience.

Note: you may want to see if a teenage volunteer from the local high school can come in to be interviewed by your 3rd graders so that they can understand the audience to target their memes. List of questions to ask the teenager.

Part 2 (1-2 sessions)

Students will craft a written argument that explains why seatbelts are important for safety during driving. Students can discuss their ideas and revisit the evidence they collected throughout the Unit. Provide students with sentence frames to help initiate their thinking. Then, they can use this template to draft their argument. Students can work in small teams to explain their thinking and elaborate their ideas before starting the process of writing their claim.

This task can also be combined with ELA learning and be expanded to have students engage in persuasive writing (essay, speech, or letter) explaining why seatbelts should be used (and why traffic rules should be followed).

How Lesson 6 Supports Next Generation Science Standards

3-PS2 Forces & Interactions

The materials/lessons/activities outlined in this activity are just one step toward reaching the Performance Expectations listed below. Additional supporting materials/lessons/ activities will be required.

https://www.nextgenscience.org/dci-arrangement/3-ps2-motion-and-stability-forces-and-interactions

Peformance Expectation	Connections to Classroom Activity, *Students:*
3-PS2-1 Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.	• Students use evidence they collected from their investigation to explain the way that balanced and unbalanced forces act in a situation where a person is driving in a car. • Students construct a model to explain their findings and support an argument based on evidence on how balanced an unbalanced forces affected the movement of their car.
SCIENCE & ENGINEERING PRACTICES	
Planning and Carrying out Investigations Computational Thinking Engaging in Argument from Evidence Communicating information	• Students analyze their data, find patterns, and construct an argument based on their data to answer the guiding question: are seatbelts important for safe driving? • Students use abstraction to condense their findings, connect to real-life, and create a meme campaigning for car safety • Students create a model to show their findings and support their argument. • Students present their findings and their arguments to their classmates.
DISCIPLINARY CORE IDEAS	
PS2.A Forces and Motion	• An object that has no net force acting on it will be at rest, while an object that has a net force acting on it will be moving in the direction of the net force. • Each force acting on an object has both strength and direction. • Patterns can be observed and used to make predictions about an objects movement.
CROSSCUTTING CONCEPTS	
Cause and Effect Patterns	• Students study how the application of forces that vary in magnitude and direction have an effect on an object's movement. • Students identify patterns in how balanced and unbalanced forces affect movement. • Students relate patterns observed with their cars to patterns that are observed in real-life when cars are carrying passengers.