Teacher Guide and Student Journal

Sample Activity and Planning Pages

Forces and Interactions
3PNG

SECOND EDITION

A third grade unit supporting Next Generation Science Standards and Michigan Science Standards

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Forces and Interactions 3PNG

A third-grade unit supporting **Next Generation Science Standards** and the **Michigan Science Standards** developed and written by the Battle Creek Area Mathematics and Science Center for

CEREAL CITY SCIENCE™ by BCAMSC

Forces and Interactions

Pre-activity Informational Pages

Activities

Appendix

NEXT GENERATION SCIENCE STANDARDS

Disciplinary Core Ideas	Activity
PS2.A: Forces and Motion • Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. • The patterns of an object's motion in various situations can be observed and measured; when the past motion exhibits a regular pattern, future motion can be predicted from it.	1,2,3,4,5,6
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.	1,2,3,4,5
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.	1,2,3,4,5,6
PS2.B: Types of Interactions • Objects in contact exert forces on each other. • Electric and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.	1,2,3,4,5,6
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.	1,2,3,4,5
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.	6
3-PS2-4. Define a simple design problem that can be solved by applying scientific ideas about magnets.	6

NEXT GENERATION SCIENCE STANDARDS

Science and Engineering Practices	Activity
Asking Questions and Defining Problems Asking questions and defining problems in grades 3-5 builds on grades K-2 experiences and progresses to specifying qualitative relationships. • Ask questions that can be investigated based on patterns such as cause-and-effect relationships. • Define a simple problem that can be solved through the development of a new or improved object or tool.	1,2,3,4,6
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.	6
3-PS2-4. Define a simple design problem that can be solved by applying scientific ideas about magnets.	6
Planning and Carrying Out Investigations • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.	1,2,3,4,5,6
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.	1,2,3,4,5
• Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.	1,2,3,4,5,6
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.	1,2,3,4,5,6

NEXT GENERATION SCIENCE STANDARDS

Crosscutting Concepts	Activity
Patterns • Patterns of change can be use to make predictions	1,4,5,6
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.	1,2,3,4,5,6
Cause and Effect • Cause-and-effect relationships are routinely identified.	1,2,3,4,5,6
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.	1,2,3,4,5
• Cause-and-effect relationships are routinely identified, tested, and used to explain change.	1,2,3,4,5,6
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.	6
Interdependence of Science, Engineering, and Technology • Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the Engineering Design Process.	1,2,6
3-PS2-4. Define a simple design problem that can be solved by applying scientific ideas about magnets.	6

UNIT AT A GLANCE

Activity	Time to Complete	Lesson Level Learning Goal	Phenomenon/ Engineering Challenge	Summary: Students will...
1 Observations of Motion: Toy Vehicle	Preparation: 20 minutes Activity: 3 classes Lesson 1A: 45–50 min. Lesson 1B: 45–50 min. 1–2 class periods	Observe, measure, and test the motion of a toy vehicle to determine patterns in motion when collisions occur.	Fire Truck Express: A toy fire truck strikes a barrier and it changes direction. Engineering challenge: Design and carry out a plan to change the motion of the truck to go from the playroom to the kitchen and back with a load.	• Use information from text to identify the wonderings of two characters in a story that leads to a design challenge. • Work collaboratively to develop a model that explains what happens when a moving object strikes a barrier and changes direction.
2 Observations of Motion	Preparation: 10 minutes Activity: 3-6 classes Lesson 2A: 45–50 min. 1–2 days Lesson 2B: 45–50 min. 1–2 days Lesson 2C: 45–50 min. 1–2 class periods	Develop an understanding of how to use information from observations, patterns, and data to change motion.	Design challenge: Design and carry out a plan to change the motion of a car to reach a determined destination and carry a load back to the starting point.	• Use prior data and observations about the motion of a toy vehicle. • Design and carry out an engineering plan to solve a problem. • Revise the engineering plan based on results.
3 Observations of Motion: Toy Vehicle	Preparation: 10 minutes Activity: 4–5 classes Lesson 3A: 45–50 min. Lesson 3B: 45–50 min. 2 days Lesson 3C: 45-50 min. 1–2 class periods	Use data to predict future motion of a variety of objects.	Video of a tumbleweed rolling across the prairie. Video of a leaping frog snatching a meal.	• Observe the motion of a living organism to raise questions for investigation. • Plan and carry out an investigation. • Determine the forces that affect the motion of the tumbleweed, frog, and toys. • Recognize patterns that can be used to predict future motion of the toys and organisms.

UNIT AT A GLANCE

Students Figure Out How To:	Practices and Crosscutting Concepts	PE at Lesson Level and Assessment
• Obtain information from text. • Develop and use models to explain phenomenon. • Raise questions based on observations and collaborative thinking.	Asking Questions and Defining Problems Developing and Using Models Planning and Carrying Out Investigations Constructing Explanations and Designing Solutions Cause and Effect Patterns	**Formative Assessment:** Science Talk Activity Pages Initial models
• Use data and observations to solve problems. • Use patterns in motion to determine future motion. • Determine when forces are balanced and unbalanced.	Asking Questions and Defining Problems Planning and Carrying Out Investigations Analyzing and Interpreting Data Constructing Explanations and Designing Solutions Developing and Using Models Cause and Effect Patterns	**Formative Assessment:** Activity pages Science Talk **Summative Assessment:** Journal Entry Science Talk Product Descriptor and Presentations
• Collect and organize data. • Use data to recognize patterns. • Use patterns to predict future motion. • Compare and contrast forces used to move a variety of objects. • Measure distance traveled using metric system. • Obtain information from text and video	Asking Questions and Defining Problems Developing and Using Models Planning and Carrying Out Investigations Analyzing and Interpreting Data Obtaining, Evaluating, and Communicating Information Constructing Explanations and Designing Solutions Cause and Effect Patterns	**Formative Assessment:** Activity Pages Science Talk What We Think chart **Summative Assessment:** Science Talk (3C) What We Think chart (3C) Final models

UNIT AT A GLANCE

Activity	Time to Complete	Lesson Level Learning Goal	Phenomenon/ Engineering Challenge	Summary: Students will...
4 Exploring Motion: Friction	Preparation: 15 minutes Activity : 5 classes Lesson 4A: 45–50 min. Lesson 4B: 45–50 min. Lesson 4C: 45–50 min. Lesson 4D: 45–50 min. Lesson 4E: 45–50 min.	Collect data to describe friction as a force that affects motion and use data to predict future motion.	The snail moves faster or slower depending on the surface it is moving on. Soles of different kinds of shoes are made of different material.	• Read a story about a problem of motion. • Make observations of friction using a variety of materials. • Conduct an investigation to determine the force of friction in a variety of materials. • Conduct an investigation to determine the effect of mass on the amount of force needed to move an object.
5 What Goes Up, Must Come Down	Preparation: 15 minutes Activity 5: 5-7 classes Lesson 5A: 45–50 min. Lesson 5B: 45–50 min. 2-3 class periods Lesson 5C: 45–50 min. 2-3 class periods	Investigate gravity as a force that affects motion and use data to predict future motion.	The snail on rollers requires a push to start its motion. The snail stops and needs another push. The snail moves faster down the hill and needs a push up the hill. Table cloth pull trick Toys in Space	• Continue to read about the problem of motion in the story. • Design an investigation to explore the effect of gravity on a variety of objects. • Recognize patterns associated with the force of gravity. • Observe motion of balls on Earth and compare to the motion of balls in space. • Demonstrate through a simple device (cup, index card, and washer) how a force is necessary for motion.
6 Forces at a Distance – Non-Contact Forces	Preparation: 20 minutes Activity 6: 6 classes Lesson 6A: 45–50 min. 2 class periods Lesson 6B: 45–50 min. Lesson 6C: 45–50 min. Lesson 6C: 45–50 min. 2 class periods	Solve a problem using magnets as a non-contact force.	Video: Homemade toy car moves without touching. Challenge: Spinning Magnets	• Demonstrate how magnets can attract and repel some objects depending on their properties. • Design an investigation to determine the strength and distance necessary to move small objects with a magnet. • Explore how objects charged due to static electricity attract and repel. • Design a device that solves a problem using magnets. • Consider the use of magnets in solving the Fire Truck Express challenge.

UNIT AT A GLANCE

Students Figure Out How To:	Practices and Crosscutting Concepts	PE at Lesson Level and Assessment
• Relate friction to real-world applications and the Fire Truck Express Engineering Challenge • Design an investigation to measure the force it takes to move an object over different surfaces. • Design an investigation to determine if adding weight will affect the force needed to move an object.	Asking Questions and Defining Problems Planning and Carrying Out Investigations Analyzing and Interpreting Data Obtaining, Evaluating, and Communicating Information Developing and Using Models Constructing Explanations and Designing Solutions Using Mathematics and Computational Thinking Patterns Cause and Effect	**Formative Assessment:** Respond to Text Activity Pages Science Talk Initial models **Summative Assessment:** Journal Entries Investigation reports (Conclusions) Revisions to models Investigation Reports
• Relate gravity to their everyday activities. • Design an investigation to determine how gravity affects a variety of objects in motion. • Use patterns in data to predict future motion. • Relate the challenges in moving the snail to changing the motion of the toy car. • Use evidence and patterns in evidence to determine the forces that affect motion.	Developing and Using Models Analyzing and Interpreting Data Constructing Explanations and Designing Solutions Cause and Effect Patterns	**Formative Assessment:** Respond to Text Activity Page **Summative Assessment:** Journal Entries Science Talk Final models
• Use data and observations to determine the force of a magnet needed to move an object over a distance. • Construct explanations regarding the ability of magnets to attract and repel one another. • Make connections between the charged balloon that attracts hair and the plastic comb that attracts paper dots. • Design a solution to a problem using magnets and non-contact forces.	Constructing Explanations Analyzing and Interpreting Data Developing and Using Models Obtaining, Evaluating, and Communicating Information Cause and Effect Patterns	**Formative Assessment:** Science Talk Journal Entry **Summative Assessment:** Science Talk Final models Consensus model Activity Pages Journal Entries Solutions to Engineering Design Challenge Product Descriptor Class presentations

OBSERVATIONS OF MOTION: TOY VEHICLE

Teacher Background Information
Motion is the changing of position of an object. The motion of an object can be described by its change in position, direction of motion, or speed. In this activity, students make observations of a car as it moves across the floor. The beginning activity is intended to lay the foundation by making observations to describe motion in terms of position, direction, and speed.

Young learners are familiar with the observable effects of motion but may not have considered the variety of motion and the cause that changes motion that they observe. The various types of motion are visible all around us; a bicycle, a yo-yo, a Slinky, and an amusement park ride are all fun examples of motion. Students may not have considerable experience observing and measuring motion, looking for patterns in data, and predicting the future motion based on solving problems with motion. The high interest in motion of toys provides an opportunity for student-led investigations into motion. Students make observations, ask questions, and design and conduct an investigation to answer their questions. It is intentional that there is very little instruction on how the data should be collected, recorded, or presented. In this activity, students will show what they know and understand about motion and recording data.

Following lessons focus on the necessity of gathering and presenting data in an organized fashion. Groups will have the opportunity to revisit this activity and use new skills in describing motion and collecting data to solve an engineering challenge.

Considerations for Students With Special Needs, Diverse Backgrounds, and Emerging Bilingual Learners
Read the *Fire Truck Express* aloud to students and have them follow along in the Student Journal. Ask a bilingual speaking student to translate or reread the story in Spanish or other language that is common in your classroom.

Students are asked to draw and write in their Student Journals. Students may benefit by working with a partner in the longer writing pieces. Students with an IEP should be allowed to dictate their ideas and answers.

This may be the first time students are asked to draw models and make the invisible, visible. Provide students with the opportunity to physically demonstrate, using a toy truck or ball what happens when something collides with a wall or other barrier. Have students talk through their ideas and then draw

ESTIMATED TIME
Lesson 1A: 45–50 minutes
Lesson 1B: 45–50 minutes
1–2 class periods

LESSON LEVEL LEARNING GOAL
Observe, measure, and test the motion of a toy vehicle to determine patterns in motion when collisions occur.

PS2.A: FORCES AND MOTION
- The patterns of an object's motion in various situations can be observed and measured; when the past motion exhibits a regular pattern, future motion can be predicted from it.

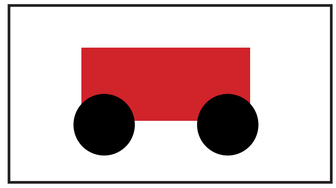
PS2.B: TYPES OF INTERACTIONS
- Objects in contact exert forces on each other.

TEACHING TIP
Throughout the activities in the Teacher Guide you will notice that specific student instructions from the Student Journal pages are italicized.
The summative assessment located in the Assessment Section of the Teacher Guide is divided into three sections. Instructions for administering the assessment are given at the end of the appropriate lesson. This assessment is not intended to be a Pre/Post Assessment but to assess the student understanding along the way.

MATERIALS NEEDED
For each student:
student pages
Teacher provides:
chart paper
markers
Post-It Notes

READING
Key Ideas and Details
RI.3.1: Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for answers.
RI.3.2: Determine the main idea of a text; recount the key details and explain how they support the main idea.
Integration of Knowledge and Ideas
RI.3.7: Use information gained from illustrations (e.g., maps, photographs) and the words in a text to demonstrate understanding of the text (e.g., where, when, why, and how key events occur).
RI.3.8: Describe the logical connection between particular sentences and paragraphs in a text (e.g., comparison, cause/effect, first/second/third in a sequence).
Range of Reading and Level of Text Complexity
RI.3.10: By the end of the year, read and comprehend informational texts, including history/social studies, science, and technical texts, at the high end of the grades 2–3 text complexity band independently and proficiently.

and write. Eliminate anxiety of drawing a fire truck by demonstrating how to draw a rectangle with wheels.



Engage the Learner
This phase of learning introduces and activates prior knowledge regarding forces and motion. Students observe the motion of a toy vehicle and make connections between what they have observed and the learning task. They will make predictions, record their observations, and develop models in the Student Journals. Students' initial ideas and questions are recorded on the What We Think chart. The chart is referred to and updated throughout the lessons, providing students with a venue in which to make conceptual change regarding motion and figuring out the problem.

LESSON 1A: FIRE TRUCK EXPRESS: ENGINEERING CHALLENGE

Advance Preparation
Duplicate copies of the unit Parent Letter and Activities To Do At Home to be sent home.

Prepare a What We Think chart:

What We Think	Questions We Have	What We Did (Practices)	What We Figured Out (DCIs)	How Does That Help Us to Figure Out the Phenomenon?

Preview the *Fire Truck Express* story in the Student Journal. Be prepared to read the story with expression.

Become familiar with the motion and features of the toy car before the students engage in their exploration. Do not show the students the car at this time.

Toy car:
- The toy car (Jeep) is equipped with two batteries and one dowel covered in foil. The car will move very quickly with two fresh batteries. Students can slow the speed by replacing one battery with the foil covered dowel.
- The treads on the tires of the toy car are the feature that makes it flip over when it runs into the wall. If students remove the treads they will find that the car will strike the wall and change direction instead of flipping. Some groups may use the flipping feature to solve the problem and others may choose to remove the treads.

- Be sure the treads are returned to the car after the task is completed.
- The batteries wear down quickly. Ask students to turn the car off when not being tested to spare the batteries.

Procedure

Engage the learner.

Read the *Fire Truck Express* text in the Student Journal as a class. Discuss the children's observations and the challenge in the story. Ask students to cite the children's observation that helped them to wonder about changing the direction of the fire truck. Ask students for their ideas of what caused the fire truck to change direction.

Ask students to share similar experiences with objects colliding. Ask students to describe observations of what happens when balls collide with the wall or other balls. Relate the students' experiences to observations of the children in the story. Discuss the wondering the children made in the story. Ask:

- Can someone explain what the wondering was when the children observed the motion of the toy fire truck?
- Can someone add to what __________ said?
- What other experiences or observations have you made where the same or similar phenomenon happens?
- Can someone relate the motion of the truck to something they have observed in sports? (Soccer? Basketball? Kickball?)
- What causes the toy truck or a ball to change direction when it strikes a wall or other object?
- Can you say more about _________ ?
- What pattern in the motion of the fire truck leads to the challenge in the story? What patterns can we use to make predictions of future motion of the truck?
- Can anyone add to that idea? What do you think the children need to find out to meet the engineering challenge?
- Can someone state the problem in the form of a question to be investigated?

As the students share their experiences and ideas, record their initial thinking on the What We Think column of the chart. Remind students that this is a record of their initial thinking and all ideas are valid and valued. Explain that as the lessons progress the class will revisit their initial thinking and make revisions as they gain new information.

CAUSE AND EFFECT

Cause-and-effect relationships are routinely identified, tested, and used to explain change.

PATTERNS

Patterns of change can be used to make predictions.

CAUSE AND EFFECT

Cause-and-effect relationships are routinely identified, tested, and used to explain change.

TEACHING TIP

The recording of individual ideas and then sharing with others will help students to recognize that their ideas may differ based on the individual experiences, point of view and the interpretation of the story.

Students may need prompting to develop their initial models using arrows to show the truck moving, stopping briefly, and then moving in a different direction.

DEVELOPING AND USING MODELS

Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.

- ~~Collaboratively develop and or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events.~~
- **Develop and/or use models to describe and/or predict phenomena.**

After students have exhausted their ideas of why they think the motion of the fire truck changed after it hit a barrier, divide the class into groups of four and allow sufficient time for the students to revisit and brainstorm about the wondering and challenge in the *Fire Truck Express* story.

Encourage students to draw and label their individual thinking and models in the Student Journal. Remind the students that models are a way to keep their thinking visible. Models help scientists and engineers represent what we cannot see. Discuss the invisible components that might be important in their models. Review the activity page as a class.

Draw a model of what you think caused the moving toy fire truck to change direction when it hit a barrier or wall. Include before the truck struck the barrier, during the time the truck was in contact with the barrier, and after the truck moved away from the barrier.

Before

During

After

After the students have put their individual ideas on paper have

them share their models with the group and collaborate to develop a group model to share with the rest of the class. When the groups are ready, distribute chart paper or white boards and Post-It notes and have them develop a model that reflects their thinking. Explain that the Post-It notes are for questions that arise as the group is brainstorming. Ask one or two students in each group to record questions as the discussion continues.

Facilitate the model development by circulating among the groups and listening to their ideas and observing the components that they think are important in explaining the phenomenon. To help the groups make connections among ideas and applications, ask:

- What components did your individual models have in common? How did you bring those components into your group model?
- How does your model represent force? Speed? Direction?
- Tell me more about ___________ idea.
- How does it relate to ...?
- Can you give me an example of how the children in the story might use that to complete the engineering challenge?
- Can someone add to _____________'s idea?
- What questions do you have about motion and the cause of the change in motion of the fire truck that might help to figure out the engineering challenge?

Remind students to record questions on the Post-It notes for future reference. Have them place their questions on their models for the Science Talk.

Science Talk

After all the groups have completed their models, have students bring their models and gather in a circle to share and look for common ideas. Encourage groups to first look at all the models developed and check for common components among the models. To help the students begin their conversation, ask one group to share their model and invite others to comment on the commonalities and differences from their own models. Remind the students that these are their initial models and as the lessons progress they will be given more opportunities to revisit and revise their models. To help the students engage in conversation, ask:

- What common components (features) do you recognize in many or all of the models?
- Why do you think that component is important?
- Can someone add to what __________ said?
- Do the rest of you agree? Why or why not?
- Some of the models include the use of arrows. Can someone explain what the arrows represent?
- What do you mean by _______________?
- *Why is that important in understanding the cause of the change in motion of the fire truck?*

ASKING QUESTIONS AND DEFINING PROBLEMS

Asking questions and defining problems in 3–5 builds on K–2 experiences and progresses to specifying qualitative relationships.

- Ask questions about what would happen if a variable is changed.
- Identify scientific (testable) and non-scientific (non-testable) questions.
- **Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause-and-effect relationships.**
- **Define a simple problem that can be solved through the development of a new or improved tool.**

TEACHING TIP

Science Talk is a conversation among students that allows them to have the opportunity to orally express their ideas and listen to the ideas of others. Allow sufficient time for each student to express ideas and opinions. Encourage student-led conversation in a circle. Conversations should be student-to-student with minimal teacher-led question and answer. (See Science Talk and Developing Effective Questions to Facilitate Science Talk in the Appendix, pps. 164-65).

TEACHING TIP

Your students may have many more questions regarding the motion of the car. Validate all questions by posting on the Questions We Have column of the What We Think chart.

Throughout the unit, the lessons will try to provide experiences and evidence to answer their questions. Be sure to revisit the questions often and determine which questions have been answered and what questions remain and new questions that arise. Move answered questions to the What We Figured Out column.

Take this opportunity to develop the Questions We Have column of the What We Think chart. Ask students to share their questions. Develop the question column by asking a group to share one question and then have others share similar or like questions. Categorize questions as they are presented by the students. Categories may include:

- forces
- direction
- speed
- collisions
- surface/tire treads (friction)
- gravity
- material (of toy truck or barrier)
- questions about the challenge

Example chart:

Assessment: Formative

Use the Activity Page, initial models, and Science Talk to assess the students' initial thinking about observations of motion and how things move.

Use the Science Talk to assess the students' initial understanding of how patterns can be used to make predictions of future motion and solve problems.

LESSON 1B: TESTING MOTION: TOY VEHICLE

Advance Preparation

Display the What We Think chart for the class.

If you have not yet become familiar with the motion and features of the toy car, do so before the students engage in their exploration. Load the batteries into each car for the students. Use the mini screw driver supplied in your unit to unscrew the battery compartment.

Toy car:

- The toy car (Jeep) is equipped with two batteries and one dowel covered in foil. The car will move very quickly with two fresh batteries. Students can slow the speed by replacing one battery with the foil covered dowel. They will require the mini screw driver to open the battery compartment.
- The treads on the tires of the toy car are the feature that makes it flip over when it runs into the wall. If students remove the treads they will find that the car will strike the wall and change direction instead of flipping. Some groups may use the flipping feature to solve the problem and others may choose to remove the treads.
- Be sure the treads are returned to the car after the task is completed.
- The batteries wear down quickly. Ask students to turn the car off when not being tested to spare the batteries.

Procedure

Explore the concept.

Review the challenge in the *Fire Truck Express* story and the list of questions the students generated in the previous lesson. Check for understanding that the children in the story will need to plan how to cause the fire truck to change its motion as it travels to the kitchen for cookies. Divide the class into groups of four and have them brainstorm ideas that will help solve the challenge in the story.

Facilitate the team brainstorming by circulating among the students and listening to their ideas. To help students solve problems and design a solution, ask:

- Can someone explain what you have discussed so far?
- How would you describe Sam and Toni's problem in your own words?
- What do you already know about motion that might help solve the problem?

MATERIALS NEEDED

For each student:
student page

For each group of 4:
1 measuring tape
1 toy vehicles (2 batteries)
dowel, foil covered

For the class:
mini screw driver

Teacher provides:
masking tape
chart paper
markers
timing devices

PS2.A: FORCES AND MOTION

- **The patterns of an object's motion in various situations can be observed and measured; when the past motion exhibits a regular pattern, future motion can be predicted from it.**

PS2.B: TYPES OF INTERACTIONS

- **Objects in contact exert forces on each other.**

CAUSE AND EFFECT

Cause-and-effect relationships are routinely identified, tested, and used to explain change.

MATERIAL MANAGEMENT

When initially loading the batteries, eliminate the tiny screw and tape the battery compartment closed so students can easily explore one battery and the foil covered dowel.

PS2.A: Forces and Motion

- **Each force acts on one particular object and has both strength and a direction.** ~~An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion.~~

TEACHING TIP

Your unit is equipped with one mini screw driver to open the battery compartment on the toy cars. If students choose to open the compartment and replace one battery with the foil covered dowel, be sure the tool is placed back in the unit.

WRITING

Text Types and Purposes

W.3.1: Write opinion pieces on topics or texts, supporting a point of view with reasons.

Production and Distribution of Writing

W.3.4: With guidance and support from adults, produce writing in which the development and organization are appropriate to task and purpose.

CAUSE AND EFFECT

- Cause-and-effect relationships are routinely identified, tested, and used to explain change.

- What did the children observe when the truck struck a chair or table leg? What caused that to happen?

Ask groups to share their ideas and justify their thinking using what they have observed about motion. Tell the class that in the following lessons, they are going to gather new information about motion and forces that affect motion that will help Sam and Toni receive cookies via the Fire Truck Express.

Discuss with the class how they might help to solve the challenge of the *Fire Truck Express*. Listen for ideas of using a battery operated toy vehicle and conducting a trial and error investigation. Show the students the battery operated toy cars (Jeeps) to use as models to test their ideas. Explain that the toy cars have two batteries and caution against playing with the car or over use of the car as the batteries will run out quickly. When testing an idea, recommend that the students place the car on the floor, turn the car on, test their idea, retrieve the car and turn it off until they are ready for their next idea to test. Show the students the wooden dowel covered in foil. Explain that the wooden dowel can be used in place of one battery. Ask students how they think replacing one battery with the wooden dowel will effect the motion of the car. Do not provide an answer for the question at this time. Give students the opportunity to explore their thinking and test their ideas.

Divide the class into groups of four students and distribute one car to each group. Provide sufficient time for students to make observations of how the car moves and what happens when it strikes a wall or barrier. Ask the students to write down how they tested the motion of the car and their observations. Encourage students to test what happens when the car hits the wall or a barrier.

Complete the chart of how you tested the motion of the car. Be sure to include what motion you tested and what you observed as the toy car moved.

Draw and write how you tested the motion of the car	*Draw and write what you observed as the car moved*		
	Trial 1	*Trial 2*	*Trial 3*

Revisit your model and make changes based on your observations of the toy car.

To facilitate the students' exploration of the motion of the car and recording of observations, circulate among the students and check their progress in recording their observations. To help students begin to construct explanations and make observations to produce data, ask:

- What was the first thing you noticed when the car started to move?
- What caused the car to move? Did you observe a push or a pull? What was the effect?
- What did you see, hear, or feel?
- How do you know that the car was moving?
- What path/direction did the car travel? How do you know?
- Did the speed of the car change or remain the same for the entire trip? How do you know?
- Did you recognize any patterns that can be used to predict future motion to solve the engineering challenge?
- What do you think causes the car to climb the wall and flip over and keep on going? Why doesn't the car just stop when it hits the wall?
- What do you think about what ___________ just said? Do you agree or disagree? Why or why not?
- How might you test your idea?

After groups have had the opportunity to complete their testing of the car and recording of observations, have them share their entries in the Student Journal with another group. Ask students to talk to one another about their entries and make adjustments based on the exchange. Look for observations that include:

- the direction the car was moving.
- that it traveled in a straight line or a curved path.
- a reference to its speed (slow, fast, constant).
- sounds that the car made.
- that the car traveled on a flat surface.
- the distance it traveled using a reference point.
- the distance traveled in a given amount of time.
- the effect of a collision with the wall or barrier.
- the effect of the angle at which the car collided with the wall or barrier.

PLANNING AND CARRYING OUT INVESTIGATIONS

Planning and carrying out investigations in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.

- **Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or to test a design solution.**
- Make predictions about what would happen if a variable changes.

PATTERNS

- Patterns of change can be used to make predictions.

TEACHING TIP

As you circulate among the groups, carry a clipboard with paper and pencil to make note of ideas for the Science Talk. Refer to interesting comments and ideas to help start or direct the Science Talk.

Keep a record of when students begin to use terms related to motion, such as, speed, friction, gravity, force. During the Science Talk, ask students to explain what they mean when using the terms. The terms and concepts will be explored as the lessons progress.

- a change in speed with one battery and one wooden dowel.
- a change caused by the removal of the treads on the tires of the cars.

Science Talk

Conduct a whole-class sharing of observations collected from the investigation. Ask students if they have further questions or ideas that they would like to learn about motion. Did the motion of the toy vehicle generate any new questions? Record their questions on the What We Think chart.

Discuss if anyone measured the distance traveled and the amount of time it took to travel that distance. Relate the student-collected data to the speed the car was moving. Ask which trial showed the fastest speed and the slowest speed. Ask:

How do you know that? What could we do to cause a difference in speed?

Ask the class to look for patterns in the data or observations collected. Discuss the students' initial thinking regarding the term *patterns* in data. Explain that patterns are repeated or regular occurrences of data. Have the class compare the data collected over the three trials. What data has a regular pattern? As a class, predict what might happen if they conducted a fourth trial. Ask:

- Can we use the data to predict what might happen if we changed a variable such as the surface the car travels over?
- What might happen if the vehicle traveled up an incline?
- What might happen if the vehicle ran into a wall or obstacle?

Ask how the patterns observed in the motion of the car can help to solve the *Fire Truck Express* challenge. Accept all reasonable responses at this time.

Revisit the What We Think chart. As a class, record what students did, what they figured out, and if their findings help them to figure out the phenomenon or design challenge. Facilitate the whole-class discussion and encourage all students to contribute to the session.

Review the *Fire Truck Express* reading in the Student Journal. Ask students what information the children will need to help them solve the challenge. What observations do they already have that will help them to solve the challenge?

TEACHING TIP

Science Talk is a conversation among students that allows them to have the opportunity to orally express their ideas and listen to the ideas of others. Allow sufficient time for each student to express ideas and opinions. Encourage student-led conversation in a circle. Conversations should be student-to-student with minimal teacher led question and answer. (See Science Talk and Developing Effective Questions to Facilitate Science Talk in the Appendix, pps. 164-65).

PATTERNS

- Patterns of change can be used to make predictions.

CONSTRUCTING EXPLANATIONS AND DESIGNING SOLUTIONS

Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.

- Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.
- Identify the evidence that supports particular points in an explanation
- Apply scientific ideas to solve design problems.

Listen for ideas of information regarding collisions and what happens when objects collide and change direction. Add a class list of student ideas of information regarding motion that will help solve the challenge to the chart. Have the students write their initial ideas in their Student Journals.

Look at the diagram of the position of the fire truck in Sam's play room and draw the path the truck must travel to get to the kitchen and back with a load of cookies. Brainstorm in your group some ideas that may help Sam and Toni get cookies delivered by the Fire Truck Express. Make a list of what Sam and Toni need to make their plan work.

1. *Write a list of what you think Sam and Toni need to solve the engineering design challenge.*
2. *Use the diagram of the position of the fire truck in Sam's play room to draw and plan your route for the toy car to travel from the playroom to the kitchen. Write what challenges or problems you may have to complete the challenge.*

Assessment: Formative
Use the Science Talk and Activity Pages to evaluate the students' initial ideas about forces that change motion and how to solve the engineering design challenge.

WRITING
Text Types and Purposes
W.3.2: Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

a. Introduce a topic and group related information together; include illustrations when useful to aid comprehension.

Production and Distribution of Writing
W.3.4: With guidance and support from adults, produce writing in which the development and organization are appropriate to task and purpose.

TEACHING TIP
The writing integration in this lesson helps students learn literacy skills directly through the science concepts they are figuring out. Through reading and writing integration in science, students recognize the importance of literacy skills within the Science and Engineering Practices and meaningful content. This writing integration can be conducted during your writing block.

ENGINEERING DESIGN PROCESS

The Engineering Design Process provides students with a series of steps to guide them as they solve problems and design and test products, models, and solutions. The process is cyclical, yet not necessarily in an order. Students are encouraged to evaluate as they progress through the process, revisit the mission often, and revise thinking and their plan multiple times as the process unfolds.

Engineers do not always follow the Engineering Design Process steps in order, one after another. It is very common to design something, test it, find a problem, and then go back to an earlier step to make a modification or change the design. Engineers must always keep in mind the mission or problem they are trying to solve and the limitations (cost, time, material, etc.) that are part of the solution to the problem. Two key elements in working as an engineer are teamwork and design-test-and-redesign.

Mission
- Defines the problem and what the engineers are trying to design or build.
- Describes the limitations within which the engineers must solve the problem.

Brainstorm Ideas
- Imagine, discuss, and sketch possible solutions.
- Conduct research into what has already been done.
- Discover what materials are available, time frame, and other limitations.

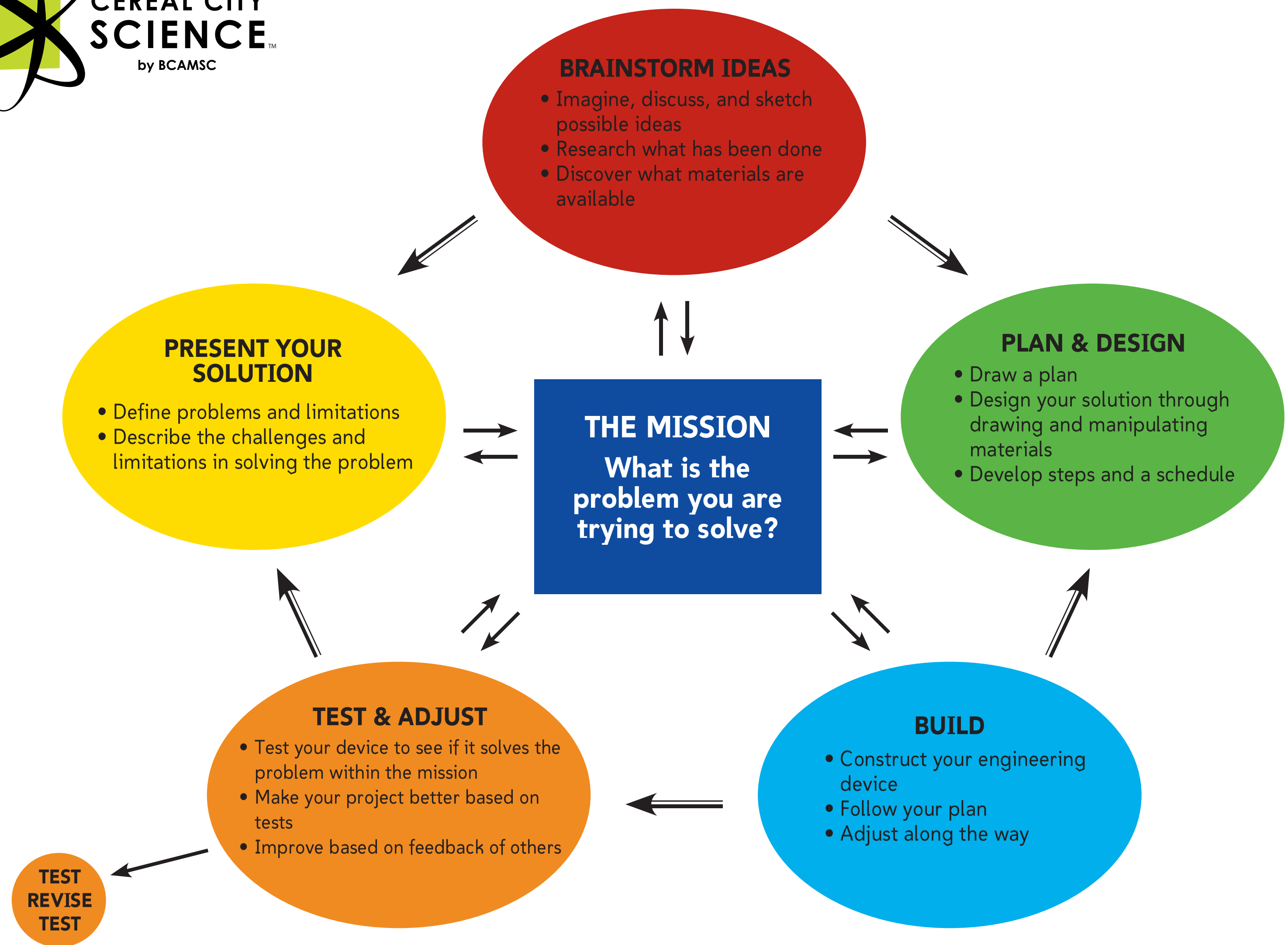
Plan and Design
- Draw and write a plan.
- Design your solution through drawing and manipulating materials.
- Develop a plan or steps and a schedule.

Build
- Construct your engineering device or project.
- Follow your plan.
- Adjust and test along the way.

Test and Adjust
- Test your device to see if it solves the problem within the mission and limitations.
- Make your project better based on tests: Test → Revise → Test.
- Improve based on feedback of others.

Present Your Solution
- Demonstrate how your solution solves the problem.
- Define problems and limitations.
- Describe the challenges and limitations in solving the problem.
- Describe additional revisions that could improve the device or project.

ENGINEERING DESIGN PROCESS



by Battle Creek Area Mathematics and Science Center
Cereal City Science
Adopted from the Carnegie Mellon Robotics Academy

CEREAL CITY SCIENCE by BCAMSC

Student Journal
3.PS.NGSS

Forces and Interactions 3PNG

SECOND EDITION

A third grade unit supporting Next Generation Science Standards and Michigan Science Standards

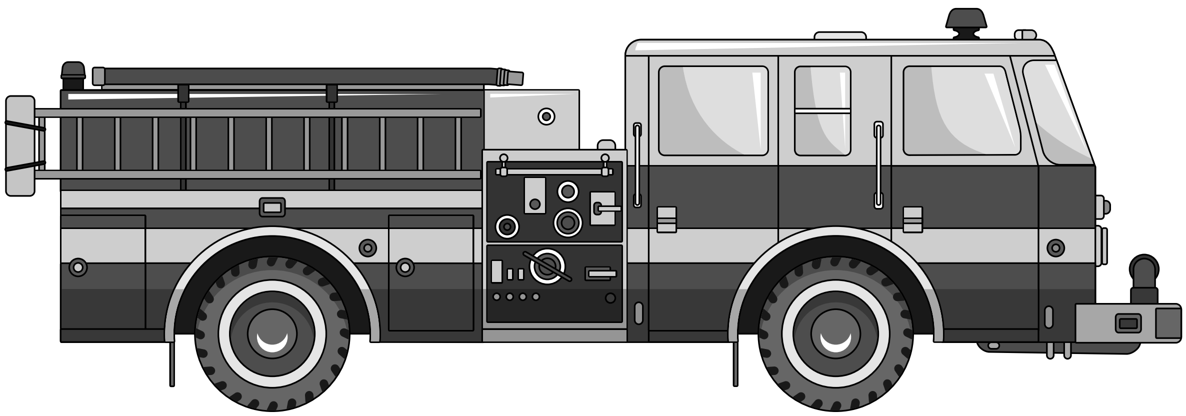
Name:______________________________

Name: ____________________________

Date: ____________________________

THE FIRE TRUCK EXPRESS!

Sam received a new fire truck from his friend Toni for his birthday. The truck ran on batteries and would travel a long distance. While Sam and Toni were playing with the fire truck they observed that each time the truck collided with an object it would change direction and keep on going in a different direction. Their observation gave them an idea.



“Hey!” said Toni. “What if we carefully place the chairs and other furniture in the path of the truck and make it go where we want it to go?”

“Good idea,” replied Sam. “Let’s make it go into the kitchen. I smell cookies baking, maybe we can send a message to my mom that there are two hungry cookie monster fire fighters in the living room.”

“We can attach a note and ask your mom to send us cookies on the fire truck express!” Toni exclaimed.

“Hmm,” thought Sam. “This will take some planning.”

1A ACTIVITY
Observations of Motion: Toy Vehicle

Name: ______________________________

Date: ______________________________

Draw a model of what you think caused the moving toy fire truck to change direction when it hit a barrier or wall. Include before the truck struck the barrier, during the time the truck was in contact with the barrier, and after the truck moved away from the barrier.

Before:

During:

After:

Name: ______________________________

Date: ______________________________

Complete the chart of how you tested the motion of the car. Be sure to include what motion you tested and what you observed as the car moved.

Draw and write how you tested the motion of the car.	Draw and write what you observed as the car moved		
	Trial 1	Trial 2	Trial 3

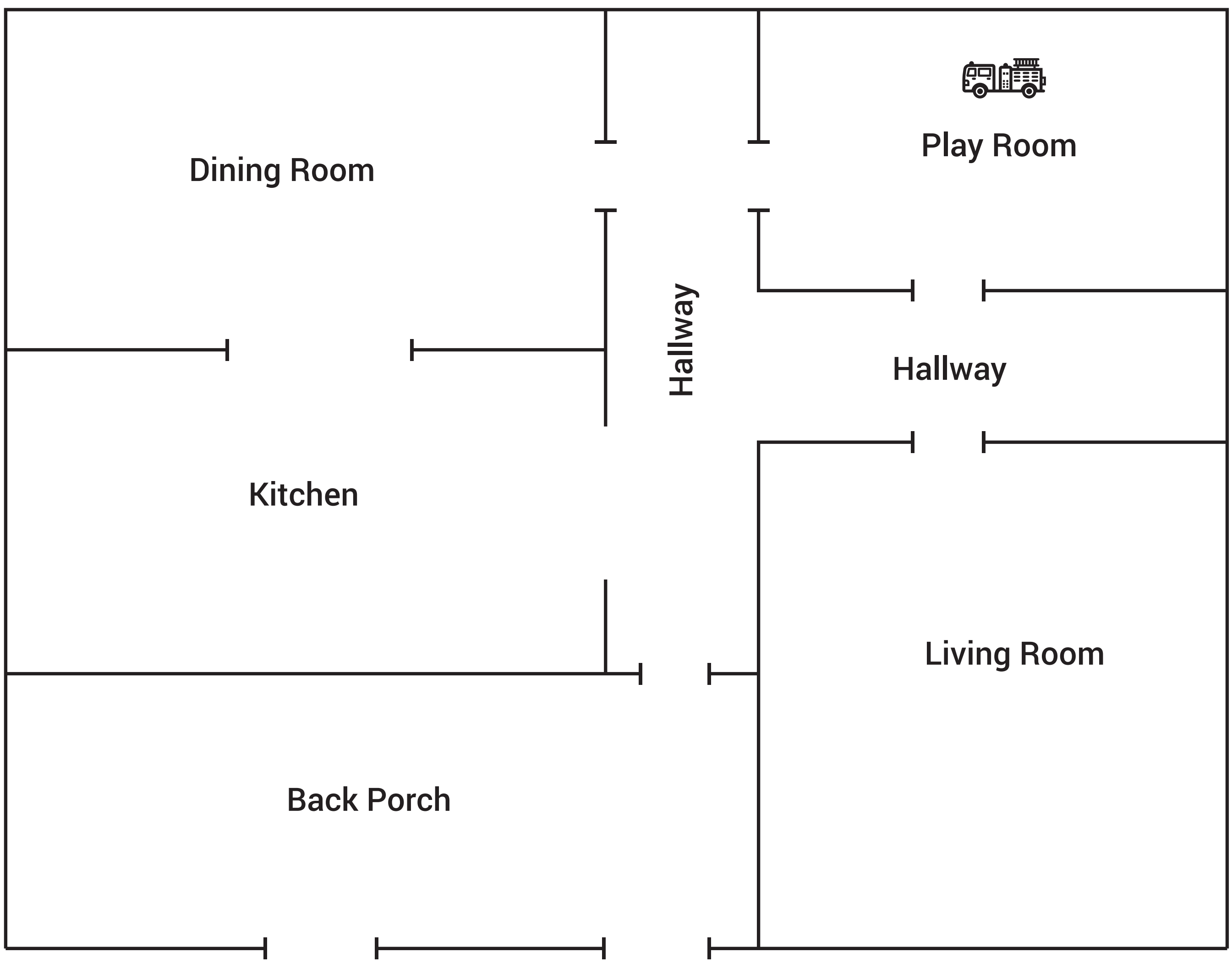
Revisit your model and make changes based on your observations of the toy car.

1B ACTIVITY
Testing Motion: Toy Vehicle

Name: ____________________________

Date: ____________________________

Look at the diagram of the position of the fire truck in Sam's play room and draw the path the truck must travel to get to the kitchen and back with a load of cookies. Brainstorm in your group some ideas that may help Sam and Toni get cookies delivered by the "fire truck express." Make a list of what Sam and Toni need to make their plan work.



Name: ______________________________

Date: ______________________________

1. Write a list of what you think Sam and Toni need to solve the engineering design challenge.

2. Use the diagram of the position of the fire truck in Sam's play room to draw and plan your route for the toy car to travel from the playroom to the kitchen. Write what challenges or problems you may have to complete the challenge.

K E Y   T E R M S

Name: ____________________

Date: ____________________