K–2

MODULE OVERVIEW – Vroom! Vroom! What Makes Cars Go?

MODULE OVERVIEW

Module Description: Students explore gravity, friction, and energy using objects and model cars. They investigate and define the concepts of motion, force, and energy, using simple hands-on activities with vehicles as well as online interactives and videos. At the end of the module, students apply the knowledge they have acquired about force, motion, energy and friction to design a functioning model car. Then, students share the cars with their classmates in a model car show.

Module Project: Students develop a model and/or diagram of a car and explain what causes the car to move, ways to keep it moving, and what makes it speed up or slow down.

Module Objectives:

- Explain what causes a vehicle to move and keep moving.
- Name things that can cause a vehicle to speed up or slow down.
- Design a model car.

Relevant STEM Topics:

- Motion
- Energy
- Forces
- Engineering Design
- Planning a Project

Please see *Standards Addressed in GK-2* for a list of the applicable science, technology, engineering, and math standards, as well as the 21st Century Skills.

Total Time: 1–2 weeks

Note: This module has been designed for the wide range of abilities found among Kindergarten, Grade 1, and Grade 2 students. Kindergarten teachers can use the first lessons, and can judge how far they wish to take their students. Similarly, Grade 2 teachers may wish to disregard the first lessons if they feel they are redundant to what children already know and instead spend more time on the design and build phase of the module.

LESSON PLANS

Lesson 1 – How Things Move: Roll, Slide, and Bounce

Students begin thinking about engineering a vehicle by taking a closer look at movement through exploring and comparing different ways that things move.

Lesson 2 – Motion and Force: Pushes and Pulls

Students investigate forces, such as pushes and pulls, to find out what is needed to cause the motion of an object and, ultimately, a vehicle.

Lesson 3 – The Force of Gravity

Using ramps and model cars, students discover how gravity acts as a force that pulls objects toward the Earth and what its effect is on vehicles.

Lesson 4 – What Makes Things Stop?

Students continue to use model cars to explore how rough and smooth surfaces and friction affect motion. Students apply their thinking to determine the factors that reduce vehicle friction.

Lesson 5 – Keep it Moving!

Students begin to test out ideas for making their own vehicles. They will explore with wheels and axles and consider solutions to make them move more smoothly.

Lesson 6 – Creating Model Cars

Students use the engineering design process to apply their knowledge from the previous five lessons to design a working model car.

Lesson 7 – Model Car Show

Students use the designs that they created in the previous lesson to build their cars. Afterward, they have a car show to allow their classmates to give positive feedback.

Acknowledgment: This material is based upon work supported by the Department of Energy, National Energy Technology Laboratory under Award Number DE-FG26-08NT03077.

GK–2

LESSON 1 — How Things Move: Roll, Slide, and Bounce

MODULE OVERVIEW

Module Title: **Vroom! Vroom! What Makes Cars Go?**

Module Description: Students explore gravity, friction, and energy using objects and model cars. They investigate and define the concepts of motion, force, and energy, using simple hands-on activities with vehicles as well as online interactives and videos. At the end of the module, students apply the knowledge they have acquired about force, motion, energy and friction to design a functioning model car. Then, students share the cars with their classmates in a model car show.

Module Project: Students develop a model and/or diagram of a car and explain what causes the car to move, ways to keep it moving, and what makes it speed up or slow down.

LESSON OVERVIEW

Lesson Time: 40 minutes

Before students can determine what makes a car *move*, they must have a good understanding of movement. In Lesson 1, students will define *motion* as "a movement or change in position." They will also explore the concept of motion by discovering that differently shaped objects move in different ways.

BACKGROUND FOR TEACHERS

Students at this age are familiar with motion, but they may not have considered how different shapes and surfaces affect an object's movement. Rolling is not frictionless, but rolling objects are much less affected by friction than flat objects that slide. This is a key understanding that helps students conceptualize the design of a vehicle. An object that bounces uses a different movement that should be noted, but the bounce movement is not often used in designing vehicles.

Have students keep an "Engineering Notebook" in which they can write or draw what they learn about vehicle design. What they record will bring their ideas together and can also be used as part of their project. This can prove to be an excellent way for students to demonstrate their understanding. The notebook can also act as an assessment tool, if it is reviewed during or at the end of class. If a notebook is not available, fold several sheets of lined paper in half and staple them in the center so the pages are held together. Students will want to keep their Engineering Notebooks at the end of the module as a record of what they have learned.

Teacher Preparation: At the end of this module, you will want to have all the materials ready for the students to build their model car. These are simple materials, but you may wish to begin collecting them now to be sure they are all ready by Lesson 6. See below for the list:

- Adhesive materials to attach all the parts (e.g. glue, hot glue gun, tape, clay, putty, playing dough, rubber bands) (Note: hot glue gun should only be handled by the teacher. Check school safety guidelines regarding the use of such equipment.)
- Precut straws
- Precut dowels, chopsticks, bamboo skewers, pencils and/or any other items that students might use as axles
- Egg cartons, foam, cardboard, tiny boxes, blocks, scrap wood, building toys, craft supplies, and/or any other items that students might use as the body of the model car
- Spools, small toy/craft wheels, round bottle caps or lids, predrilled poker chips, and/or any other items that students might use as wheels

LESSON OBJECTIVES

By the end of this lesson, students should be able to:

- Tell what *motion* is.
- Name objects that can roll, slide, and bounce.
- Explain why cars need wheels.

Please see *Standards Addressed in GK-2* for a list of the applicable science, technology, engineering, and math standards, as well as the 21st Century Skills.

Lesson Essential Questions:

1. What is motion?
2. What does an object's shape tell you about the ways it can move?
3. Why do cars need round wheels?

Key Vocabulary (appropriate for a word wall):
motion, *movement*, *move*, *wheel*, *roll*, *slide*, *bounce*, *object*, *shape*, *round*, *square*, *triangle*, *car*

RESOURCES

Materials needed:

- Chalkboard and chalk, whiteboard (or interactive whiteboard, if available), or chart paper
- Overhead projector, blank transparency, and transparency marker
- A transparency of the *How Can Different Things Move?* student worksheet (if using overhead)
- A variety of the following objects (enough for each small group of 3-4 to have two different objects from each category):
    - Rectangular prisms: blocks, small boxes (such as empty paperclip boxes), etc.
    - Cylinders: toilet paper rolls, pencils, crayons, etc.
    - Spheres: small bouncy balls, marbles, etc.
- Pencils (at least one per group)
- A transparency or chart paper to make a KWL chart (for use throughout the module)
- Clipboard, paper, and pen for recording notes
- Chart paper and marker (or if you have an interactive whiteboard, you may choose to use this) for keeping a glossary to use throughout the module
- Engineering Notebook for each student

Student Worksheets Required:

- *How Can Different Things Move?* (one copy per small group of 3–4, plus transparency)
- *Roll, Slide, and Bounce Chart* (one copy per student)

What skills do students need for this lesson?

- Some experience using charts, graphic organizers, and tables

TEACH

Engage

- Begin by writing the term *move* on the board. Ask students to brainstorm a list of all the different ways that things can move—for example, people can walk, fish can swim, and airplanes can fly. Write each suggestion on the board. Explain that in today's lesson we are going to focus on three kinds of ways that things can move.
- Display the *How Can Different Things Move?* transparency on the overhead (or use the PDF version on an interactive whiteboard). Point to or circle the following terms at the top of each column: *Roll*, *Slide*, and *Bounce*. Ask students if they can define or give examples of each kind of

movement. If necessary, model rolling, sliding, and bouncing for students before beginning the activity, in order to make sure that students can visualize each kind of movement.

- Show students the group of six objects they will be exploring today (ex. a pencil, a crayon, a marble, a small bouncy ball, a small rectangular block, and an empty paperclip box).
- Tell students that they will be working in small groups to discover which of the objects can roll, which can slide, and which can bounce.
- Read the directions on the transparency to students. Model how to complete the worksheet by using your transparency marker as a sample object. Work across the row, predicting and testing.
- Remind them to be careful with the materials, especially the ones that bounce well.

Explore

- Divide students into small groups of 3–4. Provide each group with a *How Can Different Things Move?* worksheet, pencils, and a set of the six objects. Instruct students to make predictions and test each item to see which can roll across the floor, which can slide across the floor, and which can bounce.
- Walk around and observe groups as they work, taking notes on students' understanding and participation in the activity. Provide assistance as needed.
- Have groups share their findings with the class. Write the following three terms on the board as headings of a three-column chart: "Roll," "Slide," and "Bounce." Have students copy this chart into their Engineering Notebooks. As they share their results, write the names of the objects under the appropriate heading(s) on the board. When finished, read the columns together.
- Ask students to tell what they notice about the objects in each column. Students may respond with a variety of answers, but may not realize that every object in a column is the same basic shape. To guide students to this realization, hold up each object that has a similar shape and ask students what else these objects have in common.

Explain

- Write the following question on the board and encourage students to respond based on their prior knowledge and on the exploration they just completed: *What does an object's shape tell you about the ways it can move?* If grade-level appropriate, have students write in their Engineering Notebooks adjectives describing the objects associated with each of the three types of motion. Again, hold up each object that has a similar shape to help guide students to the appropriate realization. Write students' responses on the board. Students should recognize that only the ball bounced, but they may need help recognizing that rounded objects roll and flat-sided objects slide.
- Write the title "Glossary" on the top of a piece of chart paper and post it in a visible location where it can remain throughout the module. Write "1. Motion—" on the chart. Say the word with students and allow volunteers to share what they think it means. As a clue, point to the list of things that can move (from the *Engage* activity) and tell students that all of these words, and also rolling, sliding, and bouncing, describe different kinds of motion.

- Tell students that *motion* is a movement or change in location. Write the definition on the "Glossary" chart paper and read it together. To illustrate what this means, ask all the students to look at an object you place in a location where they can see it. Now have them cover their eyes or turn around. Move the object. When they look again, ask them what happened to the object? (It moved.) Ask if it is in a different location. (Yes.) Then we say its location has changed. When something's location changes, it has moved. Have them think of examples of something moving from one place to another. If appropriate, have students write the definition in their Engineering Notebooks.

Extend

- Tell students that over the course of the module they will be learning what causes objects to move and what makes objects speed up or slow down. They will also learn ways to keep objects moving, or in motion. Read the module title with students. Ask students what they think is the specific kind of object that they will be learning about the most in these lessons (cars)? Explain to students that by the end of the module they will be designing their own cars. To make a good one, they will have to understand how things move best.
- Pair students and tell them you are going to ask a question that they should think about. Do a think-pair-share where they think about the following statement and questions, then share their answer with a partner: *Today, we studied things that slide, roll, or bounce. Which shape that we studied today would move most easily along the floor without us having to push hard? Which would keep on moving after we let it go?* You can have them share their answers or draw or write them in their Engineering Notebooks (according to age appropriateness) and save them for Lesson 2.
- Start a KWL chart on a transparency or chart paper. Ask students to contribute things that they already know about cars and motion, and write their responses in the first column. In the second column, ask students to list questions about cars and motion that they think will be answered during this module. Leave the third column blank for right now. In later lessons students will name other things that they have learned.

Evaluate

- Have students complete the *Roll, Slide, and Bounce Chart* by drawing at least one object in each column. Or they may complete this activity in their Engineering Notebooks.
- Have students share their drawings of rolling, sliding, and bouncing objects. Ask the other students to describe the shape of the object in each drawing. Verify that each object is the appropriate shape—that is, a rolling or bouncing object should be round, while a sliding object should have a flat side.

Wrap-Up

- Have students recall what they did in Lesson 1. Challenge students to identify other objects that roll, slide, or bounce that have not yet been named.
- Reread the definition of *motion* together.
- Preview Lesson 2. Explain to students that today they learned about some of the different ways that things move. They learned that the shape of an object can affect its motion. In Lesson 2, we will find out what causes motion in the first place.

Acknowledgment: This material is based upon work supported by the Department of Energy, National Energy Technology Laboratory under Award Number DE-FG26-08NT03077.

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Names: ______________________________ ______________________________________

______________________________ ______________________________________

How Can Different Things Move?

Directions:
1. Draw or write the names of your objects in the "Objects" column.
2. Circle ***Yes*** or ***No*** in the "Predict" columns to tell if you think the objects will roll, slide, or bounce.
3. Test each item to see if it can roll, slide, or bounce. Circle ***Yes*** or ***No*** in the "Test" columns.

	Can It Roll?		**Can It Slide?**		**Can It Bounce?**	
Objects	**Predict**	**Test**	**Predict**	**Test**	**Predict**	**Test**
	yes no	yes no	yes no	yes no	yes no	yes no
	yes no	yes no	yes no	yes no	yes no	yes no
	yes no	yes no	yes no	yes no	yes no	yes no
	yes no	yes no	yes no	yes no	yes no	yes no
	yes no	yes no	yes no	yes no	yes no	yes no
	yes no	yes no	yes no	yes no	yes no	yes no

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<u>Roll, Slide, and Bounce Chart</u>

Directions: Draw at least one object in each column. Label each object you draw.

Roll	Slide	Bounce

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GK–2

LESSON 2 — Motion and Force: Pushes and Pulls

MODULE OVERVIEW

Module Title: **Vroom! Vroom! What Makes Cars Go?**

Module Description: Students explore gravity, friction, and energy using objects and model cars. They investigate and define the concepts of motion, force, and energy, using simple hands-on activities with vehicles as well as online interactives and videos. At the end of the module, students apply the knowledge they have acquired about force, motion, energy and friction to design a functioning model car. Then, students share the cars with their classmates in a model car show.

Module Project: Students develop a model and/or diagram of a car and explain what causes the car to move, ways to keep it moving, and what makes it speed up or slow down.

LESSON OVERVIEW

Lesson Time: 40 minutes

Before students can determine what makes a car move, they must have a good understanding of movement and force. In Lesson 2, students will learn that a force is needed to cause motion. They will define *force* as "a push or pull." They will also discover that heavier things require more force to move than lighter things. Finally, students will observe that a greater force will move an object farther than a weaker force.

BACKGROUND FOR TEACHERS

In order for an object to begin moving, a force must be applied. All movement requires the force of a push or pull. The greater the force applied to an object, the greater the change in motion will be. Heavier objects take more force to push or pull. They take more force, and therefore more energy, to move and keep moving. They also take more force to stop once they start moving.

Teacher Preparation: A reminder: at the end of this module, you will want to have all the materials ready for the students to build their model vehicle. These are simple materials, but you may wish to begin collecting them now to be sure they are all ready by Lesson 6. See Lesson 1 for suggestions.

LESSON OBJECTIVES

By the end of this lesson, students should be able to:

- Describe what causes motion.
- Give examples of *force* in simple terms of push and pull.
- Explain that heavier objects require more force to move.
- Explain that a stronger force will make an object move farther than a weaker force.

Please see *Standards Addressed in GK-2* for a list of the applicable science, technology, engineering, and math standards, as well as the 21st Century Skills.

Lesson Essential Questions:

1. What causes motion?
2. What is force?
3. How is moving a heavy object different from moving a lighter object?
4. How can you use force to make an object go farther?

Key Vocabulary (appropriate for a word wall):

push, *pull*, *force*, *heavier*, *lighter*, *weight*, *stronger*, *weaker*, *greater*, *bigger*, *smaller*, *larger*, *harder*, *softer*, *easier*, *farther*

RESOURCES

Materials needed:

- Crayons; one per student
- Paper; one sheet per student
- Pencils; one per student
- Chalkboard and chalk, whiteboard (or interactive whiteboard, if available), or chart paper
- Glossary created in Lesson 1
- KWL chart paper or transparency created in Lesson 1
- A variety of 5–7 large, small, heavy, and light objects that students can move safely (ex. student chairs, books, backpacks, pencils, erasers, paperclips)
- Overhead transparency and transparency marker (or use an interactive white board, if available)
- A transparency of the *Moving Objects* student worksheet (if using overhead)
- At least one student computer with Internet access
- Engineering Notebook for each student

Resources from FuelOurFutureNow.com:

- Interactive Fun-damental: from *Making Things Move,* see [Pushing and Pulling]

Student Worksheets Required:

- *Moving Objects* (one copy per student, plus transparency)
- *Moving Day* (one copy per student)
- *Pushing and Pulling* (one copy per student)

What skills do students need for this lesson?

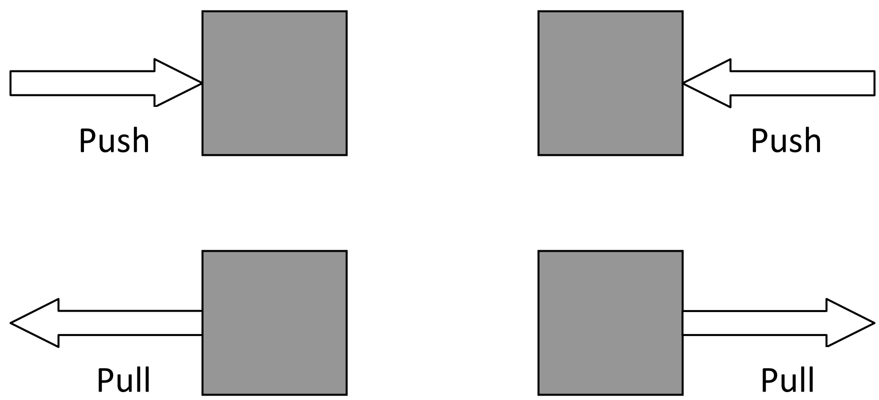
- Some experience using charts, graphic organizers, and tables
- Some experience using a computer mouse to point and click

TEACH

Engage

- Remind students of what they learned in Lesson 1. Ask students to define rolling, sliding, and bouncing, and to give examples of objects that demonstrate each kind of motion.
- If you had students answer the question about which shape is easiest to move and didn't complete a discussion, have them share their ideas out loud now.
- Ask students to think about a moving car. Does the car roll, slide, or bounce along the road? Have students write and/or draw their answers in their Engineering Notebooks. Then ask students to think about what causes the car to move down the road. Students will probably not be able to make much more than a loose association between moving and the car engine. Tell students that in this lesson they will be learning about what causes things such as cars to move.
- Give each student a crayon and a piece of paper.
- Tell students that they will be moving the crayons. Set ground rules, such as no throwing, but encourage students to try a variety of ways to move each one. Explain to students that you would like them to focus on *how* they moved each crayon. Remind them to think about what they had to do to move each one.
- Walk around and observe students as they work, providing assistance as needed. Ask questions about what they are doing and listen to their thinking. Model the language you want them to use in describing what is going on using the terms *force* and *motion*. Try drawing for them individually a sketch with arrows that indicate pulling objects and pushing objects to see if they are ready for this idea.
- After a few minutes, ask students to stop. Have volunteers describe how they moved the crayons. Guide students to determine that they used only pushes or pulls. For example, if a student says, "I picked up the crayon," ask her how she did it—was it a push or pull?

- For older children, before they record their ideas and if you feel students are ready, this is a good time to introduce the idea of using arrows to draw a force. Draw a simple box or a crayon image on the board. (See drawing below.) Place an object or the crayon on the table or floor where children can see it. As you push it, model how you can represent this with an arrow going toward the object to show force is being applied to it – it is being pushed. Draw a second object. (Do not use the first or the arrows will show both pulling and pushing.) Pull the actual object to demonstrate. Draw an arrow pointing away from the image to indicate that it is being pulled. You may need to practice having them recognize the push and pull symbols in relation to the object. Demonstrate the use of large/longer arrows for greater force vs. small/shorter arrows for less force (if age appropriate).



- Following the activity, have students draw in their Engineering Notebooks their actions and the resulting movement of the crayon as a push or a pull.
- Explain that they caused movement, or motion, by pushing and pulling things. Motion is caused by force. Pushes and pulls are forces. Give examples using responses students gave earlier in the lesson. For example, you could say: *When Angel rolled the crayon on the desk, she pushed it. She used the force of pushing. When Dominic picked up the paper, he pulled it up off the tabletop. He used the force of pulling.*
- Check students' understanding of the concepts. Write the following focus questions on the board and read them aloud: *What causes motion? What is force?* Have students whisper answers to a neighbor. Then have volunteers respond, and write their responses on the board. Read the questions and responses aloud with the class. Students should copy the questions into their Engineering Notebooks and write the answers (forces; a push or a pull) next to the questions.
- Call students' attention to the Glossary they began in Lesson 1. Reread the definition of *motion* together. Write "2. Force — a push or pull" on the chart and read it with students. If appropriate, have them write the definition in their Engineering Notebooks.

Explore

- Display the *Moving Objects* transparency on the overhead (or use the PDF version on an interactive whiteboard).

- Show students the group of objects they will be using (ex. student chairs, books, backpacks, pencils, erasers, paperclips).
- Tell students that they will be working in small groups to move each object.
- Read the directions on the transparency to students. Model how to complete a row on the worksheet by using a piece of chalk as a sample object.
- Divide students into small groups. Provide each group with one set of objects to share, but provide each student a copy of their own *Moving Objects* worksheet to complete. Instruct students to first fill in the first column by drawing or writing the names of their objects. Then have them place checks in the appropriate boxes as they push and pull each object.

Explain

- Have students share their findings with the class. Then ask them to tell if some of the things were harder to move than others. Have them tell which objects were harder to move and why they think this is.
- Guide students to conclude that heavier objects are harder to move, and therefore require more force to push or pull.
- Use an example of a student response to explain that heavier objects require more force to move. For example, say: *Kyle said that he had to pull harder in order to move the chair when Tyler was in it.* Say: *Are heavier objects harder to move than lighter objects?* Ask students to raise their hands if they think heavier objects are harder to move than lighter objects.
- Guide students to conclude that a stronger force will move an object farther than a weaker force. Have children bring a pencil and spread out on the floor. Ask students to lay their pencils on the floor and push them gently. Then have students retrieve their pencils and give them a harder push.
- Use an example of a student response to explain that a stronger force will move an object farther than a weaker force. Ask students to raise their hands if they think a harder push will cause an object to move farther than a lighter push.

Extend

- Have students respond in their Engineering Notebooks to the following question: *Which kind of car would be easiest to move: a small car or a big car?* They can draw or write their responses.
- Write the following questions on the board and read them aloud: *How is moving a heavy object different from moving a lighter object? How can you use force to make an object go farther?* Have students whisper answers to a neighbor. Then have volunteers respond, and write their responses on the board. Read the questions and responses aloud with the class. Students should copy the questions into their Engineering Notebooks and write the answers. (More force is needed to move heavy objects. Using a stronger force makes objects go farther.)

Evaluate

- Have students complete the *Moving Day* worksheet by first drawing something that is easy to move and something that is harder to move. Then have them circle the correct words to complete sentences about the objects they drew.
- You may choose to do the following as computer center work during other work time or do it with small groups depending on computer availability.
- Tell students that while they are working on their *Moving Day* worksheets, you will also be calling over students to use the computer(s) to complete an interactive activity called *Pushing and Pulling*. (The number of students called will vary based on the number of classroom computers you have, but should be no more than two students per computer.) Have students complete the *Pushing and Pulling* worksheet. If necessary, point out that the interactive has audio support for reading. (To activate, click on the audio icon in the upper-right corner of the interactive.)

Wrap-Up

- Show students the KWL chart from Lesson 1. Ask students if any of their questions were answered in this lesson. If so, write those answers in the "Learned" column. Then read the students the title of the next lesson (The Force of Gravity) and ask students if they have any new questions that might be answered going forward.
- Reread the definition of *force* together.
- Preview Lesson 3. Say: *Today we learned that* force *causes* motion*. We learned that a* force *is a push or pull. We also learned that a greater force will move an object farther than a smaller force, and that heavier objects require more force to move than lighter objects. Since cars are very heavy objects, we will need to produce a very large force to move them, as we will learn. In addition, we will learn about powerful forces that we must overcome if we are going to move a car forward. In Lesson 3, we will learn about one such powerful force—the force called* gravity*.*

Acknowledgment: This material is based upon work supported by the Department of Energy, National Energy Technology Laboratory under Award Number DE-FG26-08NT03077.

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Moving Objects

Directions: 1. Draw or write the names of your objects in the "Objects" column.
2. Write a √ in each box after you push and pull your objects.

Objects	**I Can Move It By Pushing**	**I Can Move It By Pulling**

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For more resources, visit www.FuelOurFutureNow.com.

Name: ______________________________________

Moving Day

Directions: 1. Draw something that is easy to move and something that is hard to move.
2. Circle the words to complete the sentences about your pictures.

Easy to Move	Hard to Move
I am light/heavy**.** **I need a** small/large **force to move me.**	**I am** light/heavy**.** **I need a** small/large **force to move me.**

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Name: ___________________________________

Pushing and Pulling

1. Record what you see in the *Pushing and Pulling* interactive.

	Where is the force applied?	**Is the force a push or a pull?**
Wagon		
Bulldozer		
Motorboat		

2. Draw a picture of a person opening a door. On the drawing, show where the force is that is moving the door. Label the force as a push or pull.

Check In: PUSHING AND PULLING FALLING AND SLIDING

1 *What are some different forces around us?*

Overview

In the first two parts of *Making Things Move,* you will learn about different forces. Forces make things move. Some forces make things move faster. Other forces make things move slower or change direction.

Think About This

Think of three things that are pushed. Now think of three things that are pulled.

Record What You See: Pushing and Pulling

	What is moved by the force?	Is the force a push or a pull?
Wagon		
Bulldozer		
Motorboat		

2 *What is gravity and what is friction?*

Record What You See: Falling and Sliding

Match each sled to the correct scene.

Scene	Sled
On level, On grass	**This sled is easiest to pull.**
On level, On snow	
Up hill, On grass	**This sled is hardest to pull.**
Up hill, On snow	

Explain your answers.

____

____

Check Out: PUSHING AND PULLING FALLING AND SLIDING

Use your Check In sheet and what you remember from the activity to answer these questions.

1 *What are some different forces around us?*

The BIG Picture

1. Draw a picture of a person opening a door.

2. On your picture, show the force that opens the door. Is that force a push or a pull?

____

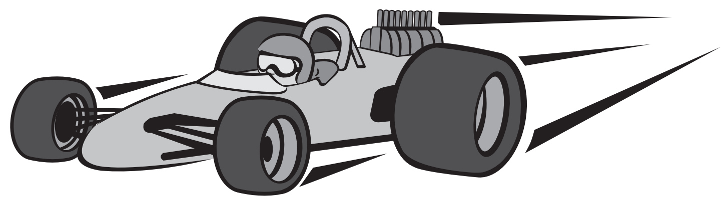
2 *What is gravity and what is friction?*

3. Describe the force of friction and the force of gravity in each situation.

	Friction	**Gravity**
You slip on a wet floor and fall down.		
You push a heavy box *down* a ramp.		
You climb *up* a slide with just your socks on your feet.		

Check In: FASTER AND SLOWER

How do things move?



Overview

In *Faster and Slower,* you will compare the speeds of two toy cars. One toy car moves faster than the other.

Think About This

Speed is how quickly something moves. To measure a moving object's speed, you have to know two things: How far did the object move? And how much time did it take for the object to move that distance?

Record What You See

Race each car around the track. Record the results in the table.

Car Color	Distance (laps)	Time (seconds)
Red		
Blue		

Which car is faster?

How do you know?

Check Out: FASTER AND SLOWER

Use your Check In sheet and what you remember from the activity to answer these questions.

How do things move?

1. Which is faster — a person walking one city block or a person running one city block? Explain using the words *time, distance,* and *speed*.

____

____

____

The BIG Picture

Here are some more tests on the track with different toy cars. For each pair of cars, which car is faster? How do you know?

Car Color	Distance (laps)	Time (seconds)
Red	2	8
Green	2	12

2. ______________________________

Car Color	Distance (laps)	Time (seconds)
Green	2	12
Purple	3	12

3. ______________________________

Car Color	Distance (laps)	Time (seconds)
White	2	6
Orange	3	9

4. ______________________________

Making Things Move

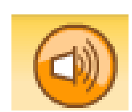
What is a Fun-damental?

Each Fun-damental is designed to introduce your younger students to some of the basic ideas about one particular area of science. The activities in the Fun-damental provide essential background knowledge that students need before they move on to the more difficult concepts that are presented in other parts of **Discovery Education Science**. In *Making Things Move,* students are introduced to some of the basic ideas behind what makes things move.

All Fun-damental activities encourage active exploration. Students should try different choices and combinations within each activity. Some responses will be correct, and the student will receive an explanation of why the response is correct. Some responses will not be correct, and the student will receive an explanation of why the response is incorrect. In online active learning, incorrect responses are often more valuable for learning than correct responses. The Fun-damental can be used by individuals, small groups, or as a whole-class demonstration.

The home page offers three choices: *Pushing and Pulling* that introduces simple force, *Falling and Sliding* that examines gravity and friction, and *Faster and Slower* that explores moving objects.

The **Home** button at the top of the screen will always bring you back to this home page. Clicking the **speaker** button at any time will activate the text reader to read the text on that screen.

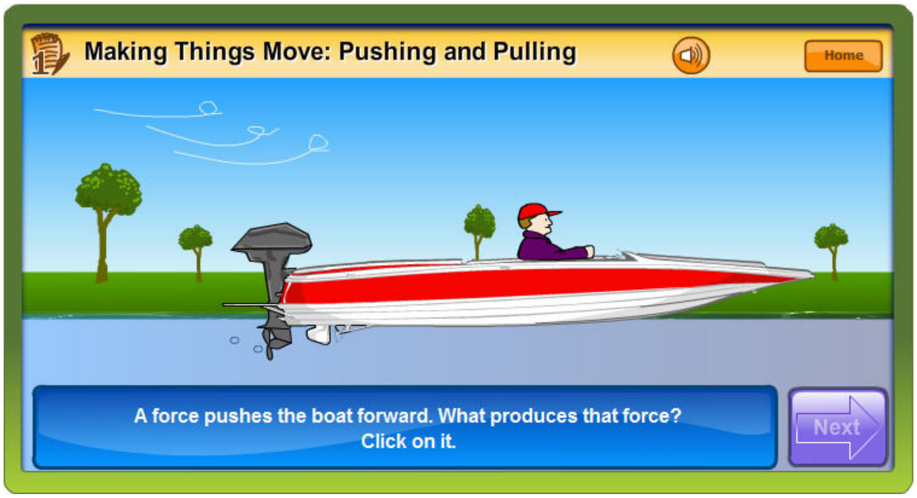


Pushing and Pulling; Falling and Sliding

How the Fun-damental Works

The first part of the *Making Things Move* Fun-damental is *Pushing and Pulling.* In this part, students do activities designed to familiarize them with the following content objectives:

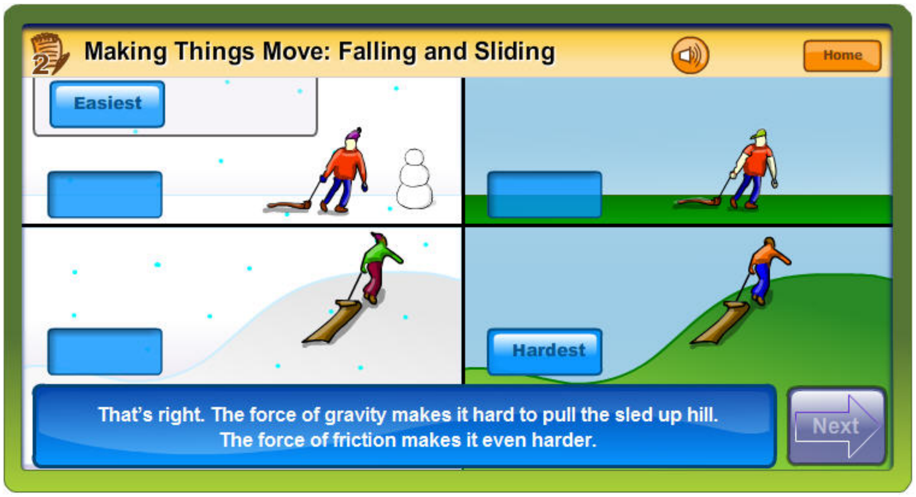
- A force is a push or pull.
- A force can cause an object to move.



In the activity on pushing and pulling forces, the student answers questions by clicking on the correct picture. For example, for the boat, the force pushing the boat forward is produced by the motor. The student clicks on the motor to get the correct response.

In *Falling and Sliding,* students do activities designed to familiarize them with the following content objectives:

- Gravity is felt as the force pulling down on all objects on Earth's surface.
- Friction is a force that resists the motion of two objects rubbing together.



In the activity, students identify forces causes by gravity and friction by clicking on pictures. In the last scene, they must combine these two forces. For instance, pulling the sled uphill in summer is hardest because it must overcome both the force of gravity and the force of friction.

Student Worksheets

Check In: Pushing and Pulling; Falling and Sliding

The *Check In: Pushing and Pulling; Falling and Sliding* worksheet is an excellent way for your students to remain on task and to record useful, relevant information. You should print out the worksheet and provide it to your students before they attempt to do the Fun-damental. Have your students read the focus questions next to the notebook icons, as well as the Overview and Think About This sections.

In the first activity, students record what they see in three scenes involving pushing and pulling. Students identify the type of force in each scene and name the thing that is moved by that force. In the first scene, the boy pulls the wagon. In the second scene, the bulldozer pushes the dirt. Finally, the motor of the boat pushes the boat.

In the second activity, students identify which sled is easiest to pull and which is hardest to pull. The sled that is easiest to pull is the sled on the level, snow-covered surface. There is less friction on snow than on grass and less resistance from the force of gravity on a flat surface than going up a hill. The sled that is hardest to pull is the sled going up a grassy hill. Here both the force of friction on the grass and the force of gravity work against the person pulling the sled.

Check Out: Pushing and Pulling; Falling and Sliding

Here are examples of possible student responses to the questions on the Check Out worksheet:

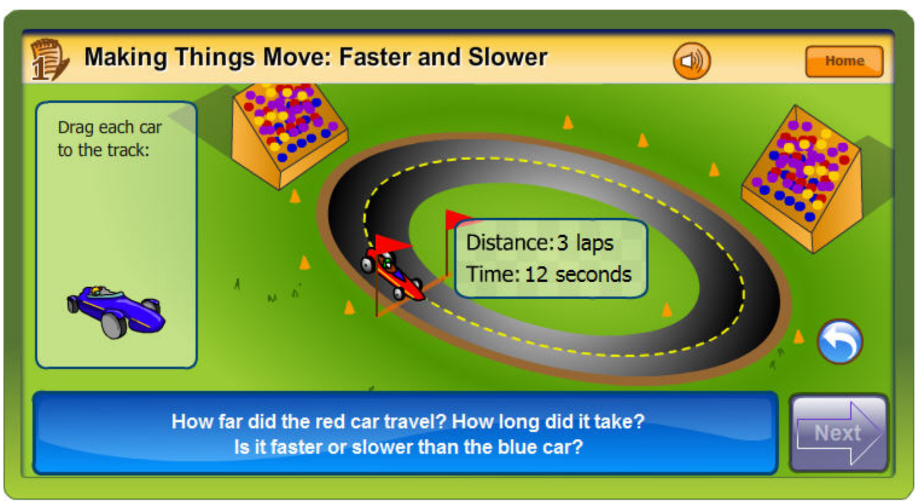
3. Describe the force of friction and the force of gravity in each situation.
    - You slip on a wet floor and fall down. *The water on the floor makes it slippery. There is less friction on the feet and that makes it easy for a person walking on it to fall over. The force of gravity pulls the falling person to the ground.*
    - You push a heavy box *down* a ramp. *Here the force of friction makes it harder to push the box. But the force of gravity pulling the box down the ramp helps out with the pushing.*
    - You climb *up* a slide with just your socks on your feet. *The force of gravity pulls against the climb making it harder to climb up. Your socks slip on the surface of the sliding board giving you less friction to grip with.*

Faster and Slower

How the Fun-damental Works

The third part of the *Making Things Move* Fun-damental is *Faster and Slower.* In this part, students do activities designed to familiarize them with the following content objectives:

- Motion is about changing position.
- Speed is related to distance and time.



In this activity, students drag a toy car onto the race track. They watch the car run for three laps around the track. They record the distance the car traveled and the time that it took on their worksheet. Then they repeat with the second car. Using their recorded information, students are asked which car traveled faster. They can repeat the activity as many times as necessary. The speed traveled for each car is always the same.

Student Worksheets

Check In: Faster and Slower

Again, you should print out the Check In worksheet and provide it to your students before they attempt to do this part of the Fun-damental. Have your students read the Overview and Think About This sections and then discuss.

The Check In worksheet provides a table for recording the results of each toy car. When students have filled in the table completely, they should use that information to answer the two questions that follow.

Help your students understand that motion involves both distance covered and travel time. In this activity, the distance is a constant—it is 3 laps for both cars. Therefore, the time taken is related to the speed of motion. The blue car is faster because it travels the 3 laps in only 6 seconds. The red car travels the same distance in 12 seconds.

Rate problems are quite challenging for student at this age and this activity is only intended to introduce the concept. Students should begin by simply comparing the travel time (6 seconds for the blue car and 12 seconds for the red car) and from those figures decide which car is traveling faster.

Some students may struggle with the inverse relationship—how the car traveling at the *greater* speed (the blue car) travels the specified distance in *less* time. The problem focuses on the logic of this relationship because the track can hold only one car at a time. If both cars ran around the course at the same time, as in a race, it is more obvious that the faster car is the one completing that race first. In that case, there is no need to calculate the time traveled, since the comparison is visible in the order that the cars cross the finish line.

More advanced students may try to calculate the time travel, although this is not necessary for the activity. That rate can be expressed as distance per second (1/2 lap per second for the blue car) or as seconds per lap (2 seconds per lap for the blue car). This calculation can lead to a discussion of units of measure. The unit “seconds” is familiar to students, of course; but the unit of distance “laps” is not; also there is no way to translate “laps” into a more familiar unit, like feet or miles. Point out to these students that the important thing is that the units are the same in both measurements. Again, this discussion is quite advanced and will only be appropriate for some students.

Check Out: Faster and Slower

Here are examples of possible student responses to the questions on the *Check Out: Faster and Slower* worksheet:

1. Which is faster—a person walking one city block or a person running one city block? Explain using the words *time*, *distance*, and *speed*. *A person running one city block is faster. She runs the same distance in less time. She has greater speed than the person who walks the same distance.*

T*he BIG Picture* section of the Check Out worksheet presents students with three sets of toy cars that produce different results. Taken together, the different combinations increase the challenge of calculating speed. Here is a summary of the results:

2. Red car vs. Green car: *This example is just like the activity, except that the distance traveled is only 2 laps for each car. Here the red car travels faster because it completes the 2 laps more quickly. The red car travels each lap in 4 seconds while the green car takes 6 seconds.*
3. Green car vs. Purple car: *In this race, the cars travel for the same length of time, 12 seconds. In that time, the purple car travels 3 laps and the green car travels only 2. Because the purple travels <u>further</u> in the time, it is traveling faster.*
4. White car vs. Orange car: *This example is the hardest. Both the distance and the time traveled change. Perhaps the simplest way to analyze the problem is to calculate how long it takes each car to travel <u>1 lap</u>. The white car travels 2 laps in 6 seconds, so it travels 1 lap in 3 seconds. The orange car also travels 1 lap in 3 seconds. Therefore, the cars are traveling at the same speed.*

At this point, you might also ask students: Of the five cars on the worksheet (red, green, purple, white, and orange), which car travels the fastest? The white car and the orange car have the same speed, so they both travel fastest. Here is another extension question: If the blue car (from the activity) and the white car raced, which car would win? This race would be a tie.

In the Classroom

As a Teacher Demonstration

You can use the Fun-damental to demonstrate basic principles of motion and speed to the entire class. Distribute the Check In worksheet before the demonstration and use it to guide student participation. For example, in *Faster and Slower,* you might first ask students what they have to do to find out which toy car travels faster. Then run the cars on the track and have students record the results. Repeat as needed. Then hold a discussion about how to interpret those results.

If you get into the calculation of speed (in laps per second), you might have students compare their calculations to the apparent motion. As your students watch the cars travel around the track, ask them which car seems to be moving faster. Then compare that observed impression with the calculated speeds.

With Small Groups

Students can also use the Fun-damental in small groups. Have the groups complete the Check In and Check Out sheets as a team. When they finish, have each group summarize its findings on a chart at the front of the classroom. When all groups have finished the activities, have the class discuss the chart. Then review the answers to the Check Out sheet.

Students Working Alone or In Pairs

If students work alone or in pairs with the Fun-damental, make sure that they have the Check In sheet and that they understand how the Fun-damental works. You might introduce the topics of force, motion, and speed with the entire class before individuals begin their work at the computer. When students finish the activity, have them complete the Check Out sheet. Tell them ahead of time that they can use their notes to do that.

FUEL OUR FUTURE NOW

GK–2

LESSON 3 — The Force of Gravity

MODULE OVERVIEW

Module Title: **Vroom! Vroom! What Makes Cars Go?**

Module Description: Students explore gravity, friction, and energy using objects and model cars. They investigate and define the concepts of motion, force, and energy, using simple hands-on activities with vehicles as well as online interactives and videos. At the end of the module, students apply the knowledge they have acquired about force, motion, energy and friction to design a functioning model car. Then, students share the cars with their classmates in a model car show.

Module Project: Students develop a model and/or diagram of a car and explain what causes the car to move, ways to keep it moving, and what makes it speed up or slow down.

LESSON OVERVIEW

Lesson Time: 40 minutes

Before students can determine what makes a car move, they need a good understanding of movement and force. In Lesson 3, students will learn about one of the greatest forces of all—gravity. They will discover how gravity affects objects on Earth and compare the forces required to move toy cars uphill, on flat land, and downhill. They will also compare speed differences in these settings. Students will use science practice to make predictions, investigate and record their findings.

BACKGROUND FOR TEACHERS

- Gravity is the natural force of attraction between any two massive bodies. Because it is a weak force, the effect is usually noticeable only around such massive objects as a moon or a planet. For children, gravity is the force that pulls all objects on Earth's surface toward the center of Earth. It is the reason why things fall when they're not held up and the reason why things roll downhill instead of uphill. It is also the force that keeps planets in orbit around the sun, but bringing up that aspect in this module could prove confusing to children as they explore force and motion.

- Children will be comparing the effect of gravity in combination with the force they apply to move vehicles. That it is harder to push or pull something uphill as opposed to downhill is part of their experience, but they probably have not paid much attention to it in terms of forces. When we design vehicles, all forces that act on those vehicles need to be considered.
- Comparing uphill, downhill, and lateral movement actually involves adding forces together: the force used to move the vehicle plus or minus the force of gravity. How far your students are able to go with this concept will depend on their experience, readiness for abstract thinking, and interest level. It is only essential that they can make a comparison in terms of outcomes (e.g. "the car goes faster downhill than uphill when I push it").
- For the purposes of this module, students will only quantify force and motion in terms of what they can measure concretely.
- It is strongly recommended that you try out the activities in advance in order to plan the logistics of using the materials in your classroom.

Teacher Preparation: A reminder: at the end of this module, you will want to have all the materials ready for the students to build their model car. These are simple materials, but you may wish to begin collecting them now to be sure they are all ready by Lesson 6. See Lesson 1 for suggestions.

LESSON OBJECTIVES

By the end of this lesson, students should be able to:

- Compare and contrast the speed of cars moving uphill, on flat land, and downhill.
- Compare and contrast the force needed to move cars uphill, on flat land, and downhill.
- Give examples of how *gravity* affects objects.
- Describe how gravity affects cars going uphill or downhill.

Please see *Standards Addressed in GK-2* for a list of the applicable science, technology, engineering, and math standards, as well as the 21st Century Skills.

Lesson Essential Questions:

1. What is the difference in speed between cars moving uphill, on flat land, and downhill?
2. What is the difference in the force needed to move a car uphill, on flat land, or downhill?
3. What is gravity?
4. How does gravity affect cars moving uphill or downhill?

Key Vocabulary (appropriate for a word wall):

faster, slower, ramp, uphill, downhill, gravity, Earth, fall, speed

RESOURCES

Materials needed:

- Chalkboard and chalk, whiteboard (or interactive whiteboard, if available), or chart paper
- Glossary started in Lesson 1
- KWL chart paper or transparency created in Lesson 1
- Ramp materials for each pair of students consisting of several small books or blocks and one board or large book. The ramp needs to exceed the length that you want the toy car to move, 60 cm or more is best.
    - Note to teachers: Make sure that the "flat land" surface is the same type of texture as the ramp. For example, a rug would probably be a poor choice because friction would skew the speed comparisons.
- One toy car for each pair of students (you can have students bring these from home – the only requirement is that the wheels move freely; avoid wind-up toy cars)
- Meter stick or ruler (if your students are able to measure the distance the vehicles travel) or a long strip of paper on which they can mark the distance a toy car has traveled
- At least one student computer station with Internet access
- Engineering Notebook for each student

Resources from the FuelOurFutureNow.com:

- Interactive Fun-damental: from *Making Things Move* - see *Falling and Sliding*

Student Worksheets Required:

- *Gravity Is Everywhere* (one copy per student)
- *Falling and Sliding* (one copy per student)

What skills do students need for this lesson?

- Some experience using charts, graphic organizers, and tables
- Some experience using a computer mouse to point and click

TEACH

Engage

- Ask students to recall how objects are moved. Have volunteers respond with the definition of a *force*. Then ask students whether a push or pull is needed when you drop something on the floor. Students should know intuitively that they do not need to either push or pull an object to get it to fall to the ground. However, if there is disagreement, demonstrate that neither a push nor pull is required by dropping an object such as a pencil to the floor. Tell students that in this lesson they will learn about a force that pulls objects toward the ground.
- Tell students that they will be working in pairs to build a ramp that they will use to find out the difference between moving cars uphill, on flat land, and downhill.

- Explain that they will be looking to see which way requires the most force. They will also observe the difference in speed when moving uphill, on flat land, and downhill. Tell students that they will find out how a car's speed changes on hills. *Speed* is how quickly something moves. We will also determine which way—uphill, on flat land, or downhill—requires the most force to travel.
- Write the following numbered questions on the board:
    1. *What is the difference in speed between cars moving uphill, on flat land, and downhill?*
    2. *What is different between the force needed to move a car uphill, on flat land, or downhill?*
- Have students predict the answers to these questions, and write their responses on the board. Challenge students to give the reasons for their predictions. If it is grade-level appropriate, students should also copy Question 1 and write their predictions in their Engineering Notebooks. Tell students to think about these questions as they work.

Explore

- Show students the materials that they will be using to build their ramps. Model creating a ramp with the materials. Model how the students should draw the ramp in their Engineering Notebooks.
- Give pairs a few minutes to build their ramps and then call them back for the next set of instructions.
- Tell students that in order for the first couple of tests to work correctly, it's important that they use the same force when pushing the car. Model using a gentle, one-finger push to push a car on flat land. Tell students to use this kind of push for now.
- Read Question 1 on the board with students again. Tell students that this is the first test. They will use a gentle force to push their cars uphill, on flat land, and downhill to see which way cars go the fastest and which way cars go the slowest.
- On the board, model how students should draw the three tests in their Engineering Notebooks using simple figures and show them where they should write the terms *fast, slow,* and *medium.*
- Dismiss the students to conduct their tests. Circulate to make sure everyone is attending to the procedures and using their Engineering Notebooks. Ask questions to find out what they are thinking and answer any questions they have about the procedure. You may wish to hold some conceptual questions for the whole group to discuss.
- After a few minutes, call pairs back to share their results with the class. Revise the predicted response to Question 1, as needed. Guide students to determine that, in general and when the same level of force is used to move the cars, cars go fastest downhill and slowest uphill.
- Read Question 2 on the board with students again. Tell students this next test has two parts. This time, they will push their cars uphill, on flat land, and downhill with a gentle force to see if there are any differences in *how far* the cars go. Dismiss pairs to perform their test. Students should again draw the three tests in their Engineering Notebooks and this time write the terms *farthest* and *shortest* beneath the corresponding drawing.

- After a few minutes, call pairs back to share their results with the class. Guide students to determine that, in general, cars go farthest with a push downhill and the least far with a push uphill.
- Ask students to recall what happened when they moved heavy and light objects. Ask students what they had to do to move the heavier object as far as the lighter object. (They had to use more force.) Demonstrate or review the idea of using a big arrow to show a stronger force and a small arrow to show a weaker force.
- Tell students that this time the challenge is to get both the uphill car and the downhill car to go the same distance. Demonstrate how they should measure the distance the toy car travels. This can be done with a meter stick or they can mark the distance on a paper strip. Younger students can simply hold their hands apart to compare distances. You can designate one person to be the pusher and the other to be measurer and recorder. Model how to record their results in their Engineering Notebooks using the big and small arrows. Make sure they know that both partners should record the results.
- Note: students will be very creative in their ideas about how to accomplish this task. Be open to any idea as long as it is safe and practical within the time frame you give them. Adjusting the push, adjusting the angle of the board/book and other options will be considered and tried. This is part of the engineering process – trying an idea out on a model. They may learn things you didn't even intend – and that is good.
- Dismiss the students to conduct their tests. Again, circulate to make sure everyone is attending to the procedures, ask questions and answer any questions they have about the procedure. You may hold some conceptual questions for the whole group to discuss.
- After a few minutes, call pairs back to share their results with the class. Ask students to share their ideas about how they got the distance traveled by the car to be the same. Some may wish to share their recorded drawings.
- Revise the predicted response to Question 2, as needed.

Explain

- Place a toy car at the top of a ramp and let it go (without pushing). Ask students to think about whether or not you pushed the car. They should give a thumbs up if they think you pushed it. Thumbs down if they think you did not, thumb sideways if they're not sure. You may need to ask them to discuss the question until they agree that you did not push the car, it went down the ramp by itself.
- Then ask them, *But what did we agree is needed to make something move* (a force)*? So where is the force that made the car move?* Some students may know the answer.
- Have those students who know share. You can tell students that scientists all agree that there is a force called *gravity*. Add to the Glossary "3. Gravity – a force that pulls objects toward the center of the Earth" as a new entry and read it with students. Ask students to share anything they may already know about this word. If appropriate, have them write the word and its definition in their Engineering Notebooks.

- Explain that gravity is the reason why things fall to the ground when they are not held up. It is also the reason why the cars rolled downhill and the reason why it was harder to move cars uphill.

Extend

- Provide a copy of the *Gravity Is Everywhere* worksheet to each student. Tell students that while they are working on their worksheets, you will also be calling over students to use the computer(s) to complete an interactive activity. (The number of students called will vary based on the number of classroom computers you have, but should be no more than two students per computer.) If necessary, point out that the interactive has audio support for reading. (To activate, click on the audio icon in the upper-right corner of the interactive.)
- Call pairs of students over to the computer(s) to work on the *Falling and Sliding* interactive. This is the second activity of the *Marking Things Move* Interactive Fun-damental. Supervise and provide assistance as needed. Provide, and instruct students to complete, the *Falling and Sliding* worksheet.

Evaluate

- Have students complete the *Gravity Is Everywhere* worksheet. Point out that in each diagram, the back of the car has a hump.
    - In the first pair of boxes, students should draw arrows to show where each object will go next. Be sure to emphasize that the blue car is not being driven or braked—it is simply resting on the hill.
    - In the second pair of boxes, students should circle the car that is most likely going faster. Be sure to emphasize that equal-sized forces are acting on both cars, and that both cars are driving on identical surfaces. The only difference is that the yellow car is going downhill and the green car is going uphill.
    - In the third pair of boxes, students should circle the car that will require more force to move. Again, emphasize that the only difference is that the red car is on flat land and the gold car is going uphill.

Wrap-Up

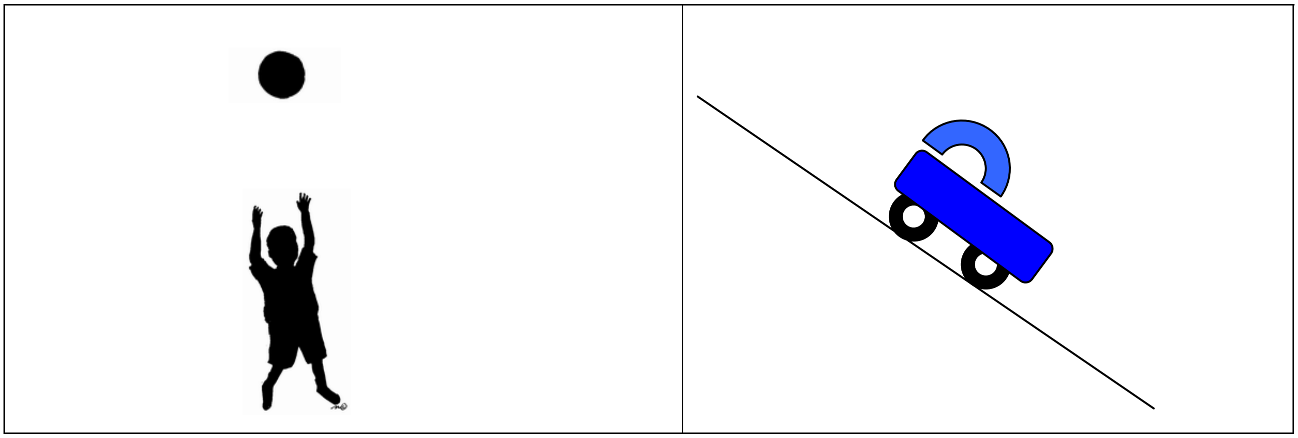
- Have students recall what they did in Lesson 3 by showing them the KWL chart. Once again review what they learned in this lesson.
- Preview Lesson 4. Say: *Today we learned that* gravity *is a force that pulls things toward the center of Earth and can speed up or slow down a car. In Lesson 4, we will learn about a different force called* friction*. To experience friction, rub your hands together. What do you notice? What questions do you have about friction?* Add student questions to the W on the KWL chart.

Acknowledgment: This material is based upon work supported by the Department of Energy, National Energy Technology Laboratory under Award Number DE-FG26-08NT03077.

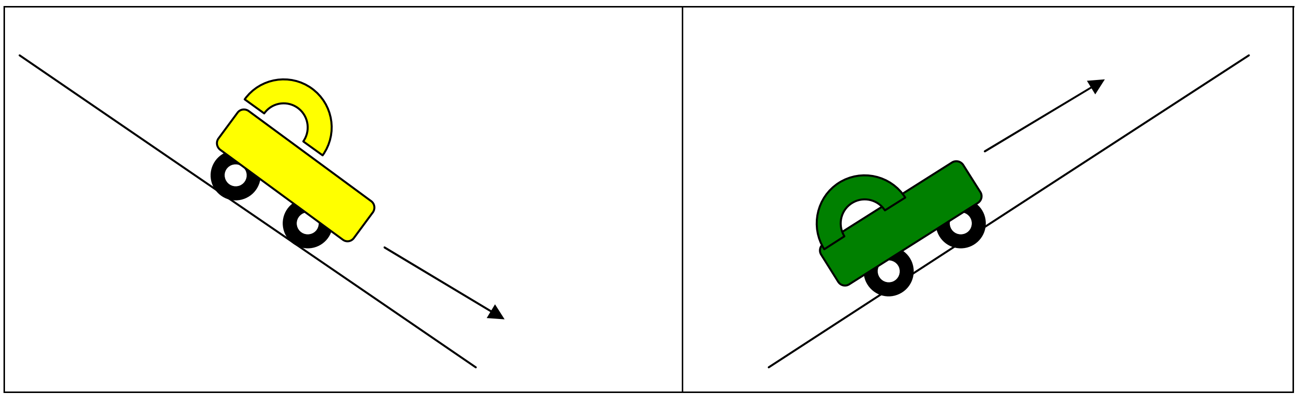
Name: ______________________

Gravity Is Everywhere

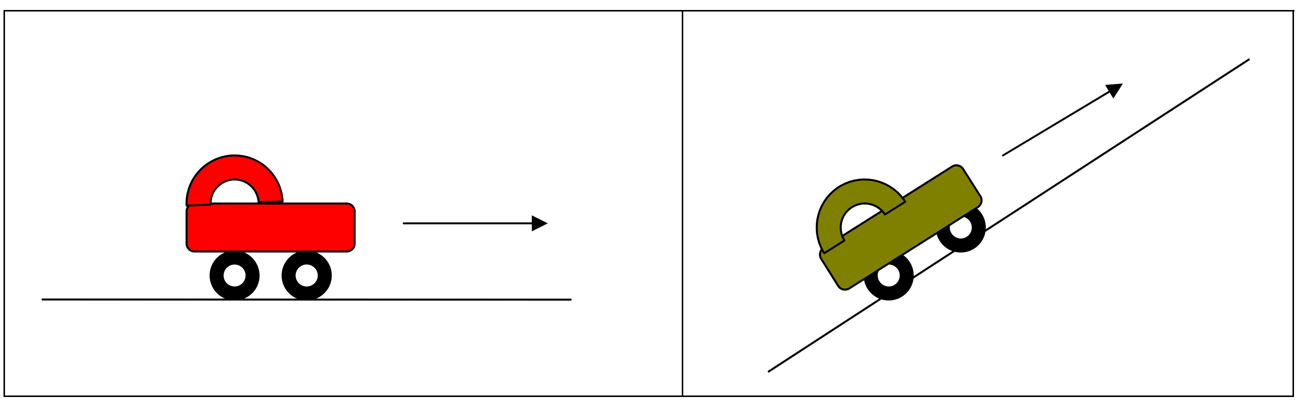
Directions: Draw arrows to show where the objects will go next. In the left picture, the boy is waiting to catch the ball. In the right picture, the car is resting on a hill.



Directions: Circle the car that is MOST LIKELY going faster by itself.



Directions: Circle the car that will take more force to move.



Name: ______________________

Falling and Sliding

1. Answer each question based on what you see in the *Falling and Sliding* interactive.

A. Which sled is moved by gravity?
   1. The child is sitting on the sled on flat land.
   2. The child is riding the sled down the hill.
   3. The child is pulling the sled on flat land.

B. Which sled is hardest to pull because of friction?
   1. The child is pulling the sled across flat, grassy land.
   2. The child is riding the sled down a snowy hill.
   3. The child is pulling the sled across flat, snowy land.

C. Circle the sled that is easiest to pull. Box the sled that is hardest to pull.
   1. The child is pulling the sled across flat, snowy land.
   2. The child is pulling the sled across flat, grassy land.
   3. The child is pulling the sled up a snowy hill.
   4. The child is pulling the sled up a grassy hill.

2. Draw a picture showing what would happen if there were no gravity. Use arrows to show the direction that objects would move.

GK–2

LESSON 4 — What Makes Things Stop?

MODULE OVERVIEW

Module Title: **Vroom! Vroom! What Makes Cars Go?**

Module Description: Students explore gravity, friction, and energy using objects and model cars. They investigate and define the concepts of motion, force, and energy, using simple hands-on activities with vehicles as well as online interactives and videos. At the end of the module, students apply the knowledge they have acquired about force, motion, energy and friction to design a functioning model car. Then, students share the cars with their classmates in a model car show.

Module Project: Students develop a model and/or diagram of a car and explain what causes the car to move, ways to keep it moving, and what makes it speed up or slow down.

LESSON OVERVIEW

Lesson Time: 40 minutes

In the first three lessons of the module, students learned about movement, force, and gravity. They discovered different factors that affect the way an object moves, how to get an object moving, and why some objects travel faster or farther than others. In Lesson 4, students will learn about a force that slows objects down—friction.

BACKGROUND FOR TEACHERS

Friction is an important force. Friction occurs when surfaces rub against each other, resulting in a release of heat and a slowing of motion. Friction is greater on rough surfaces than it is on smooth surfaces. When the surfaces are rough, more force is needed to move things.

Students may have difficulty envisioning friction as a force. To them, a force is something that pushes or pulls; it's something that they can sense. Friction seems to appear when an object moves and disappear when it sits still. You do not need to press students too far on this concept. It will be enough for this vehicle design module to have them understand what friction does to the motion of an object moving across a surface.

Teacher Preparation: A reminder: at the end of this module, you will want to have all the materials ready for the students to build their model car. These are simple materials, but you may wish to begin collecting them now to be sure they are all ready by Lesson 6. See Lesson 1 for suggestions.

LESSON OBJECTIVES

By the end of this lesson, students should be able to:

- Explain what *friction* is.
- Give examples of how friction affects motion.
- Use rulers to measure distance traveled.

Please see *Standards Addressed in GK-2* for a list of the applicable science, technology, engineering, and math standards, as well as the 21st Century Skills.

Lesson Essential Questions:

1. What is friction?
2. How does friction affect movement?
3. How can you use rulers to measure distance traveled?

Key Vocabulary (appropriate for a word wall):

friction, *rough*, *medium*, *smooth*, *surface*, *measure*, *inches*, *length*

RESOURCES

Materials needed:

- Chalkboard and chalk, whiteboard (or interactive whiteboard, if available), or chart paper
- Glossary created in Lesson 1
- KWL chart paper or transparency created in Lesson 1
- Computer with Internet access linked to a projector or TV (for whole class to view at once), PLUS at least one student computer with Internet access (for independent work)
- Overhead transparency and transparency marker (or if you have an interactive whiteboard, you may choose to use that)
- A transparency made of the *Surfaces* student worksheet (if using overhead)
- Yardsticks and/or tape measures (enough for each small group to have one)
- Toy cars (one per small group)
- Masking tape pieces (to use as starting lines for toy cars)
- A variety of at least five different surfaces for each small group to push their car across (e.g. grass, tabletop, rug, sandpaper, hardwood floor, or piece of fabric)

- Clipboard, paper, and pen for recording notes
- Engineering Notebook for each student

Resources from FuelOurFutureNow.com:

- Interactive Fun-damental: from *Making Things Move,* see *Faster and Slower*
- Video: *Discovering Math: Measurement (Grades K–2)*
  Segment 19: *Example 1: Measuring Length in Inches* (01:01)
- Video: *Discovering Simple Machines: Work and Energy*
  Segment 7: *Friction* (01:46)
- Interactive Exploration: *Friction*

Student Worksheets Required:

- *Faster and Slower* (one copy per student)
- *Surfaces* (one copy per student, plus transparency)
- *Friction* (one copy per student)

What skills do students need for this lesson?

- Some experience using charts, graphic organizers, and tables
- Some experience using a computer mouse to point and click
- Some experience measuring length with rulers, yardsticks, or tape measures

TEACH

Engage

- Review Lesson 4 by showing students (on a projector or TV) the third part of the *Making Things Move* Interactive Fun-damental: *Faster and Slower*. When you are done manipulating the interactive, have students complete the *Faster and Slower* worksheet.
- Say: *In the interactive you measured distance using laps. Today you will be comparing how far toy cars go on different surfaces, but before we begin, let's review how to measure length.* Play the *Measuring Length in Inches* video segment from *Discovering Math: Measurement (Grades K–2)*. Show the video to the entire class. Afterward, ask: *What is the most important thing to remember when measuring objects with a ruler or tape measure?* (Line up the end of the ruler or tape measure with the end of the object.)
- Show students the group of surfaces they will be using (grass, tabletop, rug, sandpaper, hardwood floor, piece of fabric, etc.). Ask students to draw a rough surface and a smooth surface in their Engineering Notebooks. Then have them write the names of the different surfaces under the appropriate heading.
- Display the *Surfaces* worksheet transparency on the overhead (or use the PDF version on an interactive whiteboard).

- Read the directions on the transparency to students. Model filling out a row on the transparency by first writing the name of the surface you will use in your demonstration and circling whether it has a smooth, medium, or rough texture. Stop to model setting up and performing the experiment on one surface. Then measure and record how far your car went on that surface.
- Model how to set up the experiment by placing a piece of tape on the end of a surface and placing your car on top. Tell students that this is your starting line. Ask students why it is important to mark the starting line. Guide them to realize that it will help them measure how far their cars go, since it is where they should line up the ends of their measuring tools.
- Before pushing your car, ask students if it matters how hard you push it. Ask students what might happen if you push harder on some surfaces than others. What rule could they write to make sure that each trial in the experiment is fair? Guide students to think of a rule that states that they should push with the same force for each trial. Write their rule on the board, and have students copy it into their Engineering Notebooks.
- Push your car across your surface. Model measuring from the starting line to where the car stopped. Say: *I wonder if we should make another rule here. I know that I want to start measuring from the end of the starting line, but where should I stop measuring—at the back of where the car stopped or at the front of where the car stopped?*
- Allow students to discuss and vote. Write their rule on the board, and use it as you measure how far your car traveled. Students should also copy the rule into their Engineering Notebooks.

Explore

- Divide students into small groups of 3–4. Provide each group with a toy car, yardstick/measuring tape, copies of the *Surfaces* worksheet, pencils, masking tape, and any portable surfaces that they will be using. Instruct students to conduct a trial for each surface by taping down a starting line, pushing their car, and measuring how far it travels.
- Walk around and observe groups as they work, taking notes on students' understanding and participation in the activity. Provide assistance as needed.
- Bring students back together and have them share their results with the class.

Explain

- Ask students to tell what they noticed about how far the cars went on the different surfaces. Guide students to conclude that the cars went farther on smooth surfaces than they did on rough surfaces. Ask: *Why do you think that is?*
- Ask: *What would we have to do to make the cars go farther on the rough surfaces?* Guide students to determine that more force is needed to make objects go farther on rough surfaces.
- Write the following questions on the board and read them aloud: *What is friction? How does friction affect movement?* Tell students that they will be watching a video clip to find the answers to these questions.
- Play the video segment *Friction* from *Discovering Simple Machines: Work and Energy*. Have students answer the questions on the board and write their responses in their Engineering Notebooks. Use the answer to the first question to make a new entry: "4. Friction—" in the

Glossary and add the definition. Read the term and definition aloud with students. If appropriate, have them write the term and its definition in their Engineering Notebooks.

Extend

- Provide copies of the *Friction* worksheets to each student. Tell students that while they are working on their worksheets, you will also be calling over students to use the computers to complete an interactive activity. (The number of students called will vary based on the number of classroom computers you have, but should be no more than two students per computer.)
- Call pairs of students over to the computers to work on the *Friction* Interactive Exploration. Supervise and provide assistance as needed. If necessary, point out that the interactive has audio support for reading. (To activate, click on the audio icon in the upper-right corner of the interactive.)

Evaluate

- Have students complete the *Friction* worksheet by first drawing surfaces beneath each picture, and then circling the correct words to describe the pictures. Students will draw different rough or smooth surfaces underneath each object, as instructed. Then students will compare each of the two groups of objects to determine which will be slowed more by friction.

Wrap-Up

- Have students recall what they did in Lesson 4. Record their answers in the "Learned" column of the KWL chart from Lesson 1, and record new questions that students think might be covered in Lesson 5 based on the title (Keep It Moving!).
- Ask students to respond to the *Lesson Essential Questions*.
- Preview Lesson 5. Say: *Today we learned that* friction *is a force that happens when two things rub together. Friction slows down an object's movement. Friction is greater on rough surfaces than it is on smooth surfaces. When surfaces are rough, we must use more force to move things. We were able to move the toy cars because they were light enough for us to push across any surface. We could not do that with real cars. In Lesson 5, we will learn what real cars need to move.*

Acknowledgment: This material is based upon work supported by the Department of Energy, National Energy Technology Laboratory under Award Number DE-FG26-08NT03077.

Name: ______________________

Faster and Slower

Directions: Record what you see in the interactive.

Car Color	**Distance (laps)**	**Time (seconds)**
Red		
Blue		

Which car moved faster?

How do you know?

For more resources, visit www.FuelOurFutureNow.com.

Name: ______________________

Surfaces

Directions:

1. Draw or write the names of your surfaces in the "Surfaces" column.
2. Circle ***smooth***, ***medium***, or ***rough*** in the middle column to tell how the surface feels.
3. Push your car across each surface and measure how far it travels. Write the inches in the column on the right.

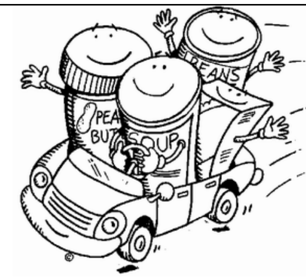
Surfaces	How Does the Surface Feel?	How Far Did the Car Go?
	smooth medium rough	_______ inches
	smooth medium rough	_______ inches
	smooth medium rough	_______ inches
	smooth medium rough	_______ inches
	smooth medium rough	_______ inches

For more resources, visit www.FuelOurFutureNow.com.

Name: ______________________

Friction

Directions:
1. Draw stones under the bus.
2. Draw a paved street under the car.
3. Draw a sidewalk under the skateboard.
4. Draw icy snow under the penguin's skis.
5. Compare the top two pictures. Then circle the words to complete the sentences about the pictures.
6. Compare the bottom two pictures. Then circle the words to complete the sentences about the pictures.



This surface is rough / smooth**.**	**This surface is** rough / smooth**.**
This surface will make the bus go slower / faster **than the car.**	**This surface will make the car go** slower / faster **than the bus.**

This surface is rough / smooth**.**	**This surface is** rough / smooth**.**
This surface will make the boy go slower / faster **than the penguin.**	**This surface will make the penguin go** slower / faster **than the boy.**

PROGRESSIVE AUTOMOTIVE X PRIZE — U.S. DEPARTMENT OF ENERGY — Discovery EDUCATION

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Name _______________________________ Date _______________

EXPLORATIONS

Exploration Student Worksheet: Friction

Overview

In this Exploration, you will learn that friction slows down or stops a moving object. You will also learn that different surfaces create different amounts of friction.

Questions

1. If there is too much friction for an object to move along a surface, what could you do to move the object further?

   ____

   ____

2. How can friction be helpful?

   ____

   ____

3. Sometimes people put oil on machine parts to make them work better. How does oil make machines work better?

   ____

   ____

How to Use This Exploration

1. Read the Introduction and click the **Continue** button.
2. Read the text and follow the instructions to learn about friction between different surfaces.
3. Watch the animations and read the outcome explanations as they appear. Record observations in the data table.
4. Click the **Reset** button to restart thatscreen.
5. Click the **Close** button to close the Exploration.

Name ______________________________ Date ______________

EXPLORATIONS

Data

Surface	How Far the Box Slid	Description of Surface	Amount of Friction
Metal			
Wood			
Sandpaper			

Friction

Overview
Students will learn that friction slows down or stops the movement of a moving object. They will also learn that different surfaces create different amounts of friction.

Student Learning Objectives
- Describe why different surfaces produce different amounts of friction.
- Explain that friction is a force that reduces the speed of a moving object.
- Categorize different materials based on the friction they create.

Student Worksheet
The student worksheet includes questions to focus the student and to check understanding, instructions for how to use the Exploration independently, and a section for recording data. Students will review questions before participating in the activity and may respond to the questions either during or after completion of the activity. The section for recording data includes a table in which to record their observations.

Exploration Procedure
Explain that the purpose of this Exploration is to learn how friction reduces the speed of a moving object and that different surfaces create different amounts of friction. Follow either of procedures below.

Student Performs Exploration

1. Tell students how much time they will have to complete the Exploration and the student worksheet.
2. Explain how students should proceed:
   - Read the questions before starting the Exploration.
   - Follow the instructions on the worksheet to perform the Exploration.
   - Record their observations.
   - Respond to the questions in writing.
3. Explain that you will be available to help any students who need assistance.
4. Address any questions that the students might have.
5. Tell students to begin the Exploration.
6. When time is up, ask students to share their results.
7. Talk about the Discussion Question.

Friction

Teacher Performs Exploration

1. Display the questions from the student worksheet and ask students to tell you what they think they will learn from the Exploration based on its questions. Highlight key words.
2. Read the Introduction and click the **Continue** button.
3. Read the text and follow the instructions to learn about friction on different surfaces.
4. Watch the animation, read the outcome explanations as they appear, and discuss. Record observations in the data table.
5. Click the **Reset** button to restart the screen.
6. Click the **Close** button to close the Exploration.
7. Discuss each of the questions with the class. Replay parts of the Exploration as necessary to illustrate the answers.
8. Talk about the Discussion Question.

Optional: Use this Exploration as a small-group activity at a computer station. Assign it to students who need specific reinforcement of the concept.

Questions

1. If there is too much friction for an object to move along a surface, what could you do to move the object further? *(Application-Level Objective)*
   Answer: Apply a greater force, reduce the friction by changing the surface, or change the incline of the surface so that gravity will help it move.
2. How can friction be helpful? *(Evaluation-Level Objective)*
   Answer: Friction is helpful in many ways. We can walk because of friction, but we slide on a sheet of ice, a surface with little friction. Brakes use friction to slow down and stop a moving car.
3. Sometimes people put oil on machine parts to make them work better. How does oil make machines work better? *(Analysis-Level Objective)*
   Answer: Some parts of a machine rub against each other, like a wheel and its axle. If there is friction between these parts, then they will not move easily. Friction will cause parts to wear out. Applying oil between the parts in a machine reduces friction and keeps the parts in good condition.

Discussion Question

Swimmers sometimes shave the hair off their legs, arms, and heads before races. What advantage would that give them in a race?
Possible answer: By removing hair from their legs, arms, and heads, they reduce the friction of their bodies against the water and can move faster.

GK–2

LESSON 5 — Keep it Moving!

MODULE OVERVIEW

Module Title: **Vroom! Vroom! What Makes Cars Go?**

Module Description: Students explore gravity, friction, and energy using objects and model cars. They investigate and define the concepts of motion, force, and energy, using simple hands-on activities with vehicles as well as online interactives and videos. At the end of the module, students apply the knowledge they have acquired about force, motion, energy and friction to design a functioning model car. Then, students share the cars with their classmates in a model car show.

Module Project: Students develop a model and/or diagram of a car and explain what causes the car to move, ways to keep it moving, and what makes it speed up or slow down.

LESSON OVERVIEW

Lesson Time: 40 minutes (two 40-minute periods if students do group problem-solving, pre-design, and sharing of pre-designs)

Students take what they have learned about force, motion, friction, and gravity to begin to test out ideas for making their own cars. They will explore with wheels and axles and consider solutions to make them move more smoothly.

BACKGROUND FOR TEACHERS

- Most children can tell you that without wheels, it's harder to move a heavy object. But wheels are only part of the solution. In order to use wheels in designing their vehicles, students have to understand the way in which wheels are connected to a vehicle.
- Adult engineers talk about rolling friction and sliding friction, but all that children will need to understand is that when a wheel is attached to a vehicle, something must rub against something else. With a fixed axle, the axle is fixed to the vehicle body and cannot turn; the wheels turn

around the axle. With a fixed wheel, the axle must turn against the vehicle; the wheel is fixed to the axle and cannot turn around it.

- Engineers over time have discovered many different ways to reduce friction in wheel/axle systems:
  - Use grease or smooth touching surfaces.
  - Use ball bearings between the surfaces to allow them to roll past each other.
- The solution that students will be working with in this lesson will be simple: one straw within another straw, allowing the inner straw to turn inside the larger straw. The wheel is fixed to the inner straw. The vehicle body is fixed to the outer straw allowing the inner axle to turn inside this housing.
- For young children, working together collaboratively on problem solving is a new challenge. Some children will want to work by themselves on this activity. Others will take to the idea of working out a problem with others. You, the expert on the young child, will be the best judge of how to proceed.
- The wheel and axle assembly you'll have them make is very simple and students may notice things that they don't like about it: the wheels wobble, they slide on the axle, etc. Use this as an opportunity to challenge them to think about how they could make it stronger or work better.
- You may or may not wish to introduce using lubricants to students to improve the vehicle motion. Be aware that various lubricants work better on some materials than others. Machine oil is best on metals, but has some good effects on plastic. Spray lubricants can just as easily gum up some situations as they help in others. Try some out before you decide to use them with students and bring plenty of paper towels to class. (Note: Some lubricants can be poisonous or cause irritation. Check your school's safety guidelines and observe safety precautions and reduce student contact with any lubricant.)

Teacher Preparation: A reminder: at the end of this module, you will want to have all the materials ready for the students to build their model car. These are simple materials, but you may wish to begin collecting them now to be sure they are all ready by Lesson 6. See Lesson 1 for suggestions.

LESSON OBJECTIVES

By the end of this lesson, students should be able to:

- Explain how turning motion can also have friction.
- Use the engineering process to try out designs to solve a problem.
- Describe one way to use rolling to help move a vehicle.

Please see *Standards Addressed in GK-2* for a list of the applicable science, technology, engineering, and math standards, as well as the 21st Century Skills.

Lesson Essential Questions:

1. How does friction affect a turning wheel?
2. How do people work together to solve an engineering problem?
3. What are some solutions to getting a wheel on a vehicle to turn?

Key Vocabulary (appropriate for a word wall):

wheel, friction, axle, turn, spin, roll, slide, vehicle base

RESOURCES

Materials needed:

- Chalkboard and chalk, whiteboard (or interactive whiteboard, if available), or chart paper
- Glossary created in Lesson 1
- KWL chart paper or transparency created in Lesson 1
- Large straws; one per student, cut in half
- Small straws; one per student, should fit inside the large straws, full length
- Cardboard circles (wheels) with an X cut in the center to fit onto the straws; one set of two per student
- Cardboard squares or rectangles to serve as car (vehicle) bases; one per student
- Masking tape – rolls or strips available for students as they need it
- 1 box or cardboard car (vehicle) body (see Lesson 1 or 6 for an example)
- Engineering Notebook for each student

Student Worksheets Required:

- *Where are the Wheels and Axels?* (one copy per student)
- *Where are the Wheels?* (one copy per student)

What skills do students need for this lesson?

- Some experience using charts, graphic organizers, and tables

TEACH

Engage

- Have students recall what they have learned about force and motion throughout the module. Guide students to recall that motion, or movement, is caused by a force and that a force is a push or pull.
- Review with them what they have learned about friction and how it impedes movement.
- Explain to students that you have a problem. Show students the "wheels" you have prepared for today and the car (vehicle) body. Tell them you want to add them to your car, but when you do, they won't turn by themselves. Tape one on and show them that it won't turn.
- Ask: *What would we need to do to get this wheel to be able to turn around in a circle?*
- Have children turn to each other and discuss some solutions. Invite some pairs to suggest their solutions. Try one or two out. Help students to see that there is a problem with getting the

wheel to turn. It is possible you will get some students who suggest that the wheel needs an axle. They won't likely use that vocabulary, but they may suggest something like sticking a pin in the center. If you have a pin or a thumbtack, try it and point out that this is called adding an axle. It's not critical that they come to an understanding about the need for an axle just yet, but someone may suggest it.

- Explain that there are many ways to connect wheels to cars. We will be investigating one today. Reiterate that it is not the only way.

Explore

- Bring out the large straws, small straws, cardboard "wheels" and cardboard "car bases" and make them visible to the students.
- Tell them that they will each receive a set of these things and name each item.
- Ask them to imagine that the cardboard rectangle is the bottom of a car. Their challenge is to get the wheels attached to it so that they turn. A further challenge is to make the wheel turn as easily as possible. We want our car to roll a long distance. The highest level of the challenge is to suggest that the best solution involves using all four pieces you have given them.
- For older children, this is a time to have them turn to their Engineering Notebooks and, looking at the materials, sketch out their ideas. You may wish to have them problem-solve in pairs or small teams at this point. They should then come back and share their drawings and plans.
- Ask students to talk through with a partner how they might solve the problem. After some time, ask the pairs/groups to share their ideas. Don't try these in front of them, but tell students that they should listen closely and be ready to try out some of the ideas. (It is unlikely that someone will figure out the straw-within-a-straw solution, but it is possible.)
- Have students go to where you will let them work on the problem. They should get out their Engineering Notebooks so they can sketch out their solutions. Then, pass out the materials.
- Repeat the challenge: they are to attach the wheels to the base so that the wheels will turn easily. (The word "easily" is the trick. A simple solution is to just push the wheel onto one of the straws. This meets the simplest level of the challenge, but does not allow the wheel to turn "easily.")
- Note: as they work on adding the wheels, there will be a problem with "slippage" of the wheel on the straw. It will wiggle a bit and slide back and forth. You can control this to some degree by showing students how to add a piece of tape on the straw that will keep the wheel from sliding.
- Allow students the time they need to work on the problem. Go around and ask questions, answer questions, repeat the "rules" of the problem, and listen to their thinking. Most will choose the easiest, most obvious method. Continue to ask them if they can make it move more easily.
- Bring the students back in a circle and have them show their solutions to the others. Talk about what worked and what didn't. By this point, you should have someone who figured out the straw-in-a-straw technique, but if not, you can show it to them.

Explain

- Ask students to hold up their index finger on one hand and show them yours. Have them take that finger in their other hand and squeeze it. (For safety and comfort, they should not try this with a partner as the squeezing and turning can become painful.) Now try to turn that finger inside the hand. It will be difficult. They should be able to feel the friction involved.
- Ask them to think about how this is like the problem they just worked on. *What force is causing the problem with the wheel* (friction)*?*
- Have them write in their Engineering Notebooks their ideas about turning wheels and friction.

Extend

- Ask students to name some of the things that they use that have wheels, especially those things that they ride.
- Ask students to go home and find a vehicle they have used themselves like a bicycle, skateboard, or a wagon. They are to find the wheels and axles and see if they can figure out how they are attached to the vehicle. They should draw a picture of what they find and be ready to describe it to others. If you think they will bring them back, have them take their Engineering Notebooks home to do this step. If not, provide them with a sheet to sketch what they find.

Evaluate

- Have students complete the attached *Where are the Wheels and Axles?* worksheet.
- Review the solutions and ask students to name the parts of the system that they built today with the straws, bases, and wheels.

Wrap-Up

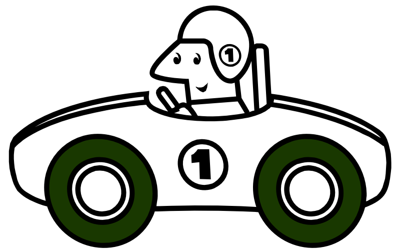
- Review the parts of the system they developed today and discuss how this system overcomes friction and uses rolling motion to make it easier to move the vehicle.
- Preview Lesson 6 explaining that they are almost ready to build their own car. They may want to think about what things would work well for wheels and how they want their car to look.

Acknowledgment: This material is based upon work supported by the Department of Energy, National Energy Technology Laboratory under Award Number DE-FG26-08NT03077.

Name: ______________________

Where are the Wheels and Axles?

Directions: Circle one wheel on each drawing. Put an X on one of the axles.



In the space below, draw a wheel with an axle.

Name: ______________________

Where are the Wheels?

Directions: 1. Draw a vehicle that you have at home that is not a car.
2. Explain in words or in a drawing how the wheels are connected to the vehicle.

I drew a(n) ____.

For more resources, visit www.FuelOurFutureNow.com.

GK–2

LESSON 6 — Creating Model Cars

MODULE OVERVIEW

Module Title: **Vroom! Vroom! What Makes Cars Go?**

Module Description: Students explore gravity, friction, and energy using objects and model cars. They investigate and define the concepts of motion, force, and energy, using simple hands-on activities with vehicles as well as online interactives and videos. At the end of the module, students apply the knowledge they have acquired about force, motion, energy and friction to design a functioning model car. Then, students share the cars with their classmates in a model car show.

Module Project: Students develop a model and/or diagram of a car and explain what causes the car to move, ways to keep it moving, and what makes it speed up or slow down.

LESSON OVERVIEW

Lesson Time: 45 – 90 minutes: one class for initial work and beginning to build, the second for building the design. You can choose to add more time as students continue to modify and improve their vehicles.

In Lesson 6, students will learn about vehicle design and then plan, design, and draw a diagram of their model cars, before beginning to construct them.

BACKGROUND FOR TEACHERS

- At this point in the lessons, students are ready to bring together their thinking and work on building a model car of their own.
- You will want to build your own vehicle in advance to understand the process. You should make yours in such a way that you can remove the wheels to show students how it goes together as you explain the trial and error process.
- Having completed the activity in lesson 5, students should now be able to add working wheels to their vehicles. The new design challenges will be adding a body to the base and making a vehicle that travels well down a ramp. Each time engineers solve a problem with a design, there

is a desire to continue to improve it, even if they've already solved the original problem. This is a desire that is good to instill in children, so encourage them to keep improving their models.

- In vehicle design, engineers are always trying to get the best movement out of the least amount of energy. There are, of course, other factors like comfort, safety, and style. Those factors can be addressed in future modules for students. It will be enough for this one for them to work with the first factor: how to design a vehicle that will move well.

Teacher Preparation:

Before the day of this lesson, it will be helpful for you to do the following:

- Read this lesson thoroughly and look at the pictures and steps in the attached *Sample Vehicle* worksheet.
- You may wish to do an Internet search to find pictures of vehicles made with other materials. This particular sample model comes from a "balloon-powered vehicle design". This module does not call for the use of balloons, as it is a bit too high-level for some primary students. In this module, we will depend on gravity and the ramp to move the vehicles. As you search, you will find some great ideas for alternative materials to use for wheels, bodies, adhesives, and axles. Note, if you have additional time, you may wish to add power to your vehicles, using balloons, rubber bands, or other methods. In that case, you should first get them to make working vehicles, then come back and add the power. Doing both at once can be very confusing. You will be adding the concept of energy to the module at that point.
- Read the materials list in the *Resources* section below, and decide which materials you would like to make available to students. Collect more vehicle parts than are needed per student to allow for choice and to anticipate mistakes.
- Try to offer as much variety as you can for vehicle bodies, axles, adhesives, and wheels, keeping in mind the following:
    - Vehicle bodies should all be about the same width.
    - Axles must be able to fit through and move freely inside the straws or wheels must be able to move freely around the axles.
- Collect or modify vehicle body materials so that they are all about the same width.
- You can choose to add some more mathematics to this exercise by having the students cut the straws to a particular length. How far you wish to take this depends on student readiness to measure the dimensions of the vehicle parts and the vehicles.
- Precut the axles so that they are one to two inches longer than the width of the vehicle's body. (The wheels, once attached, need to clear the side of the body in order to roll.)
- Precut straws so that they are less than the width of the body.
- Make a vehicle by following all the steps below in the *Sample Vehicle* worksheet EXCEPT for adding the straw within a straw design that students worked with in lesson 5. Instead, tape the axles directly to the vehicle. You will use this "error" to discuss how designing and building a solution works.
- Separate materials when you set them out, so that there are clear groups (e.g. vehicle bodies, straws and tape, axles, adhesives, wheels, and decorations).

- Set up test ramp.

LESSON OBJECTIVES

By the end of this lesson, students should be able to:

- Build a model and/or diagram of a vehicle.
- Identify the vehicle body, wheels, and axles of a model vehicle.

Please see *Standards Addressed in GK-2* for a list of the applicable science, technology, engineering, and math standards, as well as the 21st Century Skills.

Lesson Essential Questions:

1. What parts do all vehicles have?
2. Which of these parts must model vehicles have?

Key Vocabulary (appropriate for a word wall):

model, *diagram*, *design*, *vehicle body*, *axle*, *wheel*, *decorations*, *steps*, *project*

RESOURCES

Materials needed:

- Chalkboard and chalk, whiteboard (or interactive whiteboard, if available), or chart
- Computer with Internet access linked to a projector or TV (for whole class to view at once)
- Glossary created in Lesson 1
- KWL chart paper or transparency created in Lesson 1
- Pre-made sample model vehicle (see *Background for Teachers*)
- A ramp made from a piece of stiff cardboard (triple-layer box cardboard works well) or other stiff material; ramp should be twice as wide as your vehicles and long enough for them to run down to gain speed (100 cm or longer); books can be stacked to lift one end of the ramp
- Materials to decorate the vehicle and/or draw a vehicle design (paper, pencils, colored pencils, markers, crayons, construction paper, glue, glue sticks, stickers, etc.)
- Adhesive materials to attach all the parts (e.g. glue, hot glue gun, tape, clay, putty, playing dough, rubber bands) (Note: hot glue gun should <u>only</u> be handled by the teacher. Check school safety guidelines regarding the use of such equipment.)
- Precut straws
- Precut dowels, chopsticks, bamboo skewers, pencils and/or any other items that students might use as axles
- Egg cartons, foam, cardboard, tiny boxes, blocks, scrap wood, building toys, craft supplies, and/or any other items that students might use as the body of the model vehicle

- Spools, small toy/craft wheels, round bottle caps or lids, predrilled poker chips, and/or any other items that students might use as wheels
- Engineering Notebook for each student

Student Worksheets Required:

- *Project Checklist* (for the teacher: one copy per student)
- *Sample Vehicle* (projected digitally or converted to transparency)

What skills do students need for this lesson?

- Create and follow a step-by-step plan
- Use drawings and diagrams to represent ideas
- Modify designs using trial and error

TEACH

Engage

- Prior to class, follow the steps in *Background for Teachers* to construct a sample model vehicle.
- Begin class by telling students that today they will make their model cars. Ask student volunteers what they have learned about in the previous five lessons that might apply to model cars. Student responses will vary, but they should recognize that vehicles need forces to move, that friction will slow vehicles down, and that gravity will pull vehicles downhill. Write the student responses on the board.
- Explain that even though their cars are models, they have done a lot of the same things that vehicle designers do. Before vehicle designers can make an actual vehicle, they do a lot of research to learn what makes vehicles move, keep moving, speed up, and slow down. By learning about movement, forces, and friction, we have also done this research. Next, vehicle designers focus on deciding what design they want to use and what vehicle parts they need to get that design. They also must think about sizes of parts and how each part will connect to the others. That is what they will do first today—they will look at vehicle parts and designs to decide what they would like to do, as well as what they do not want to do.

Explain

- Have students gather around where they can see the materials and the ramp.
- Explain that engineers begin with a problem that needs to be solved. With these models, you will be trying to make a car that travels easily down the ramp by itself. You may wish to write this on the board to keep the goal in mind for the students.
- Explain that when engineers think about their designs, they consider the materials they will use, then sketch out or write out their designs. Engineers may not get the design right the first time (in fact they often don't). Show students your vehicle with the single axle.

- Try to run it down the ramp. Ask students: *Why doesn't it work as well as it should?* Make sure they can see that you did not use the straw-in-a-straw axle method.
- Demonstrate how this would be a change in the design that you would need to make, which is okay because engineers use *trial and error* (or a *do over*) to get a design to work. Students may not understand the term *trial and error*, so you may need to break down the words and explain it to them, or use the term *do over* instead. What you are doing here is giving your students permission to make mistakes. In science and engineering, we learn as much or more from something that doesn't work as from something that does work.
- Re-make your vehicle in front of them this time using the straw-in-a-straw technique. Place the vehicle at the top of the ramp and allow it to run down the ramp. Explain that all the models will be allowed to do this. It will be interesting to see if anyone can do it better than yours.

Explore

- Show students the materials you have set out and explain the options that are available for car parts. Also, encourage students to be creative with their decorations.
- Explain that before they begin building they should think about the parts that they plan to use and draw their design in the Engineering Notebook. It is okay if a drawing doesn't look perfect. The idea is just to show what parts will be used. Write the following terms on the board for students to use on their diagrams: *vehicle body*, *axle*, and *wheels*.
- Give students time to draw their designs, and then have them begin work on their cars. Walk around and provide assistance as needed. Ask questions and listen to their thinking, guiding them as they work. Remind them that *trial and error* (or *do overs*) are part of the design.
- When they think they have a model that is ready, they should notify you and you can take them to the ramp and run a trial. The model should always be started at the top of the ramp so that when you are comparing the motion of two vehicles, it is a fair test.
- As you walk around, ask students to answer questions about their vehicles such as: *How will you get your car to move? What could you do to make your car move faster? What could you do to make your car move slower? Why did you choose a particular design?*

Evaluate

- Use the attached *Project Checklist* to begin scoring the projects. Assess only items 1 and 2 during this lesson. Save the checklists for Lesson 7, where the remaining items will be assessed.

Wrap-Up

- Have students recall what they did in Lesson 6. Call on volunteers to talk about challenges they have encountered in designing and building their cars, and ask them to explain how they have overcome these challenges. Remind students that it is normal to make errors—the important thing is to apply what you learn from each error to the next trial.
- Ask students to respond to the *Lesson Essential Questions*.
- Preview Lesson 7. Explain that they have learned about vehicle designing and then designed and started making their model cars. In Lesson 7, they will finish making their cars. They will also get to see each other's cars.

Acknowledgment: This material is based upon work supported by the Department of Energy, National Energy Technology Laboratory under Award Number DE-FG26-08NT03077.

Name: ______________________

Project Checklist

Directions: Use the space provided to assess each item for the student identified above.

1. Labeled diagram: ____

____

2. Work habits: ____

____

3. Vehicle: ____

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4. Explanation of how the vehicle moves: ____________________________

____

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5. Identifies one way to make the vehicle go faster: __________________

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6. Identifies one way to make the vehicle slow down: ______________________________

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7. Makes appropriate comments about other students' vehicles: ____________________

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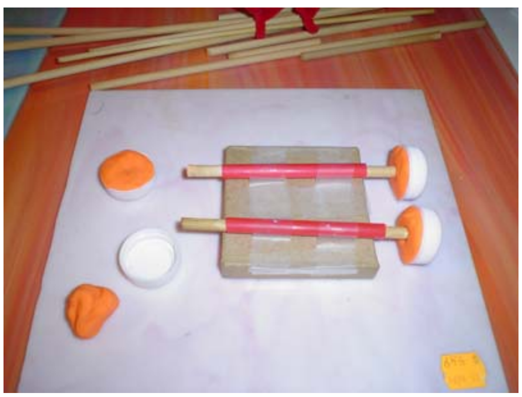
____

Sample Vehicle

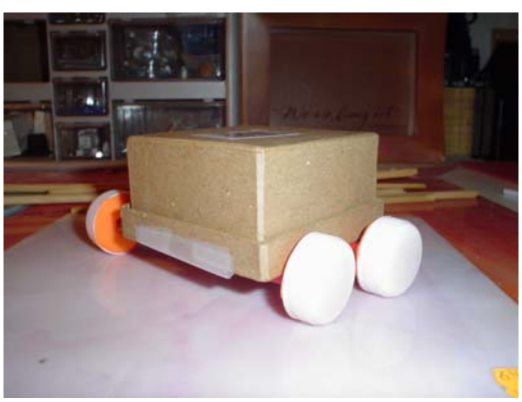
Step 1: Tape straws to the underside of the vehicle's body.

Step 2: Slide axles into the straws.

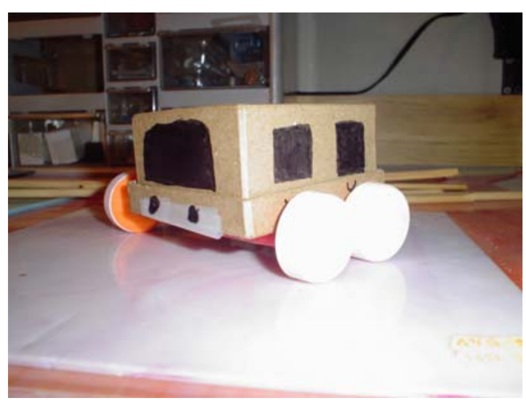


Step 3: Attach wheels to the axles. (In this instance, playing dough was stuffed inside water bottle lids.)

Step 4: Turn the vehicle right-side up.



Step 5: Add to the vehicle's body, if desired.



Step 6: Decorate your vehicle.

GK–2

LESSON 7 — Model Car Show

MODULE OVERVIEW

Module Title: **Vroom! Vroom! What Makes Cars Go?**

Module Description: Students explore gravity, friction, and energy using objects and model cars. They investigate and define the concepts of motion, force, and energy, using simple hands-on activities with vehicles as well as online interactives and videos. At the end of the module, students apply the knowledge they have acquired about force, motion, energy and friction to design a functioning model car. Then, students share the cars with their classmates in a model car show.

Module Project: Students develop a model and/or diagram of a car and explain what causes the car to move, ways to keep it moving, and what makes it speed up or slow down.

LESSON OVERVIEW

Lesson Time: 40 minutes

In Lesson 7, students will put any final touches on their cars and will use the ramp as a way of testing how well their cars move. They will share their designs with other students and participate in a positive critique of each other's designs.

BACKGROUND FOR TEACHERS

- In the previous lesson, students created designs for building a model car, based on a sample and the material that they covered in the first five lessons. In this lesson, students will put final touches on the car and show it to their classmates for constructive criticism.
- In engineering as in science, sharing ideas and solutions—provided they are backed up by evidence—is as critical a step as any in the process. Scientists and engineers believe strongly that we all learn from each other.

- The challenge was to make a vehicle that runs "easily" down a ramp. Children naturally want to compare their vehicle designs to each others' and it is easy for this to turn into a contest for the "best" vehicle. This is a natural part of engineering—engineers compete with each other, but in a collaborative way.
- Most children at these ages are still focused on their own accomplishments and are just beginning to learn how to interact with others.
- You will need to set up rules for positive feedback. Comments should be kept to positive responses about someone else's vehicle. If something doesn't work perfectly, a suggestion about how it could work better may be appreciated. How this interaction is handled will play a big part in how much children are willing to take risks in the future and how much they like designing solutions that others will see. Err on the side of positive reinforcement.
- Be sure that students have had a chance to test their vehicles and make sure they travel down the ramp before they do so in front of the whole class.

Teacher Preparation: See Lesson 6 for setup. Supply additional materials as necessary for students to finalize their models. Set up ramp.

LESSON OBJECTIVES

By the end of this lesson, students should be able to:

- Build a model car and/or make a diagram of a car.
- Explain what causes a car to move and to keep moving.
- Name things that can cause a car to speed up or slow down.

Please see *Standards Addressed in GK-2* for a list of the applicable science, technology, engineering, and math standards, as well as the 21st Century Skills.

Lesson Essential Questions:

1. What causes a car to move and to keep moving?
2. What things can make a car speed up?
3. What things can make a car slow down?

Key Vocabulary (appropriate for a word wall):

feedback, *questions*, *details*

RESOURCES

Materials needed:

- Glossary made in earlier lessons

- Classroom computer with Internet connection hooked to a projector or TV (or if you have an interactive whiteboard, you may choose to use that)
- Premade sample model car (from Lesson 6)
- Materials to decorate the car and/or draw a car design (paper, pencils, colored pencils, markers, crayons, construction paper, glue, glue sticks, stickers, etc.)
- Adhesive materials to attach all the parts (e.g. glue, hot glue gun, tape, clay, putty, playing dough, rubber bands) (Note: hot glue gun should only be handled by the teacher. Check school safety guidelines regarding the use of such equipment.)
- Precut straws
- Precut dowels, chopsticks, bamboo skewers, pencils and/or any other items students might use as axles
- Egg cartons, foam, cardboard, tiny boxes, blocks, scrap wood, building toys, craft supplies, and/or any other items students might use as the body of the model car
- Spools, small toy/craft wheels, round bottle caps or lids, predrilled poker chips, and/or any other items students might use as wheels
- Index cards (enough for each student to have one for every other member of the class; it may be helpful if you count out a stack for each student ahead of time); plus one to identify the designer for each vehicle
- Engineering Notebook for each student

Student Worksheets Required:

- *Project Checklist* (for the teacher, one copy per student), same as used in Lesson 6
- *Sample Vehicle* from Lesson 6 (projected digitally or converted to transparency), same as used in Lesson 6

What skills do students need for this lesson?

- Create and follow a step-by-step plan
- Use drawings and diagrams to represent ideas
- Modify designs using trial and error
- Write short phrases or sentences

TEACH

[* Note: The Explore and Explain sections of this lesson are intentionally reversed.]

Engage

- Tell students that today they will have a quick review, finish making their model cars, and then look at each other's cars and give each other positive feedback.
- Review the words and definitions from the Glossary with students.

- Ask students to respond to the *Lesson Essential Questions*. Guide students to conclude that most cars are run by an engine, but that their cars will move and keep moving by pushing (people power). They can make their car go faster by pushing harder (larger force), sending it down a ramp, or pushing it on a smooth surface. They can make their car slow down or go more slowly if they give it a smaller push (smaller force), send it up a ramp, or push it over a rougher surface.

Explain

- Students will inevitably finish building at different times. Have them test their cars and decide if they want to make any improvements. If not, they can put their car on display.
- Explain that as they complete their cars and are satisfied that they work well, they will be putting them in the display area and adding their names on a card next to their model. Hand them a card or some other way they can put their name next to the car so that it is easy to see who made each car.
- For students who complete their work, you will provide a set of index cards. They will begin to review the other cars and add constructive praise and criticism to an index card for each car.
- Give examples of acceptable and unacceptable feedback. For example, explain that you do not want students to just write, "I like your car" or "Good job." Instead, their feedback should have some detail, such as "I like the way you attached the wheels" or "I like how you made headlights and door handles with construction paper." Also, students should make only positive comments. If something is not working perfectly with a car model, they may make a suggestion about how it could be improved. You may wish to write a list of helpful words and phrases on the board to help students with their spelling (although spelling should not be graded here).
- Ask students to repeat what they are to do. You may wish to write each step on the board as a numbered list, such as:
    1. *Finish building the car.*
    2. *Test the car on the ramp.*
    3. *Clean up.*
    4. *Put the car on display. Write your name on a card to identify your car.*
    5. *Get set of index cards.*
    6. *Write feedback for classmates.*

Explore

- Pull up the *Sample Vehicle* worksheet on the projector and set out your sample model car from Lesson 6 for students to use as references as they work, but remind them that you want them to be creative and not make their cars look just like yours.
- Dismiss students to finish work on their cars and write their feedback notes. Walk around and provide assistance as needed.

Extend

- If your schedule allows, you may wish to give students time at the end of the lesson to test their cars on ramps and different surfaces.
- You may wish to extend this whole concept to adding power to the vehicles. This will require adding a power source such as a rubber band or balloon. It also requires getting into the concept of energy as way of continuing to add force to a moving vehicle.
- You may wish to have students do more measurements with the ramp distances.

Evaluate

- Assess students by completing the *Project Checklist* from Lesson 6 while students work.

Wrap-Up

- Have students comment on their experience with the project and the module. If appropriate, have them write their comments in their Engineering Notebooks. Lead a discussion of how the material that they learned in the first five lessons was applied to building the model car. For example, students probably realized that friction between the wheel and the axle would slow the car down.
- Encourage students to make connections between what they learned in this module and their everyday lives. In addition to increasing their understanding of motion and forces, students might comment on how the skills they learned in this module might be applied to solving other problems that are unrelated to cars. For example, students may find it useful to build models of other objects to help them explain how those objects work.

Acknowledgment: This material is based upon work supported by the Department of Energy, National Energy Technology Laboratory under Award Number DE-FG26-08NT03077.

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Name: ______________________

<u>Project Checklist</u>

Directions: Use the space provided to assess each item for the student identified above.

1. Labeled diagram: ____

____

2. Work habits: ____

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3. Vehicle: ____

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4. Explanation of how the vehicle moves: ____________________________

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5. Identifies one way to make the vehicle go faster: ___________________

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6. Identifies one way to make the vehicle slow down: ______________________________

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7. Makes appropriate comments about other students' vehicles: ____________________

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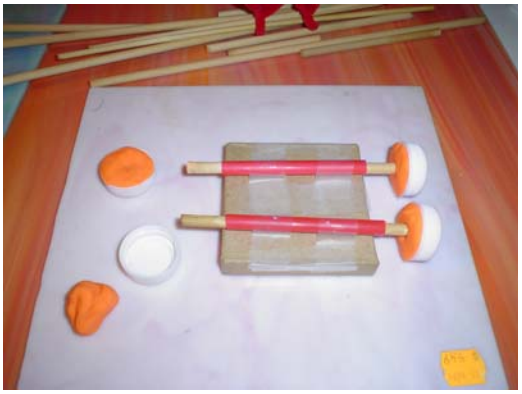
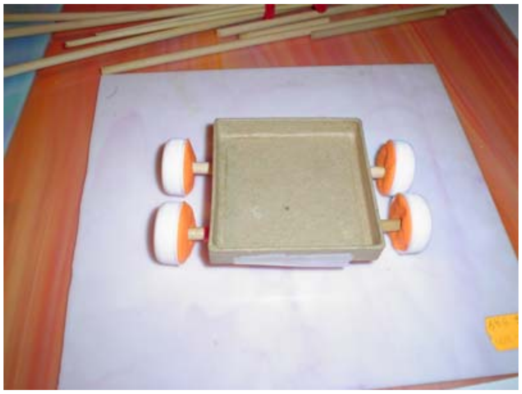
Sample Vehicle

Step 1: Tape straws to the underside of the vehicle's body.

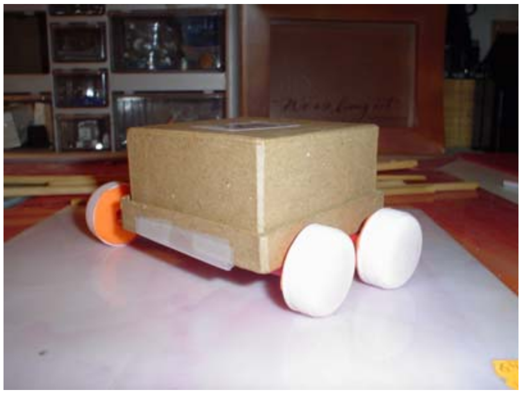
Step 2: Slide axles into the straws.



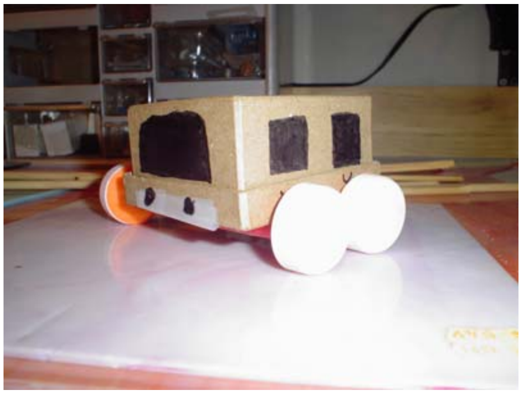
Step 3: Attach wheels to the axles. (In this instance, playing dough was stuffed inside water bottle lids.)



Step 4: Turn the vehicle right-side up.



Step 5: Add to the vehicle's body, if desired.



Step 6: Decorate your vehicle.

For more resources, visit www.FuelOurFutureNow.com.

Standards Addressed in GK–2

Lesson 1

Science:

NSES Content Standards	
Code	**Standard**
4ASI1.4	Use data to construct a reasonable explanation.
4ASI1.5	Communicate investigations and explanations.
4BPS1.1	Objects have many observable properties.
4BPS2.1	The position of an object can be described by locating it relative to another object or the background.
4BPS2.2	An object's motion can be described by tracing and measuring its position over time.

AAAS Project 2061 Benchmarks	
Code	**Standard**
2A/P1*	Circles, squares, triangles, and other shapes can be found in nature and in things that people build.
2A/P3	Things move, or can be made to move, along straight, curved, circular, back-and-forth, and jagged paths.

Math:

NCTM Standards	
Code	**Standard**
	Describe qualitative change, such as a student's growing taller.
	Recognize, name, build, draw, compare, and sort two- and three-dimensional shapes.
	Describe attributes and parts of two- and three-dimensional shapes.
	Describe, name, and interpret relative positions in space and apply ideas about relative position.
	Describe, name, and interpret direction and distance in navigating space and apply ideas about direction d distance.
	Sort and classify objects according to their attributes and organize data about the objects.
	Represent data using concrete objects, pictures, and graphs.
	Describe parts of the data and the set of data as a whole to determine what the data show.

AAAS Project 2061 Benchmarks	
Code	**Standard**
1B/P1	People can often learn about things around them by just observing those things carefully, but sometimes they can learn more by doing something to the things and noting what happens.
1C/P2	In doing science, it is often helpful to work with a team and to share findings with others. All team members should reach their own individual conclusions, however, about what the findings mean.
4F/P1	Things move in many different ways, such as straight, zigzag, round and round, back and forth, and fast and slow.

Technology:

AAAS Project 2061 Benchmarks	
Code	**Standard**
8B/P1*	Some kinds of materials are better than others for making any particular thing. Materials that are better in some ways, such as stronger or cheaper, may be worse in other ways, such as heavier or harder to cut.
11B/P3	One way to describe something is to say how it is and isn't like something else.

ITEA Standards	
Code	**Standard**
Standard 4.	**Students will develop an understanding of the cultural, social, economic, and political effects of technology** o Students in kindergarten through second grade should learn that the use of tools or machines can be harmful or helpful
Standard 10.	**Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.** o Students in kindergarten through second grade should learn that asking questions and making observations helps a person to figure out how things work.
Standard 12.	**Students will develop abilities to use and maintain technological products and systems.** o Students in kindergarten through second grade will discover how things work

21st-Century Skills:

Code	Standard
Critical Thinking and Problem Solving	Exercising sound reasoning in understanding
	Framing, analyzing and synthesizing information in order to solve problems and answer questions
Communication and Collaboration	Articulating thoughts and ideas clearly and effectively through speaking and writing
	Assuming shared responsibility for collaborative work
Flexibility & Adaptability	Articulating thoughts and ideas clearly and effectively through speaking and writing
	Assuming shared responsibility for collaborative work
	Working appropriately and productively with others

Lesson 2

Science:

NSES Content Standards	
Code	**Standard**
4ASI1.4	Use data to construct a reasonable explanation.
4ASI1.5	Communicate investigations and explanations.
4ASI2.2	Scientists use different kinds of investigations depending on the questions they are trying to answer.
4ASI2.4	Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge).
4BPS1.1	Objects have many observable properties, including weight.
4BPS2.1	The position of an object can be described by locating it relative to another object or the background.
4BPS2.2	An object's motion can be described by tracing and measuring its position over time.
4BPS2.3	The position and motion of objects can be changed by pushing or pulling. The size of the change is related to the strength of the push or pull.

AAAS Project 2061 Benchmarks	
Code	**Standard**
1A/P1	When a science investigation is done the way it was done before, we expect to get a very similar result.

1A/P2*	When a science investigation is done again in a different place, we expect to get a very similar result.
1B/P1	People can often learn about things around them by just observing those things carefully, but sometimes they can learn more by doing something to the things and noting what happens.
2A/P3	Things move, or can be made to move, along straight, curved, circular, back-and-forth, and jagged paths.
4F/P2	The way to change how something is moving is to give it a push or a pull.

Math:

NCTM Standards	
Code	**Standard**
	Describe qualitative change, such as a student's growing taller.
	Describe, name, and interpret relative positions in space and apply ideas about relative position.
	Describe, name, and interpret direction and distance in navigating space and apply ideas about direction and distance.
	Recognize the attributes of length, volume, weight, area, and time.
	Compare and order objects according to these attributes.
	Represent data using concrete objects, pictures, and graphs.
	Describe parts of the data and the set of data as a whole to determine what the data show.

AAAS Project 2061 Benchmarks	
Code	**Standard**
1B/P1	People can often learn about things around them by just observing those things carefully, but sometimes they can learn more by doing something to the things and noting what happens.
1C/P2	In doing science, it is often helpful to work with a team and to share findings with others. All team members should reach their own individual conclusions, however, about what the findings mean.
4F/P1	Things move in many different ways, such as straight, zigzag, round and round, back and forth, and fast and slow.
11D/P1	Things in nature and things people make have very different sizes, weights, ages, and speeds.
12B/P5*	Make quantitative estimates of time intervals and the lengths and weights of familiar objects.
12D/P1*	Describe and compare real-world objects in terms of number, shape, texture, size, weight, color, and motion.

Technology:

AAAS Project 2061 Benchmarks	
Code	**Standard**
12D/P2*	Draw pictures that portray some features of the thing being described.
11B/P3	One way to describe something is to say how it is and isn't like something else.

ITEA Standards	
Code	**Standard**
Standard 10.	**Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.** o Students in kindergarten through second grade should learn that asking questions and making observations helps a person to figure out how things work.
Standard 12.	**Students will develop abilities to use and maintain technological products and systems.** o Students in kindergarten through second grade should discover how things work

21st-Century Skills:

Code	**Standard**
Critical Thinking and Problem Solving	Exercising sound reasoning in understanding
	Framing, analyzing and synthesizing information in order to solve problems and answer questions
Communication and Collaboration	Articulating thoughts and ideas clearly and effectively through speaking and writing
	Assuming shared responsibility for collaborative work
ICT Literacy	Using digital technology, communication tools and/or networks appropriately to access, manage, integrate, evaluate, and create information in order to function in a knowledge economy
Initiative & Self-Direction	Monitoring one's own understanding and learning needs
	Defining, prioritizing and completing tasks without direct oversight
	Utilizing time efficiently and managing workload
	Demonstrating commitment to learning as a lifelong process

Social & Cross-Cultural Skills	Working appropriately and productively with others

Lesson 3

Science:

NSES Content Standards	
Code	**Standard**
4ASI1.4	Use data to construct a reasonable explanation.
4ASI1.5	Communicate investigations and explanations.
4ASI2.2	Scientists use different kinds of investigations depending on the questions they are trying to answer.
4ASI2.4	Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge).
4BPS1.1	Objects have many observable properties, including weight.
4BPS2.1	The position of an object can be described by locating it relative to another object or the background.
4BPS2.2	An object's motion can be described by tracing and measuring its position over time.
4BPS2.3	The position and motion of objects can be changed by pushing or pulling. The size of the change is related to the strength of the push or pull.

AAAS Project 2061 Benchmarks	
Code	**Standard**
1A/P1	When a science investigation is done the way it was done before, we expect to get a very similar result.
1A/P2*	When a science investigation is done again in a different place, we expect to get a very similar result.
1B/P1	People can often learn about things around them by just observing those things carefully, but sometimes they can learn more by doing something to the things and noting what happens.
1B/P3	Describing things as accurately as possible is important in science because it enables people to compare their observations with those of others.
4F/P1	Things move in many different ways, such as straight, zigzag, round and round, back and forth, and fast and slow.
4F/P2	The way to change how something is moving is to give it a push or a pull.
4G/P1	Things near the earth fall to the ground unless something holds them up.

Math:

NCTM Standards	
Code	**Standard**
	Describe qualitative change, such as a student's growing taller.
	Describe, name, and interpret relative positions in space and apply ideas about relative position.
	Describe, name, and interpret direction and distance in navigating space and apply ideas about direction and distance.
	Recognize the attributes of length, volume, weight, area, and time.
	Compare and order objects according to these attributes.
	Represent data using concrete objects, pictures, and graphs.
	Describe parts of the data and the set of data as a whole to determine what the data show.

AAAS Project 2061 Benchmarks	
Code	**Standard**
11D/P1	Things in nature and things people make have very different sizes, weights, ages, and speeds.
12B/P5*	Make quantitative estimates of time intervals and the lengths and weights of familiar objects.
12D/P1*	Describe and compare real-world objects in terms of number, shape, texture, size, weight, color, and motion.

Technology:

AAAS Project 2061 Benchmarks	
Code	**Standard**
11C/P2	People can keep track of some things, seeing where they come from and where they go.
11B/P3	One way to describe something is to say how it is and isn't like something else.

ITEA Standards	
Code	**Standard**
Standard 4.	**Students will develop an understanding of the cultural, social, economic, and political effects of technology** o Students in kindergarten through second grade should

	the use of tools or machines can be harmful or helpful
Standard 10.	**Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.** o Students in kindergarten through second grade should learn that asking questions and making observations helps a person to figure out how things work.
Standard 12.	**Students will develop abilities to use and maintain technological products and systems.** o Students in kindergarten through second grade will discover how things work
Standard 13.	**Students will develop abilities to assess the impact of products and systems.** o Students in kindergarten through second grade should learn that collect information about everyday products and systems by asking questions

21st-Century Skills:

Code	**Standard**
Critical Thinking and Problem Solving	Exercising sound reasoning in understanding
	Framing, analyzing and synthesizing information in order to solve problems and answer questions
Communication and Collaboration	Articulating thoughts and ideas clearly and effectively through speaking and writing
	Assuming shared responsibility for collaborative work
ICT Literacy	Using digital technology, communication tools and/or networks appropriately to access, manage, integrate, evaluate, and create information in order to function in a knowledge economy
Initiative & Self-Direction	Monitoring one’s own understanding and learning needs
	Defining, prioritizing and completing tasks without direct oversight
	Utilizing time efficiently and managing workload
	Demonstrating commitment to learning as a lifelong process
Social & Cross-Cultural Skills	Working appropriately and productively with others

Lesson 4

Science:

NSES Content Standards	
Code	**Standard**
4ASI1.3	Employ simple equipment and tools to gather data and extend the senses.
4ASI1.4	Use data to construct a reasonable explanation.
4ASI1.5	Communicate investigations and explanations.
4ASI2.3	Simple instruments such as magnifiers, thermometers, rulers, provide more information than scientists obtain using only their senses.
4ASI2.4	Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge).
4ASI2.6	Scientists review and ask questions about the results of other scientists' work.
4BPS1.1	Objects have many observable properties that can be measured.
4BPS2.1	The position of an object can be described by locating it relative to another object or the background.
4BPS2.2	An object's motion can be described by tracing and measuring its position over time.
4BPS2.3	The position and motion of objects can be changed by pushing or pulling. The size of the change is related to the strength of the push or pull.
4EST2.5	Tools help scientists make better observations, measurements, and equipment for investigations.

AAAS Project 2061 Benchmarks	
Code	**Standard**
1A/P1	When a science investigation is done the way it was done before, we expect to get a very similar result.
1A/P2*	When a science investigation is done again in a different place, we expect to get a very similar result.
1B/P1	People can often learn about things around them by just observing those things carefully, but sometimes they can learn more by doing something to the things and noting what happens.
1B/P2	Tools such as thermometers, magnifiers, rulers, or balances often give more information about things than can be obtained by just observing things unaided.
1B/P3	Describing things as accurately as possible is important in science because it enables people to compare their observations with those of others.
1C/P2	In doing science, it is often helpful to work with a team and to share findings with others. All team members should reach their own individual conclusions, however, about what the findings mean.

4F/P1	Things move in many different ways, such as straight, zigzag, round and round, back and forth, and fast and slow.
4F/P2	The way to change how something is moving is to give it a push or a pull.

Math:

NCTM Standards	
Code	**Standard**
	Describe qualitative change, such as a student's growing taller.
	Describe, name, and interpret relative positions in space and apply ideas about relative position.
	Describe, name, and interpret direction and distance in navigating space and apply ideas about direction and distance.
	Recognize the attributes of length, volume, weight, area, and time.
	Compare and order objects according to these attributes.
	Understand how to measure using nonstandard and standard units;
	Use tools to measure.
	Represent data using concrete objects, pictures, and graphs.
	Describe parts of the data and the set of data as a whole to determine what the data show.

AAAS Project 2061 Benchmarks	
Code	**Standard**
9A/P1*	Numbers can be used to count things, place them in order, measure them, or name them.
11D/P1	Things in nature and things people make have very different sizes, weights, ages, and speeds.
12B/P1*	Use whole numbers in ordering, counting, identifying, measuring, and describing objects and events.
12C/P4*	Measure the length in whole units of objects using rulers and tape measures.
12D/P1*	Describe and compare real-world objects in terms of number, shape, texture, size, weight, color, and motion.

Technology:

AAAS Project 2061 Benchmarks	
Code	**Standard**
3A/P1	Tools are used to do things better or more easily and to do some things that could not otherwise be done at all. In technology, tools are used to observe, measure, and make things.
11C/P2	People can keep track of some things, seeing where they come from and where they go.
11B/P3	One way to describe something is to say how it is and isn't like something else.
12D/P2*	Draw pictures that portray some features of the thing being described.
12D/P3**	Interpret pictures, drawings, and videos of real-world objects and events.

ITEA Standards	
Code	**Standard**
Standard 4.	**Students will develop an understanding of the cultural, social, economic, and political effects of technology** o Students in kindergarten through second grade should learn that the use of tools or machines can be harmful or helpful
Standard 10.	**Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.** o Students in kindergarten through second grade should learn that asking questions and making observations helps a person to figure out how things work.
Standard 12.	**Students will develop abilities to use and maintain technological products and systems.** o Students in kindergarten through second grade will discover how things work

21st-Century Skills:

Code	**Standard**
Critical Thinking and Problem Solving	Exercising sound reasoning in understanding

	Framing, analyzing and synthesizing information in order to solve problems and answer questions
Communication and Collaboration	Articulating thoughts and ideas clearly and effectively through speaking and writing
	Exercising flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal
	Assuming shared responsibility for collaborative work
ICT Literacy	Using digital technology, communication tools and/or networks appropriately to access, manage, integrate, evaluate, and create information in order to function in a knowledge economy
Initiative & Self-Direction	Monitoring one's own understanding and learning needs
	Defining, prioritizing and completing tasks without direct oversight
	Utilizing time efficiently and managing workload
	Demonstrating commitment to learning as a lifelong process
Social & Cross-Cultural Skills	Working appropriately and productively with others

Lesson 5

Science:

NSES Content Standards	
Code	**Standard**
4ASI2.4	Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge).
4BPS1.1	Objects have many observable properties that can be measured.
4BPS1.2	Objects are made of one or more materials, such as paper, wood and metal.
4BPS2.1	The position of an object can be described by locating it relative to another object or the background.
4BPS2.2	An object's motion can be described by tracing and measuring its position over time.
4BPS2.3	The position and motion of objects can be changed by pushing or pulling. The size of the change is related to the strength of the push or pull.
4FSPSP5.2	Science and technology have greatly improved food quality and quantity, transportation, health, sanitation, and communication.

AAAS Project 2061 Benchmarks	
Code	**Standard**
1B/P1	People can often learn about things around them by just observing those things carefully, but sometimes they can learn more by doing something to

	the things and noting what happens.
1B/P2	Tools such as thermometers, magnifiers, rulers, or balances often give more information about things than can be obtained by just observing things unaided.
1B/P3	Describing things as accurately as possible is important in science because it enables people to compare their observations with those of others.
4F/P1	Things move in many different ways, such as straight, zigzag, round and round, back and forth, and fast and slow.
4F/P2	The way to change how something is moving is to give it a push or a pull.
8C/P2	People burn fuels such as wood, oil, coal, or natural gas, or use electricity, to cook their food and warm their houses.

Math:

NCTM Standards	
Code	**Standard**
	Describe qualitative change, such as a student's growing taller.
	Describe, name, and interpret relative positions in space and apply ideas about relative position.
	Describe, name, and interpret direction and distance in navigating space and apply ideas about direction and distance.
	Recognize the attributes of length, volume, weight, area, and time.

AAAS Project 2061 Benchmarks	
Code	**Standard**
9A/P1*	Numbers can be used to count things, place them in order, measure them, or name them.
11D/P1	Things in nature and things people make have very different sizes, weights, ages, and speeds.
12B/P1*	Use whole numbers in ordering, counting, identifying, measuring, and describing objects and events.
12D/P1*	Describe and compare real-world objects in terms of number, shape, texture, size, weight, color, and motion.

Technology:

AAAS Project 2061 Benchmarks	
Code	**Standard**
3A/P1	Tools are used to do things better or more easily and to do some things that could not otherwise be done at all. In technology, tools are used to observe, measure, and make things.
11A/P1	Most things are made of parts.
11A/P3	When parts are put together, they can do things that they couldn't do by themselves.
11B/P1	Many toys are like real things in some ways but not others. They may not be the same size, are missing many details, or are not able to do all of the same things.
11B/P2	A model of something is different from the real thing but can be used to learn something about the real thing.
11B/P3	One way to describe something is to say how it is and isn't like something else.
12D/P2*	Draw pictures that portray some features of the thing being described.
12D/P3**	Interpret pictures, drawings, and videos of real-world objects and events.

ITEA Standards	
Code	**Standard**
Standard 1.	**Students will develop an understanding of the characteristics and scope of technology.** o Students in kindergarten through second grade should learn that all people use tools and techniques to help them do things.
Standard 2.	• **Students will develop an understanding of the core concepts of technology.** o Students in kindergarten through second grade should learn that ▪ systems have parts or components that work together to accomplish a goal. ▪ people plan in order to get things done.
Standard 4.	**Students will develop an understanding of the cultural, social, economic, and political effects of technology** o Students in kindergarten through second grade should learn that the use of tools or machines can be harmful or helpful
Standard 9.	• **Students will develop an understanding of engineering design.**

	o Students in kindergarten through second grade should learn that ▪ the engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others. ▪ expressing ideas with others verbally and through sketches and models is an important part of the design process.
Standard 10.	**Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.** o Students in kindergarten through second grade should learn that asking questions and making observations helps a person to figure out how things work.
Standard 11.	• **Students will develop the abilities to apply the design process.** o Students in kindergarten through second grade will ▪ brainstorming people's needs and wants and pick some problems that can be solved through the design process. ▪ build or construct an object using the design process. ▪ investigate how things are made and how they can be improved.
Standard 18.	• **Students will develop an understanding of and be able to select and use transportation technologies.** o Students in kindergarten through second grade should learn that vehicles move people or goods from one place to another in water, air, or space and on land.

21st-Century Skills:

Code	**Standard**
Critical Thinking and Problem Solving	Exercising sound reasoning in understanding
	Understanding the interconnections among systems

	Framing, analyzing and synthesizing information in order to solve problems and answer questions
Communication and Collaboration	Articulating thoughts and ideas clearly and effectively through speaking and writing
Initiative & Self-Direction	Monitoring one's own understanding and learning needs
	Demonstrating commitment to learning as a lifelong process

Lesson 6

Science:

NSES Content Standards	
Code	**Standard**
4ASI1.4	Use data to construct a reasonable explanation.
4ASI1.5	Communicate investigations and explanations.
4ASI2.4	Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge).
4BPS1.1	Objects have many observable properties that can be measured.
4BPS2.1	The position of an object can be described by locating it relative to another object or the background.
4BPS2.2	An object's motion can be described by tracing and measuring its position over time.
4BPS2.3	The position and motion of objects can be changed by pushing or pulling. The size of the change is related to the strength of the push or pull.

AAAS Project 2061 Benchmarks	
Code	**Standard**
1A/P1	When a science investigation is done the way it was done before, we expect to get a very similar result.
1A/P2*	When a science investigation is done again in a different place, we expect to get a very similar result.
1B/P1	People can often learn about things around them by just observing those things carefully, but sometimes they can learn more by doing something to the things and noting what happens.
1B/P3	Describing things as accurately as possible is important in science because it enables people to compare their observations with those of others.
2A/P3	Things move, or can be made to move, along straight, curved, circular, back-and-forth, and jagged paths.
4F/P1	Things move in many different ways, such as straight, zigzag, round and

	round, back and forth, and fast and slow.
4F/P2	The way to change how something is moving is to give it a push or a pull.

Math:

NCTM Standards	
Code	**Standard**
	Describe qualitative change, such as a student's growing taller.
	Describe quantitative change, such as a student's growing two inches in one year.
	Investigate and predict the results of putting together and taking apart two- and three-dimensional shapes.
	Describe, name, and interpret relative positions in space and apply ideas about relative position.
	Describe, name, and interpret direction and distance in navigating space and apply ideas about direction and distance.
	Recognize the attributes of length, volume, weight, area, and time.
	Recognize and apply mathematics in contexts outside of mathematics

AAAS Project 2061 Benchmarks	
Code	**Standard**
9A/P1*	Numbers can be used to count things, place them in order, measure them, or name them.
11D/P1	Things in nature and things people make have very different sizes, weights, ages, and speeds.
12B/P1*	Use whole numbers in ordering, counting, identifying, measuring, and describing objects and events.
12D/P1*	Describe and compare real-world objects in terms of number, shape, texture, size, weight, color, and motion.

Technology:

NSES Content Standards	
Code	**Standard**
4EST1.3	Children should develop abilities to work individually and collaboratively and to use suitable tools, techniques, and quantitative measurements when appropriate.
4EST1.4	Evaluate a product or design.
4EST1.5	Student abilities should include oral, written, and pictorial communication

	of the design process and product.
4EST2.2	People have always had problems and invented tools and techniques (ways of doing something) to solve problems.
4FSPSP5.2	Science and technology have greatly improved food quality and quantity, transportation, health, sanitation, and communication.

AAAS Project 2061 Benchmarks	
Code	**Standard**
3A/P2	When trying to build something or to get something to work better, it usually helps to follow directions if there are any or to ask someone who has done it before for suggestions.
3B/P1*	People may not be able to actually make or do everything that they can design.
8B/P1*	Some kinds of materials are better than others for making any particular thing. Materials that are better in some ways, such as stronger or cheaper, may be worse in other ways, such as heavier or harder to cut.
8B/P2	Several steps are usually involved in making things.
3A/P1	Tools are used to do things better or more easily and to do some things that could not otherwise be done at all. In technology, tools are used to observe, measure, and make things.
11A/P1	Most things are made of parts.
11A/P2	Something may not work if some of its parts are missing.
11A/P3	When parts are put together, they can do things that they couldn't do by themselves.
11B/P1	Many toys are like real things in some ways but not others. They may not be the same size, are missing many details, or are not able to do all of the same things.
11B/P2	A model of something is different from the real thing but can be used to learn something about the real thing.
11B/P3	One way to describe something is to say how it is and isn't like something else.
12C/P3*	Make something out of paper, cardboard, cloth, wood, plastic, metal, or existing objects that can actually be used to perform a task.
12D/P1*	Describe and compare real-world objects in terms of number, shape, texture, size, weight, color, and motion.
12D/P2*	Draw pictures that portray some features of the thing being described.
12D/P3**	Interpret pictures, drawings, and videos of real-world objects and events.

ITEA Standards	
Code	**Standard**
Standard 1.	**Students will develop an understanding of the characteristics and scope of technology.** o Students in kindergarten through second grade should learn that all people use tools and techniques to help them do things.
Standard 2.	• **Students will develop an understanding of the core concepts of technology.** o Students in kindergarten through second grade should learn that ▪ systems have parts or components that work together to accomplish a goal. ▪ people plan in order to get things done.
Standard 6.	• **Students will develop an understanding of the role of society in the development and use of technology.** o Students in kindergarten through second grade should learn that products are made to meet individual needs and wants.
Standard 8.	• **Students will develop an understanding of the attributes of design.** o Students in kindergarten through second grade should learn that ▪ everyone can design solutions to a problem. ▪ design is a creative process.
Standard 9.	• **Students will develop an understanding of engineering design.** o Students in kindergarten through second grade should learn that ▪ the engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others. ▪ expressing ideas with others verbally and through sketches and models is an important part of the design process.
Standard 11.	• **Students will develop the abilities to apply the design process.** o Students in kindergarten through second grade will ▪ brainstorming people's needs and wants and pick some problems that can be solved through the design process. ▪ build or construct an object using the design

	▪ investigate how things are made and how they can be improved.
Standard 18.	• **Students will develop an understanding of and be able to select and use transportation technologies.** o Students in kindergarten through second grade should learn that vehicles move people or goods from one place to another in water, air, or space and on land.

21st-Century Skills:

Code	**Standard**
Creativity and Innovation	Demonstrating originality and inventiveness in work
	Developing, implementing, and communicating new ideas to others
Critical Thinking and Problem Solving	Exercising sound reasoning in understanding
	Making complex choices and decisions
	Understanding the interconnections among systems
	Framing, analyzing and synthesizing information in order to solve problems and answer questions
Communication and Collaboration	Articulating thoughts and ideas clearly and effectively through speaking and writing
Initiative & Self-Direction	Monitoring one's own understanding and learning needs
	Defining, prioritizing and completing tasks without direct oversight
	Utilizing time efficiently and managing workload
	Demonstrating commitment to learning as a lifelong process
Productivity & Accountability	Setting and meeting high standards and goals for delivering quality work on time

Lesson 7

Science:

NSES Content Standards	
Code	**Standard**
4ASI1.4	Use data to construct a reasonable explanation.
4ASI1.5	Communicate investigations and explanations.

4ASI2.4	Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge).
4ASI2.6	Scientists review and ask questions about the results of other scientists' work.
4BPS1.1	Objects have many observable properties that can be measured.
4BPS1.2	Objects are made of one or more materials, such as paper, wood and metal.
4BPS2.1	The position of an object can be described by locating it relative to another object or the background.
4BPS2.2	An object's motion can be described by tracing and measuring its position over time.
4BPS2.3	The position and motion of objects can be changed by pushing or pulling. The size of the change is related to the strength of the push or pull.

AAAS Project 2061 Benchmarks	
Code	**Standard**
1A/P1	When a science investigation is done the way it was done before, we expect to get a very similar result.
1A/P2*	When a science investigation is done again in a different place, we expect to get a very similar result.
1B/P1	People can often learn about things around them by just observing those things carefully, but sometimes they can learn more by doing something to the things and noting what happens.
1B/P3	Describing things as accurately as possible is important in science because it enables people to compare their observations with those of others.
2A/P3	Things move, or can be made to move, along straight, curved, circular, back-and-forth, and jagged paths.
4F/P1	Things move in many different ways, such as straight, zigzag, round and round, back and forth, and fast and slow.
4F/P2	The way to change how something is moving is to give it a push or a pull.

Math:

NCTM Standards	
Code	**Standard**
	Describe qualitative change, such as a student's growing taller.
	Describe quantitative change, such as a student's growing two inches in one year.
	Investigate and predict the results of putting together and taking apart

	two- and three-dimensional shapes.
	Describe, name, and interpret relative positions in space and apply ideas about relative position.
	Describe, name, and interpret direction and distance in navigating space and apply ideas about direction and distance.
	Recognize the attributes of length, volume, weight, area, and time.
	Recognize and apply mathematics in contexts outside of mathematics

AAAS Project 2061 Benchmarks	
Code	**Standard**
9A/P1*	Numbers can be used to count things, place them in order, measure them, or name them.
11D/P1	Things in nature and things people make have very different sizes, weights, ages, and speeds.
12B/P1*	Use whole numbers in ordering, counting, identifying, measuring, and describing objects and events.
12D/P1*	Describe and compare real-world objects in terms of number, shape, texture, size, weight, color, and motion.

Technology:

NSES Content Standards	
Code	**Standard**
4EST1.3	Children should develop abilities to work individually and collaboratively and to use suitable tools, techniques, and quantitative measurements when appropriate.
4EST1.4	Evaluate a product or design.
4EST1.5	Student abilities should include oral, written, and pictorial communication of the design process and product.

AAAS Project 2061 Benchmarks	
Code	**Standard**
3A/P2	When trying to build something or to get something to work better, it usually helps to follow directions if there are any or to ask someone who has done it before for suggestions.
3B/P1*	People may not be able to actually make or do everything that they can design.
8B/P1*	Some kinds of materials are better than others for making any particular thing. Materials that are better in some ways, such as stronger or cheaper,

	may be worse in other ways, such as heavier or harder to cut.
8B/P2	Several steps are usually involved in making things.
3A/P1	Tools are used to do things better or more easily and to do some things that could not otherwise be done at all. In technology, tools are used to observe, measure, and make things.
11A/P1	Most things are made of parts.
11A/P2	Something may not work if some of its parts are missing.
11A/P3	When parts are put together, they can do things that they couldn't do by themselves.
11B/P1	Many toys are like real things in some ways but not others. They may not be the same size, are missing many details, or are not able to do all of the same things.
11B/P2	A model of something is different from the real thing but can be used to learn something about the real thing.
11B/P3	One way to describe something is to say how it is and isn't like something else.
12C/P3*	Make something out of paper, cardboard, cloth, wood, plastic, metal, or existing objects that can actually be used to perform a task.
12D/P1*	Describe and compare real-world objects in terms of number, shape, texture, size, weight, color, and motion.

ITEA Standards	
Code	**Standard**
Standard 1.	**Students will develop an understanding of the characteristics and scope of technology.** o Students in kindergarten through second grade should learn that all people use tools and techniques to help them do things.
Standard 2.	• **Students will develop an understanding of the core concepts of technology.** o Students in kindergarten through second grade should learn that ▪ systems have parts or components that work together to accomplish a goal. ▪ people plan in order to get things done.
Standard 6.	• **Students will develop an understanding of the role of society in the development and use of technology.** o Students in kindergarten through second grade should learn that products are made to meet individual needs and wants.

Standard 8.	• **Students will develop an understanding of the attributes of design.** o Students in kindergarten through second grade should learn that ▪ everyone can design solutions to a problem. ▪ design is a creative process.
Standard 9.	• **Students will develop an understanding of engineering design.** o Students in kindergarten through second grade should learn that ▪ the engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others. ▪ expressing ideas with others verbally and through sketches and models is an important part of the design process.
Standard 11.	• **Students will develop the abilities to apply the design process.** o Students in kindergarten through second grade will ▪ brainstorming people's needs and wants and pick some problems that can be solved through the design process. ▪ build or construct an object using the design process. ▪ investigate how things are made and how they can be improved.
Standard 18.	• **Students will develop an understanding of and be able to select and use transportation technologies.** o Students in kindergarten through second grade should learn that vehicles move people or goods from one place to another in water, air, or space and on land.

21st-Century Skills:

Code	**Standard**
Creativity and Innovation	Demonstrating originality and inventiveness in work
	Developing, implementing, and communicating new ideas to others
Critical Thinking and Problem Solving	Exercising sound reasoning in understanding
	Making complex choices and decisions
	Understanding the interconnections among systems

	Framing, analyzing and synthesizing information in order to solve problems and answer questions
Communication and Collaboration	Articulating thoughts and ideas clearly and effectively through speaking and writing
Flexibility & Adaptability	Adapting to varied roles and responsibilities
Initiative & Self-Direction	Monitoring one's own understanding and learning needs
	Defining, prioritizing and completing tasks without direct oversight
	Utilizing time efficiently and managing workload
	Demonstrating commitment to learning as a lifelong process
Productivity & Accountability	Setting and meeting high standards and goals for delivering quality work on time