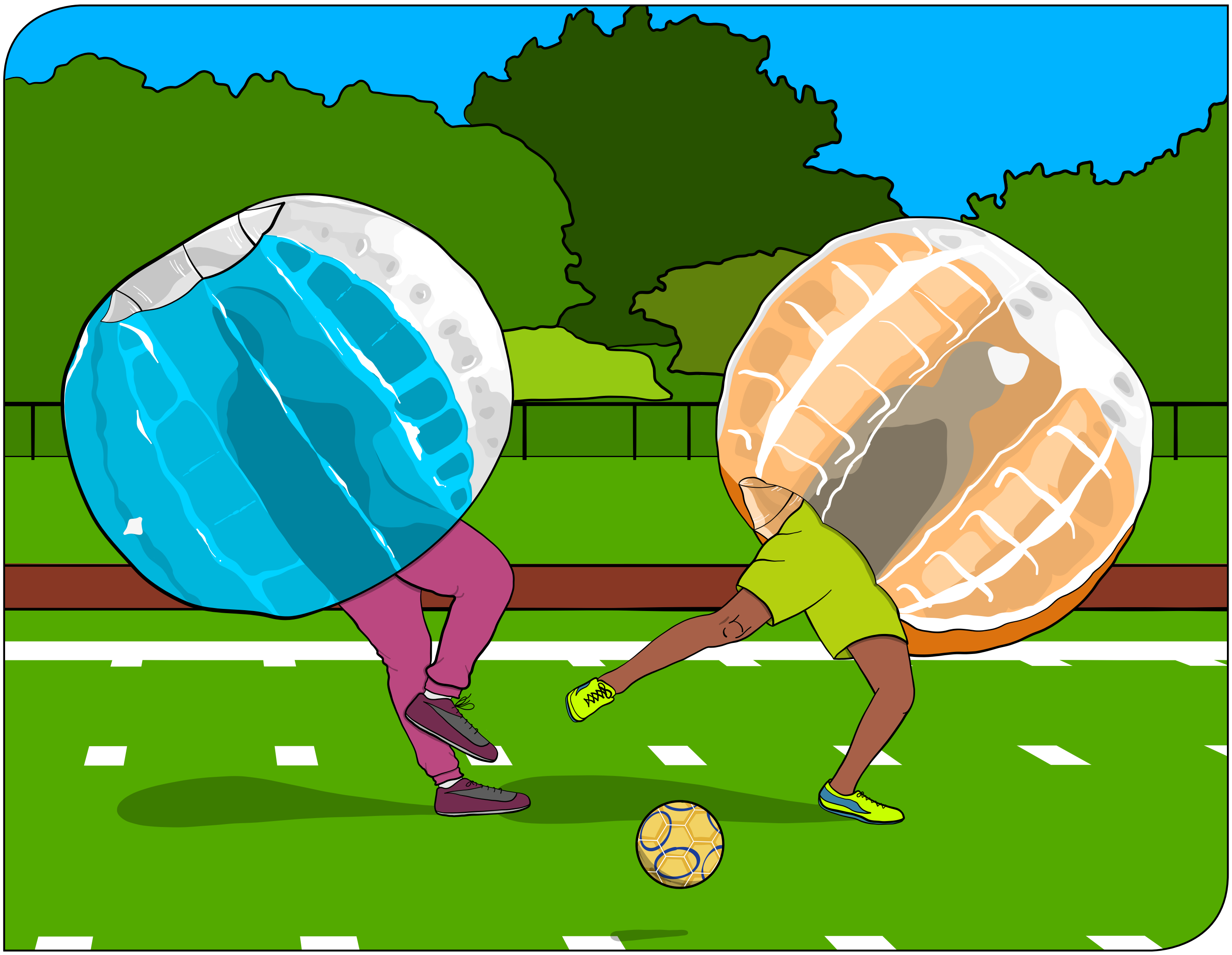
Teacher Guide and Student Journal
Sample Activity and Planning Pages

Forces: Contact and Non-Contact
MSPNG1



A Middle School Unit supporting Next Generation Science Standards and Michigan Science Standards

Forces: Contact and Non-Contact MSPNG1

A Middle School Unit supporting
Next Generation Science Standards
and the Michigan Science Standards

developed and written by
Battle Creek Area Mathematics and Science Center
for

CEREAL CITY SCIENCE
by BCAMSC

Forces: Contact and Non-Contact

Pre-activity Informational Pages

Activities

Appendix

PLANNING

NEXT GENERATION SCIENCE STANDARDS

Disciplinary Core Ideas/Performance Assessments	Activity
PS2.A: Forces and Motion • For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). (MS-PS2-1) • The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2) • All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. (MS-PS2-2)	1,2,3
MS-PS2-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.*	1,2,3
MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.	1,2,3
PS2.B: Types of Interactions • Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. (MS-PS2-3) • Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun. (MS-PS2-4) • Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, a magnet, or a ball, respectively). (MS-PS2-5)	4,5,6
MS-PS2-3. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.	4,5,6
MS-PS2-4. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.	4,5,6
MS-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.	4,5,6

NEXT GENERATION SCIENCE STANDARDS

Disciplinary Core Ideas/Performance Assessments	Activity
Asking Questions and Defining Problems Asking questions and defining problems in grades 6–8 builds from grades K–5 experiences and progresses to specifying relationships between variables and clarifying arguments and models. • Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.	1,5,6
MS-PS2-3. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.	4,5,6
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–WHST.6-8.6: Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently. goals of the investigation.	2,5
MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.	2
MS-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.	4,5,6
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Apply scientific ideas or principles to design an object, tool, process, or system.	1,2,3,4,5
MS-PS2-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.*	1,2,3
Engaging in Argument from Evidence Engaging in argument from evidence in 6–8 builds from K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world. • Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	3,4,5,6
MS-PS2-4. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.	4,5,6

NEXT GENERATION SCIENCE STANDARDS

Disciplinary Core Ideas/Performance Assessments	Activity
Cause and Effect • Cause-and-effect relationships may be used to predict phenomena in natural or designed systems.	1,5,6
MS-PS2-3. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.	5,6
MS-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.	4,5,6
Systems and System Models • Models can be used to represent systems and their interactions—such as inputs, processes, and outputs—and energy and matter flows within a system.	1,2,3,4,5,6
MS-PS2-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.*	1,2,3
MS-PS2-4. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.	4,5,6
Stability and Change • Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.	
MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.	

* The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

UNIT AT A GLANCE

Activity	Time to Complete	Questions	Phenomena	Summary: Students Will…
1 **Collisions on the Bubble Soccer Field**	Preparation: 20 minutes Activity: 4 classes Lesson 1A: 60–65 min., 2 classes Lesson 1B: 60–65 min. Lesson 1C: 60–65 min.	How can we develop a model that will explain why some players on the bubble soccer field are knocked out of play harder than others?	**Collisions on the bubble balls soccer field.**	• Make observations of collisions on a bubble soccer field. • Use balls of different mass to design an investigation into the effect of mass and strength of force on motion. • Investigate the effect of mass of objects that collide. • Explore motion stations to gather data about how mass and strength of force affect motion. • Develop anchor papers to use for facilitation of Science Talk.
2 **What About the Effect of Speed on a Moving Object?**	Preparation: 10 minutes Activity: 5 classes Lesson 2A: 55–60 min. Lesson 2B: 55–60 min., 2 classes Lesson 2C: 55–60 min., 2 classes	What is the effect of speed on the change in motion of two colliding objects? How can we use our investigation results to relate changes in motion to potential and kinetic energy?	**Collisions on the bubble balls soccer field.**	• Plan and carry out an investigation into the effect of speed on colliding objects. • Use ramps and balls of different sizes to investigate the effect of speed on objects that collide. • Present findings/data to others. • Critique the design plan and results of their own investigations and investigations of others.
3 **Solving Problems in Motion**	Preparation: 10 minutes Activity: 5 classes Lesson 3A: 60–65 min., 2 classes Lesson 3B: 55–60 min., 2 classes Lesson 3C: 60–65 min.	How can we apply what we have learned about motion, changes in motion, mass, and speed to solve the problem of Charlene's inability to stay in play on the soccer field?	**Collisions on the bubble balls soccer field.**	• Work in groups to develop a solution to the problem on the bubble soccer field. • Use material from investigations to develop their solutions. • Obtain information from text.

UNIT AT A GLANCE

Students Figure Out How to:	Practices/Crosscutting	PE at Lesson Level and Assessment
• Develop a model to explain how the mass of objects affects the motion of objects. • Use data to support explanations. • Recognize patterns in data to predict future motion and support explanations. • Engage in productive Science Talk.	**Constructing Explanations and Designing Solutions** **Asking Questions and Defining Problems** **Developing and Using Models** **Cause and Effect** **Patterns** **Systems and System Models**	**PE at Lesson Level** Explore how different forces affect the motion of objects. Plan and carry out investigations into the effect of weight on the motion of objects after a collision. **Formative Assessment** Activity Page models **Summative Assessment** What We Think chart Science Talk Models Journal Entry
• Plan and carry out an investigation into the effect of speed on objects that collide. • Use data from their investigations to develop an explanation.	**Planning and Carrying Out Investigations** **Constructing Explanations and Designing Solutions** **Analyzing and Interpreting Data** **Developing and Using Models** **Obtaining, Evaluating, and Communicating Information** **Patterns** **Cause and Effect** **Systems and System Models**	**PE at Lesson Level** Plan and carry out investigations into the effect of speed on the motion of objects after a collision. **Formative Assessment** Activity Page **Summative Assessment** models Science Talk investigations Journal Entry
• Develop a solution to the problem on the bubble soccer field. • Apply information and data to develop a solution to the soccer problem. • Present solution to problem. • Critique the solution of others. • Use patterns to develop a rule about motion. • Apply their solution to Newton's third law.	**Constructing Explanations and Designing Solutions** **Engaging in Argument from Evidence** **Obtaining, Evaluating, and Communicating Information** **Cause and Effect** **Patterns** **Systems and System Models**	**PE at Lesson Level** Use information from Activities 1 and 2 to develop a solution to a collision on the bubble soccer field. **Formative Assessment** Activity Page **Summative Assessment** presentations Science Talks Journal Entries

UNIT AT A GLANCE

Activity	Time to Complete	Question	Phenomena	Students Will…
4 **Gravity as a Non-Contact Force**	Preparation: 15 minutes Activity: 6 classes Lesson 4A: 60–65 min., 2 classes Lesson 4B: 60–65 min., 2 classes Lesson 4C: 60–65 min., 2 classes	What causes objects to fall down? Why doesn't the moon fall to Earth?	**Observe rockfalls in Yosemite National Park**	• Make observations of a large rockfall at Yosemite National Park. • Reread information from text to apply to the rock fall. • Manipulate an interactive website to relate mass to gravitational force. • Present arguments that explain why the moon does not fall to Earth and the large rocks do.
5 **Non-Contact Forces: Magnetism**	Preparation: 20 minutes Activity 5: 6–8 classes Lesson 5A: 60–65 min., 2 classes Lesson 5B: 60–65 min., 2–3 classes Lesson 5C: 60–65 min., 2–3 classes	How can we use magnets to move an object without coming in contact with the object?	**Observe a device that makes a pencil float.**	• Make observations of a floating pen stand. • Investigate different magnets to develop an explanation of the floating pen and non-contact forces. • Use magnets to attract objects over a distance. • Use magnets to repel. • Explore ring magnets to apply findings to floating pen device. • Use iron filings to map a magnetic field.
6 **Non-Contact Forces: Electricity**	Preparation: 5 minutes Activity 6: 1–2 classes Lesson 6A: 55–60 min. Lesson 6B: 55–60 min. Lesson 6C: 55–60 min. (with multiple days of observations of solar stills)	How can we use electricity to move an object and not come in contact with the object? How can one balloon reach across space and pull a second balloon toward it or push it away?	**Make observations of static cling.**	• Make observations of charged balloons. • Make observations of charged balloons pushing and pulling to cause motion as a non-contact force. • Use batteries and wires to build a model of an electromagnet. • Demonstrate the electromagnet as a non-contact force.

UNIT AT A GLANCE

Students Figure Out How to:	Practices/Crosscutting	PE at Lesson Level and Assessment
• Develop a model of the cause of the rockfall. • Relate Newton's reasoning to figure out why the rocks fall and the moon does not fall to Earth. • Use Newton's third law to explain the rockfall and position of the moon in the sky. • Revise models based on new information. • Critique the arguments of others.	**Developing and Using Models** **Obtaining, Evaluating, and Communicating Information** **Constructing Explanations and Designing Solutions** **Engaging in Argument from Evidence** **Cause and Effect** **Systems and System Models**	**PE at Lesson Level** Obtain information through investigation and resources to explain cause-and-effect relationships between objects and the force of gravity. **Formative Assessment** initial models Journal Entries presentation plans **Summative Assessment** Science Talk presentations Journal Entry
• Develop a model of how the pen stays suspended. • Use information from their investigations to revise models and develop explanations. • Use reasoning from floating-ring explanation to draw a model of magnetic fields and non-contact forces. • Use observations of iron filings to explain magnetic fields.	**Constructing Explanations and Designing Solutions** **Developing and Using Models** **Planning and Carrying Out Investigations** **Engaging in Argument from Evidence** **Asking Questions and Defining Problems** **Cause and Effect** **Systems and System Models**	**PE at Lesson Level** Recognize that magnets can be used to push or pull magnetic objects. **Formative Assessment** individual models group models Activity Pages group activity **Summative Assessment** Science Talk presentations Journal Entry final models
• Use observations of charged balloons to develop a model of the electric field between the balloons. • Relate motion caused by an electric field to a magnetic field. • Develop a model of the field between charged balloons. • Explain non-contact forces as they relate to magnetism and electricity. • Solve a problem on the bubble soccer field using a non-contact force.	**Developing and Using Models** **Constructing Explanations and Designing Solutions** **Cause and Effect** **Systems and System Models**	**PE at Lesson Level** Determine that electrically charged objects have a field between objects that can push or pull. **Summative Assessment** Activity Pages Journal Entries group presentations Science Talk

Collisions on the Bubble Soccer Field

Teacher Background Information

In previous units *KPNG Motion: Pushes and Pulls* and *3PNG Forces and Interactions*, students were given the opportunity to explore and raise questions about how things move and what causes a change in direction and speed of moving objects. This activity reviews and explores Newton's first law of motion, one of the basic concepts related to force and motion. Newton's first law states:

> *An object at rest tends to remain at rest unless acted on by an unbalanced force. An object in motion in a straight line tends to remain in motion in a straight line unless acted upon by an unbalanced force.*

This activity provides students with an introduction into how scientists use observation and investigation to develop "scientific laws" that they have found useful in describing motion. Research on students' misconceptions in science has found that simply stating a physical principle as fact does nothing to convince students that the law is fact or that their own views are incorrect. This activity gives students the opportunity to observe, demonstrate, and question Newton's first law. Newton's first law can be divided into two parts:

> **First part:** *An object at rest tends to remain at rest unless acted on by an unbalanced force.*
>
> **Second part:** *An object in motion in a straight line tends to stay in motion in a straight line unless acted upon by another force.*

The understanding of the second half of Newton's first law of motion is not as obvious as the first half. Students tend to reason that objects need an applied force to continue to move, which was the thinking of early scientists, such as Aristotle. Aristotle and his contemporaries claimed that objects needed an applied force to keep moving rather than come to rest on Earth, which is an object's natural tendency and supported through observation.

Students will most likely reflect the same belief. They may comment that "the object has no more force," or "it wasn't pushed hard enough," or even that "Newton was wrong!" Students mention friction as the force that stops the object, but their explanations stop short of Newton's explanation. There are no examples from everyday experiences and observations of objects obeying the second half of Newton's first law of motion.

ESTIMATED TIME

Lesson 1A: 55–60 minutes, 2 classes

Lesson 1B: 55–60 minutes

Lesson 1C: 55–60 minutes

OBJECTIVE

Develop and use a model that will explain how different forces change motion.

KEY QUESTION

How can we develop a model that will explain why some players on the bubble soccer field are knocked out of play harder than other players?

PRE ASSESSMENT

- Give the Pre Assessment to assess the students' prior knowledge of the topics included in this unit.
- Additional time may be necessary beyond the estimated lesson time.
- This same assessment will be given at the end of the unit so the students' Pre and Post Assessment responses can be compared.
- Be consistent in administering the Pre and Post Assessment.
- The assessment and rubric are located in the Assessment section of the unit.

LESSON 1A

MATERIALS NEEDED
For each student:
student page
For each group of four:
Word Sort Card Set (motion, force, push, pull, direction, collision, speed, weight, mass, bounce)
For the class:
tennis ball, 1
Teacher provides:
chart paper
markers
masking tape

PS2.A: FORCES AND MOTION

- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.

What We Think About Motion

What We Think About Motion	How Can We Find Out?	What Do We Conclude?

This unit builds on the third-grade *Forces and Interactions* unit, in which students conducted investigations and explored the following Disciplinary Core Idea:

PS2.A: Forces and Motion

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

Engage the Learner
This phase of the learning introduces and activates prior knowledge regarding forces and motion involving collisions and changes in motion. Students observe the changes in motion when objects collide and make connections between what they have observed and the learning task of explaining the phenomenon. They will make predictions, record their observations, and develop a model in their Student Journals and on chart paper. Students' initial ideas are recorded on the What We Think About Motion chart. The chart is referred to and updated throughout the lessons, providing students with a venue in which to recognize conceptual change in their ideas about motion.

Lesson 1A: Collisions on the Bubble Soccer Field

Advance Preparation
Make copies of the Pre Assessment for the class.

Prepare a *Word Sort Card Set* for each group of four (see Materials Needed).

Make a What We Think About Motion chart. The What We Think chart serves as an ongoing record of students' initial ideas and how they evolve as the lessons progress. Be sure to keep the chart visible and visit the chart often to help students recognize important information and shifts in their thinking.

Write the following headings at the top of four pieces of chart paper:

1. Asking Clarifying Questions
2. Asking a Probing Question
3. Adding to an Idea
4. Respectfully Disagreeing with an Idea

Preview the Bubble Soccer videos:

https://www.youtube.com/watch?v=me1y78yMOSo

https://www.youtube.com/watch?v=k7tHkeVR1Ms

Choose one or two collisions and ball kicks to review after the students have viewed the whole video. Example: minutes 1:21, 1:52, and (head kick with bubble) in the first video.

Procedure

Engage the learner.

Explain to the class that they are beginning a unit of study on motion and its forces and interactions and that the class is going to try to solve a problem for a soccer player. Read the problem to the class:

Charlene is a very fast runner and loves to play soccer. But, when she plays bubble soccer, she keeps getting bumped and knocked away from the ball and out of play. When Charlene tries to run into other players with her bubble to bump them out of play, the opposite happens and Charlene goes flying in a different direction. How can we help Charlene stay on her feet and in the field of play?

Discuss the problem with the class and ask students for their initial ideas of what is happening to Charlene on the bubble soccer field. Entertain all ideas at this time. Explain that you are going to show a video of a bubble soccer game where there are many examples of forces and interactions as related to motion. Ask students to observe the video carefully and jot down in their Student Journals when they observe a force that results in a change in motion.

Show the video of the bubble soccer game:

https://www.youtube.com/watch?v=me1y78yMOSo

Allow time for students to share their previous experiences with bubble soccer and ideas about the sport. Ask students to share their observations of motion and changes in motion. Display the What We Think About Motion chart. Ask students to share their ideas and observations of motion and what is happening in the video of the players on the soccer field. Discuss any ideas that relate to how things move, forces that change motion, and what they need to know to figure out the phenomenon that is happening to Charlene in the story.

Record all ideas at this time. Take this brainstorming opportunity to help students turn their ideas into questions about changes in motion caused by collision and how they might find out how to answer their questions. Listen for useful vocabulary that students use in the discussion. Keep a record of the use of the terms.

To steer the brainstorming in the correct direction and encourage students to draw on their previous experiences and learning, place a tennis ball on the floor and give it a gentle kick. To get students thinking about their basic understanding of motion, ask:

- What did we need to know about moving objects? What makes objects move? What do you mean by that?
- Why did the ball start moving?
- Why did the ball stop moving?
- How might it change direction or speed?

ASKING QUESTIONS AND DEFINING PROBLEMS

Asking questions and defining problems in grades 6–8 builds from grades K–5 experiences and progresses to specifying relationships between variables and clarifying arguments and models.

- Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.

TEACHING TIP

Do not introduce terms or content at this time. Allow students to orally express what they have figured out from previous units about motion, *3PNG Forces and Interaction*, and from their own experiences. New terms will be introduced as the students begin to understand and relate ideas about content.

The brainstorming session and What We Think chart serve as a formative assessment of what they recall and their current understandings of motion.

LESSON 1A

DEVELOPING AND USING MODELS

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict abstract phenomena and design systems.

- Develop and/or use a model to predict and/or describe phenomena.

CAUSE AND EFFECT

- Cause-and-effect relationships may be used to predict phenomena in natural or designed systems.

TEACHING TIP

Modeling in the Next Generation Science Standards is emphasized as a tool to help students understand the science concepts. Students construct and revise their own models (drawings or three-dimensional models) and/or use simulations and interactive media. Models serve as a tool to think with, to conceptualize the mechanics involved, and highlight the conceptual gaps in their thinking. Modeling supports sense-making and is a great assessment tool.

- What do you think about what ________ said?
- Do the rest of you agree? Why or why not?
- Does anyone have the same idea but a different way to explain it?
- Does what ___________ said make sense? Why or why not?
- What was moving on the soccer field? What was changing direction? What made that happen?

Continue to record students' initial ideas on the What We Think chart.

After the whole class has exhausted their ideas about the motion on the soccer field, suggest that it might be a good idea for the class to break down the different types of motion and forces and focus on one event in the video. Ask students to make a list of the different types of collisions that occurred on the soccer field. Listen for ideas that include:

Two players collide and both change direction.

Two players collide and one changes direction and the other stays upright and keeps running.

The foot of the player collides with the soccer ball (kicked).

The ball collides with the bubble and changes direction.

The ball collides with the ground and changes direction.

The player collides with the ground and there is a change in motion.

Show a short segment of the video for the students to analyze. Ask students to explain their thinking about the forces and reaction to forces in the video segment. Listen for ideas that relate to cause-and-effect relationships.

Ask:

Why were some players knocked down harder or sent farther in another direction than others on the bubble soccer field?

Divide the class into groups of four and ask the students to brainstorm within their groups and draw a model of what they think is happening when Charlene collides with another player on the bubble soccer field. Distribute the *Word Sort Card Set* to each group. Encourage students to discuss the meaning of the words and how they can help them to complete the writing.

Encourage the groups to draw, write, and label their initial ideas in their Student Journals. Remind students that in the brainstorming process there are no right or wrong ideas and that as the unit progresses, they will revisit their models often and make adjustments as they gain new information.

Draw, label, and write a model of what you think is happening when Charlene collides with another player on the bubble soccer field.

Facilitate the group brainstorming activity by circulating among the students, listening to their ideas and observing their initial attempts at drawing a model of the phenomenon. To help groups that are stuck and to check progress, ask:

- Can someone explain what you have done so far?
- How would you describe the phenomenon that we are trying to figure out?
- Would it help to make a list of what you know about motion and forces? What background information do you have that might help you?
- Would it help to break down your observations of the collision between two players? Where would you start? What about putting your observations in order?
- How does your idea relate to the motion of the soccer ball?
- What happened when the soccer ball bounced off a player's bubble? How is that different from a soccer header?
- Why do you think that?
- What do you know about forces that helps you explain the phenomenon and Charlene's problem?

Allow sufficient time for students to brainstorm ideas in their Student Journal and then as a group, draw and label their model on chart paper. Distribute chart paper to each group when you feel they are nearing completion of their brainstorming about motion, forces, and changes in motion.

When groups are satisfied with their initial models, have them display them in the room.

Explain that the class is going to do a gallery walk and listen to the ideas of others. Ask a student volunteer to explain how sharing ideas might help students help each other in their pursuit of understanding Charlene's problem.

In order to conduct a friendly, nonthreatening critique, ask the class to establish some guidelines and rules for their critiquing methods. Ask students to create four anchor posters that will guide the class throughout the year. Display the four charts with the questioning and critiquing categories. As a class, have students suggest how they might start a question that asks a group to clarify, probe or dig deeper, disagree wit, and add to an idea.

TEACHING TIP

The initial drawings of students' models for the collisions will be revisited and revised as their understanding of motion progresses. Provide additional chart paper and encourage groups to draw their plans in progression of learning on chart paper to display in the classroom to watch the modifications unfold as they build knowledge.

CONSTRUCTING EXPLANATIONS AND DESIGNING SOLUTIONS

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Apply scientific ideas or principles to design an object, tool, process, or system.

SYSTEMS AND SYSTEM MODELS

- Models can be used to represent systems and their interactions—such as inputs, processes, and outputs—and energy and matter flows within a system.

TEACHING TIP

Throughout the unit students will be engaged in critiquing, challenging, and refuting claims of others. Establish ground rules early and reinforce often to ensure a risk-free, friendly exchange of ideas. As a class, develop anchor posters that guide student discussion, and keep the anchor posters displayed in the classroom throughout the unit. The example charts provide ideas to get students started in how to approach their classmates with friendly, probing questions about their work.

Creating a nonthreatening, open classroom will help students be comfortable and learn from failures and incomplete ideas. Keep the charts visible in the room throughout the unit. Students may have additional ideas as the unit progresses.

TEACHING TIP

Science Talk is a conversation among the students that allows them to have the opportunity to orally express their ideas and listen to the ideas of others. Allow sufficient time for each student to express ideas and opinions. Encourage "student-led" conversation in the classroom.

Example Charts:

Respectfully Disagreeing With an Idea

- I agree with . . . but . . .
- I disagree with . . . because . . .
- I agree with part of your model but disagree with this part . . .
- I respectfully disagree because . . .
- I understand where you are coming from, but I have a different idea.
- I agree with you but also think . . .
- I see your reasoning, but I disagree with some of the ideas because...

Asking a Clarifying Question

- What do you mean by . . .?
- Can you be more specific about . . .?
- What makes you think that?
- What evidence do you have that supports that?
- How do you know?
- Can you tell us more about . . .?
- What do you mean by . . .?

Asking a Probing Question

- What do you mean by . . .?
- What makes you think that?
- If that were true, then wouldn't _________ be true?
- Where did you get this idea?
- How did you come up with . . .?

Adding to an Idea

- I agree with you, but also . . .
- I would like to add . . .
- I agree but also think . . .
- I agree with this part, but could you add . . .?
- Do you think adding _____ would make it more clear?
- I agree but have an idea that might add more clarity or information.
- Would it make it more clear if you added...?

Science Talk

After the class has completed their questioning anchor guidelines, do a whole-class gallery walk and invite each group to explain their models and thinking behind their models. Encourage students to ask questions of one another and make suggestions. If groups are hesitant to ask questions or make suggestions, begin the conversation by asking:

- Can you tell us more about this representation in your model?
- Do the rest of you agree? Why or why not?

- How is this model different from or similar to the previous model we viewed?
- What information from this model might you use to improve your own model?

At the conclusion of the Science Talk, ask the class what more they need to know about motion, forces, and gravity that might help them to better explain the collisions and motion in bubble soccer phenomenon. Write their ideas on the What We Think chart. Explain that in the following lessons, the class will be exploring motion in a variety of investigations that will give them more information for their models and to help solve Charlene's problem.

Assessment: Formative
Use the Activity Pages and bubble soccer collision models to assess the students' initial understanding of how the sum of the forces acting on an object affects the motion of the object.

Use the Activity Pages and initial bubble soccer collision models to assess the students' initial ability to develop a model to explain a phenomenon.

TEACHING TIP
The What We Think charts are designed to be a record of the whole class's initial ideas about a concept, their conceptual shifts as learning progresses, and their final conclusions and explanations for a phenomenon. The chart helps students follow their thinking and how their ideas have changed due to evidence. The chart should be referred to regularly and revised as the lessons progress.

Lesson 1B: Mass and Motion

Teacher Background Information
In this activity, students explore how more massive objects require a greater force than do less massive objects for the same acceleration. The force of gravity pulls more strongly on objects that have more mass than on objects that have less mass. Although there is a direct relationship between mass and weight, they are not the same. Mass is the measure of how much matter or "stuff" is in an object. Weight is the measure of the pull of gravity on the object. Weight is affected by the mass of the objects and the surface gravity of the planet the object is on. A person can lose five-sixths of his or her weight just by going to the moon, where the surface gravity is much weaker than on Earth. But even though the person would weigh less, he or she would have the same mass. The person would have the same amount of matter in his or her body.

The spring scale is used to measure weight, and the balance is used to measure mass. Students measure the mass of two balls and then the weight of the same two balls. By weighing the balls, students can see the direct relationship between mass and weight. In this activity, students continue to follow Newton's laws of motion and focus on the second law.

Second Law of Motion:

> *An object's acceleration depends on the mass of the object and the size of the force acting on it.*

Newton wrote the following formula: force = mass x acceleration.

A greater unbalanced external force causes a greater acceleration of an object in the direction of the force. A greater unbalanced external force is required to accelerate an object with more mass. Acceleration is the rate of change in the speed or direction of an object. It can mean speeding up, slowing down, or changing direction. In this activity, students explore acceleration in the context of change in speed only. Students explore the motion and forces of two balls with different masses and then apply Newton's second law of motion in predicting which ball will fall faster when both balls are dropped from the same height at the same time.

Explore the Concept
Before students can successfully understand forces and interactions of motion, it is imperative that they have a student-developed operational understanding of motion that can become more refined and scientific as student knowledge becomes more sophisticated. Students explore forces in relationship to gravity and mass to help them complete the engineering design challenge.

LESSON 1B

MATERIALS NEEDED

For each student:
- student pages

For each group of 4:
- *Word Sort Card Set* (gravity, force, push, pull, weight, mass, distance, speed, traveled)

For the class:
- precision balance, 1
- *Station Label Cards*
- wooden ball, 7
- steel ball, 6
- marble shooter, 6
- spring scale, 5
- measuring tape, 5
- cloth bag, 5
- metric ruler, plastic, 3
- ramps, 4
- rubber track, 1
- foil tray, 1
- sand, 2 cups

Teacher provides:
- chart paper
- markers
- books (for propping up ramps)

TEACHING TIP
Students may demonstrate prior knowledge related to forces and motion from the third-grade unit *Forces and Interactions*.

LESSON 1B

PS2.A: FORCES AND MOTION

- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.
- All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.

TEACHING TIP

Students should demonstrate prior knowledge related to forces and motion from the third-grade unit *Forces and Interactions*.

Listen for an exchange of ideas that may include that when objects collide, they exert a force on each other and there is a change in motion. Some students may also include the transfer of energy within the system.

Advance Preparation

Prepare a *Word Sort Card Set* for each group of four students (see Materials Needed).

Find an area in the classroom or hallway where you can roll a tennis ball without interference from objects or barriers.

This session is broken down into five stations. Make sure to provide station cards for each activity as there are specific instructions for the students. Students can start at different stations and rotate through all of them. Students should spend ten minutes at each station. There is time built in for transition between stations and to reset stations. Students will have the opportunity to do the final station and finish the analysis during the next class period. Set up five stations around the classroom.

Station 1: Get the Balls Rolling: Same Force/Different Weight

Materials: 1 wooden ball, 1 steel ball, 1 shooter marble, spring scale, tape measure, cloth bag, 1 plastic metric ruler/striker setup map

Station 2: J-Track and Different Balls

Materials: 1 rubber track, 1 steel ball, 1 wooden ball, 1 marble shooter, 1 plastic metric ruler, measuring tape, spring scale, cloth bag

Station 3: Rolling on Ramps

Materials: 2 ramps, 2 steel balls, 2 wooden balls, 2 marble shooters, measuring tape, timing device, spring scale, cloth bag, large books for propping up ramps

Station 4: Colliding Balls

Materials: 2 ramps, 1 steel ball, 2 wooden balls, 1 marble shooter, measuring tape, spring scale, cloth bag, large books for propping up ramps

Station 5: Look Out Below! Dropping Balls

Materials: 1 steel ball, 1 wooden ball, 1 marble shooter, measuring tape, spring scale, cloth bag, foil tray with sand, metric ruler

Procedure

Explore the concept.

Review the What We Think About Motion chart from the previous lesson and conduct a consensus-building discussion that reorients students to the unit storyline and engineering design challenge: what do engineers need to understand about forces and motion to help Charlene stay upright on the soccer field? Review the questions that have been generated and recorded on the chart.

Place one of each of the balls on a table or the floor. Ask the students to describe the forces acting on the balls at rest and what is needed to start the balls moving. Listen for understanding that a force is needed to start the ball rolling and that the ball will continue to roll until a force acts on the ball to stop it, change its speed, or change its direction. Push the ball so it rolls across the floor and comes to a stop. Discuss ideas of what stopped the ball. Listen for ideas about friction and gravity as forces.

Tell the students that they will be working in groups at four different stations to explore motion and forces using three balls with different weights. Demonstrate how to place the ball in the cloth bag and use the spring scale to measure the weight of each ball. Ask students if they think the different weight will affect the amount of force needed to get the balls moving and the motion of the ball. Ask them to justify their answers.

Review the different materials and setups at each station with the class. Divide the class into groups and allow sufficient time for groups to explore stations.

Facilitate the group activity at each station by circulating among the students, listening to their ideas and observing their procedures and setups. To help students reason scientifically and elaborate on their explanations, ask:

- Can someone explain the question you are trying to answer at this station?
- What do you think will happen? What makes you think that?
- Can someone explain your results? Does that make sense? Why or why not?
- What did you notice when ______________?
- What would happen if _________________?
- Can you think of where you have observed something like this happen outside the classroom? How is that similar? Different?
- How does this relate to the other stations you have explored?

After students have completed their investigations at each station, have them complete their explanations in their Student Journals (questions 4 and 5).

Pre-Writing Strategy: *Word Sort Card Set*
Divide the class into groups of four and distribute the *Word Sort Card Set* to each group. Encourage the groups to use the terms on the cards to help them to organize their ideas and write their responses.

ANALYZING AND INTERPRETING DATA

Analyzing and interpreting data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and possible error analysis.

- Distinguish between causal and correlational relationships in data.
- Analyze and interpret data to provide evidence for phenomena.
- Consider limitations of data analysis (e.g., measurement error) and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials).

TEACHING TIP

Pre-writing strategies help students to organize their ideas and give them the opportunity to orally express their ideas and listen to the ideas of others **before** they begin the writing process.

The *Word Sort Card Set* provides the opportunity to engage in conversation over key terms and develop understandings as needed.

In their groups, students sort cards and develop a graphic organizer to assist them in their writing.

Station 1: Get the Balls Rolling: Same Force/ Different Weight

1. Write the question you are investigating.
2. Measure and record the weight of each ball.
3. Complete the data chart.
4. What did you find out?
5. How will your new information help in explaining the phenomenon and solving the problem?

Station 2: J-Track and Different Balls

1. Write the question you are investigating
2. Measure and record the weight of each ball.
3. Complete the data chart.
4. What did you find out?
5. How will your new information help in explaining the phenomenon and solving the problem?

Station 3: Rolling on Ramps

1. Write the question you are investigating.
2. Measure and record the weight of each ball. Record the height of the ramp.
3. Complete the data chart.
4. What did you find out?
5. How will your new information help in explaining the phenomenon and solving the problem?

Station 4: Colliding Balls

1. Write the question you are investigating.
2. Measure and record the weight of each ball. Record the height of the ramps.
3. Complete the data chart.
4. What did you find out?
5. How will your new information help in explaining the phenomenon and solving the problem?

Station 5: Look Out Below! Dropping Balls

1. Write the question you are investigating.
2. Measure and record the weight of each ball. Record the height from which you are dropping the balls.
3. Complete the data chart.
4. What did you find out?
5. How will your new information help in explaining the phenomenon and solving the problem?
6. Extension: What did you observe when all three balls were dropped from the same height at exactly the same time?

Assessment: Formative

Use the class discussion Activity Page to assess the students' understanding of how the motion of an object is determined by the forces acting on it and its weight or mass.

Lesson 1C: Making Sense of Our Station Data

Teacher Background Information
This lesson provides the opportunity for students to share, compare, and make sense of their findings from the stations in the previous lesson. Students will look for patterns and cause-and-effect relationships in their collective data.

Advance Preparation
If all students have not had the opportunity to visit each station, reset the stations.

Make a classroom data chart to display all data for each station. Use the data charts in the Student Journal to build your collective chart.

Procedure
Explain the concept and define the terms.
Review the What We Think chart from the earlier lessons and conduct a consensus-building discussion that reorients students to the unit storyline and engineering design challenge: what do engineers need to understand about motion to help solve Charlene's problem on the bubble soccer field? Review the questions that have been generated and recorded on the chart.

If all stations have not yet been completed by all groups, take this opportunity to have students complete the stations and their findings in their Student Journals.

Science Talk
After students have completed the stations and recorded their findings in their Student Journals, ask one person from each group to record their data on the class chart.

Discuss the "What did you find out?" questions from each station as a class. Use follow-up questions related to the patterns in data observed at each station and about the relationships and factors that influence motion. To help students use evidence from their station explorations to justify their answers, ask:

- How did you reach that conclusion? What evidence do you have in your data?
- Does that make sense? What do you think about what _________said? Do the rest of you agree? Why or why not?
- Does anyone have the same answer but a different way to explain it? What is your evidence?
- Why was it important to measure the weight of the balls?
- What patterns do you see emerge from station to station?
- What statements about motion can we make based on patterns in our data?
- Is there a cause-and-effect relationship between the weight of the balls and their motion? What makes you think that? What is your evidence?

LESSON 1C

MATERIALS NEEDED
For each student:
student pages
For each group of 4:
Word Sort Card Set (gravity, force, push, pull, weight, mass, distance, speed, traveled)
For the class:
precision balance, 1
Station Label Cards
wooden ball, 5
steel ball, 5
marble shooter, 5
spring scale, 4
measuring tape, 4
cloth bag, 4
metric ruler, plastic, 3
striker setup map
ramps, 2
rubber track, 1
Teacher provides:
chart paper
markers
books (for propping up ramps)

CROSSCUTTING CONCEPT PATTERNS
- Graphs and charts can be used to identify patterns in data.
- Patterns can be used to identify cause-and-effect relationships.

TEACHING TIP
Science Talk is a conversation among the students that allows them to have the opportunity to orally express their ideas and listen to the ideas of others. Allow sufficient time for each student to express ideas and opinions. Encourage student-led conversation in the classroom.

TEACHING TIP

KEY TERMS—The development of their own glossary of key terms is essential for students to be able to use, recognize, and apply the terms to the appropriate science concepts and reasoning through new discoveries. Students may take considerable time developing a reasonable definition that is useful and meaningful for their learning.

CONSTRUCTING EXPLANATIONS AND DESIGNING SOLUTIONS

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Return to the What We Think chart and add new information and make adjustments as students suggest.

Write the terms *balanced forces* and *unbalanced forces* on the board or chart paper. Ask students for their ideas of the meaning of the terms and to give an example of when forces are balanced.

Return to the tennis ball at rest from the beginning of Lesson 1B and ask if the forces are balanced or unbalanced and how students know that. Listen for responses that objects at rest have balanced or equal forces acting on them and that objects in motion have unbalanced forces acting on them. Ask students to give an example of each and how balanced and unbalanced forces are related to the forces and motion in the different stations.

As a class, develop a student-friendly definition for the terms and have students enter them in their Student Journal.

Write the terms *mass* and *weight* on the board. Take this opportunity to discuss the difference between mass and weight. Show the class the balance and the spring scale. Explain that they have been using the spring scale to measure the weight of the balls. Ask a student volunteer to explain how the spring scale works. Listen for ideas of the force of gravity pulling down on the object and measuring the weight in terms of how much force is required to pull the spring down.

Demonstrate how to measure the mass of one of the balls using the precision balance. Give the class sufficient time to think about the difference in the measuring devices and how they relate to mass and weight. Entertain all initial ideas at this time.

Use what students know about the difference in gravity on the moon and on Earth and ask students to think of weight and mass on the moon. Use a think-aloud to help students develop the analogy. Example:

On Earth, I measured the weight of the steel ball to be ________ grams and the mass of the ball on the balance measured _______ grams.

On the moon, the force of gravity is one-sixth that of the force of gravity on Earth. So, if gravity is pulling downward only one-sixth as hard, what would the ball weigh? Write the mathematic equation on the board for the students.

Allow sufficient time for students to do the math.

Ask students to share their answers.

If the math is not consistent, you may need to solve the equation together.

After the class has determined how much the ball would weigh, ask if there would be a difference in the mass of the ball on the moon compared to the mass on Earth. Ask:

- What are we measuring when we measure mass?
- Is gravity a part of that measurement? What makes you think that?

Continue the think-aloud:

If we were to take the balance with us on a trip to the moon, how would we measure the ball? Remember, the moon has some gravity, one-sixth as much as Earth.

Pretend we are on the moon and I place the steel ball on one side of the balance. What will happen? What makes you think that?

Now we have established that the side of the balance will go down when we put the steel ball on one side. If I want to find the mass of the steel ball I will need to place the gram measures on the opposite side. How many grams will it take to balance the ball? What makes you think that? Has the steel ball lost any of the matter that makes up the ball just because it is on the moon?

Discuss the difference between mass and weight. Check for understanding that weight is the measurement of the pull of gravity on a given object and mass is the measurement of how much matter makes up a given object. The weight changes when gravity changes, but the mass always stays the same. The steel ball is still made up of the same amount of steel so the mass stays the same, but the pull of gravity changes from Earth to the moon, so the weight of the ball changes when the amount of gravity changes.

As a class, develop definitions of the terms *mass* and *weight* and have students write them in their Student Journals.

Explain to the class that now that they have working definitions of *balanced and unbalanced forces* and *weight* and *mass*, they can use the terms to describe the problem they are trying to solve.

Have the class rejoin their groups of four and ask students to use the data from the stations to explain why Charlene is having trouble staying with the ball and getting bounced every time someone runs into her or she runs into someone else.

Facilitate the group brainstorming by circulating among the students, listening to their reasoning and how they are applying their data. To help the students rely on their data and reason scientifically, ask:

- Can someone explain what you have discussed so far?
- What evidence do you have that makes you think that?
- Is that true for all cases?

PS2.A: FORCES AND MOTION

- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.
- All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.

LESSON 1C

TEACHING TIP

Listen for students to begin to use the term *energy* when describing balanced and unbalanced forces, motion, and the results of their investigations. If the term *energy* has started to become a part of student discussion, make a note of how and when it is used to revisit their ideas in Lesson 2C.

CAUSE AND EFFECT

- Cause-and-effect relationships may be used to predict phenomena in natural or designed systems.

- Can you think of a counterexample?
- How would you prove that?
- What assumptions are you making?
- What do you mean when you say?
- Tell me more about…?
- How does the information help us to solve Charlene's problem?

Listen for students to use their data to explain what happens when:

- Two balls of the same mass going the same speed collide.
- Two balls of different mass going the same speed collide.
- Two balls of the same mass going different speeds collide.
- Two balls of different mass going different speeds collide.

Revisit the What We Think chart and make additions and adjustments as the students gain new information.

Have the groups revisit their models of what is happening to Charlene and make additions and adjustments to their models.

Journal Entry

1. *Your class visited four motion stations to explore the effect of mass on the motion of objects. Use your data from one of the stations to explain the effect of mass on motion.*
   *Station #*_______________

2. *Explain how your understanding of the effect of mass on the motion of an object will help to solve Charlene's problem on the bubble soccer field.*

Assessment

Use the What We Think chart, Science Talk, group models, and Journal Entry to assess the students' understanding of the effect of mass on the motion of an object.

ENGINEERING DESIGN PROCESS

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

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

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

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

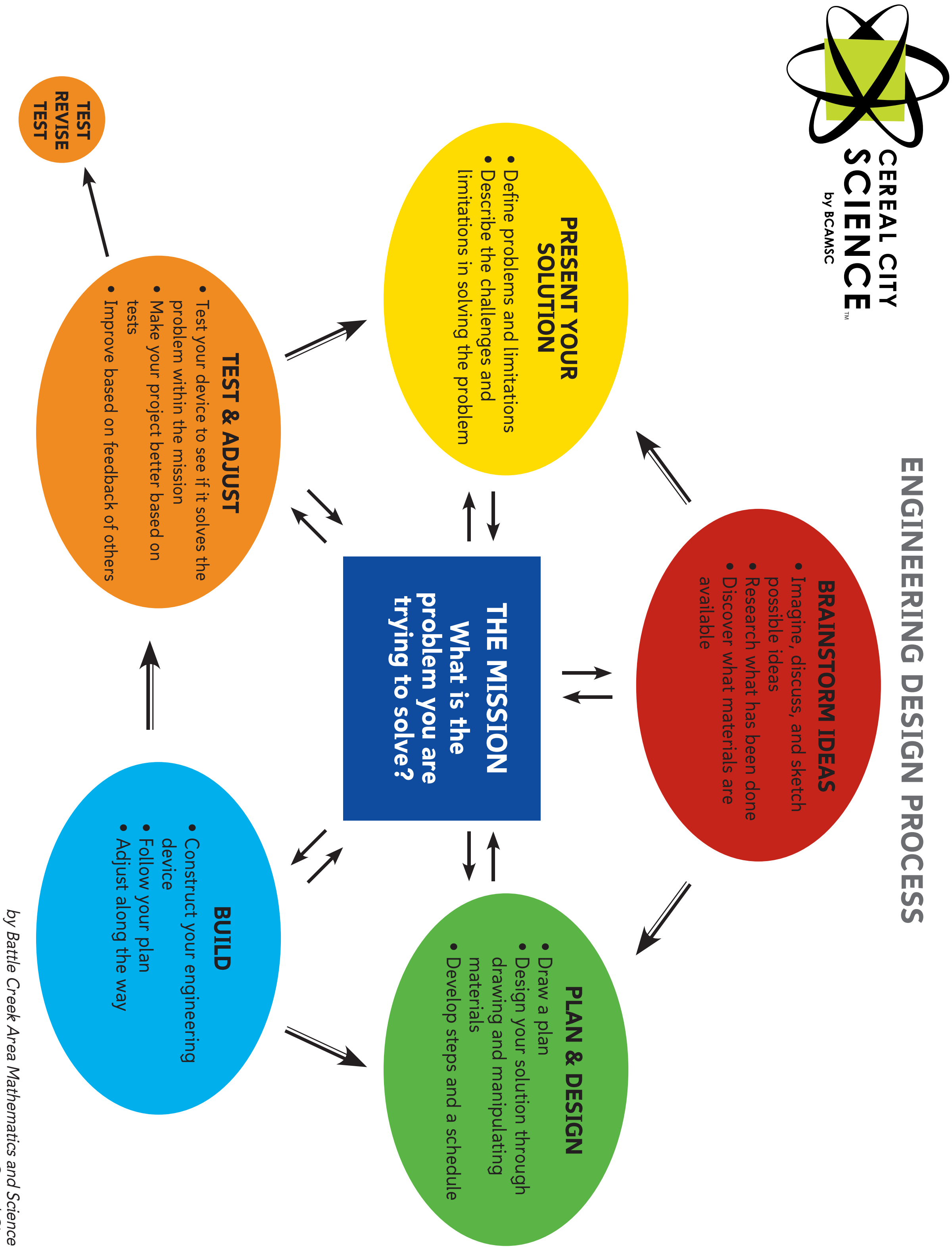
Plan and Design
- Draw and write a plan.
- Design your solution through drawing and manipulating materials.
- Develop a plan or steps and a schedule.

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

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

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

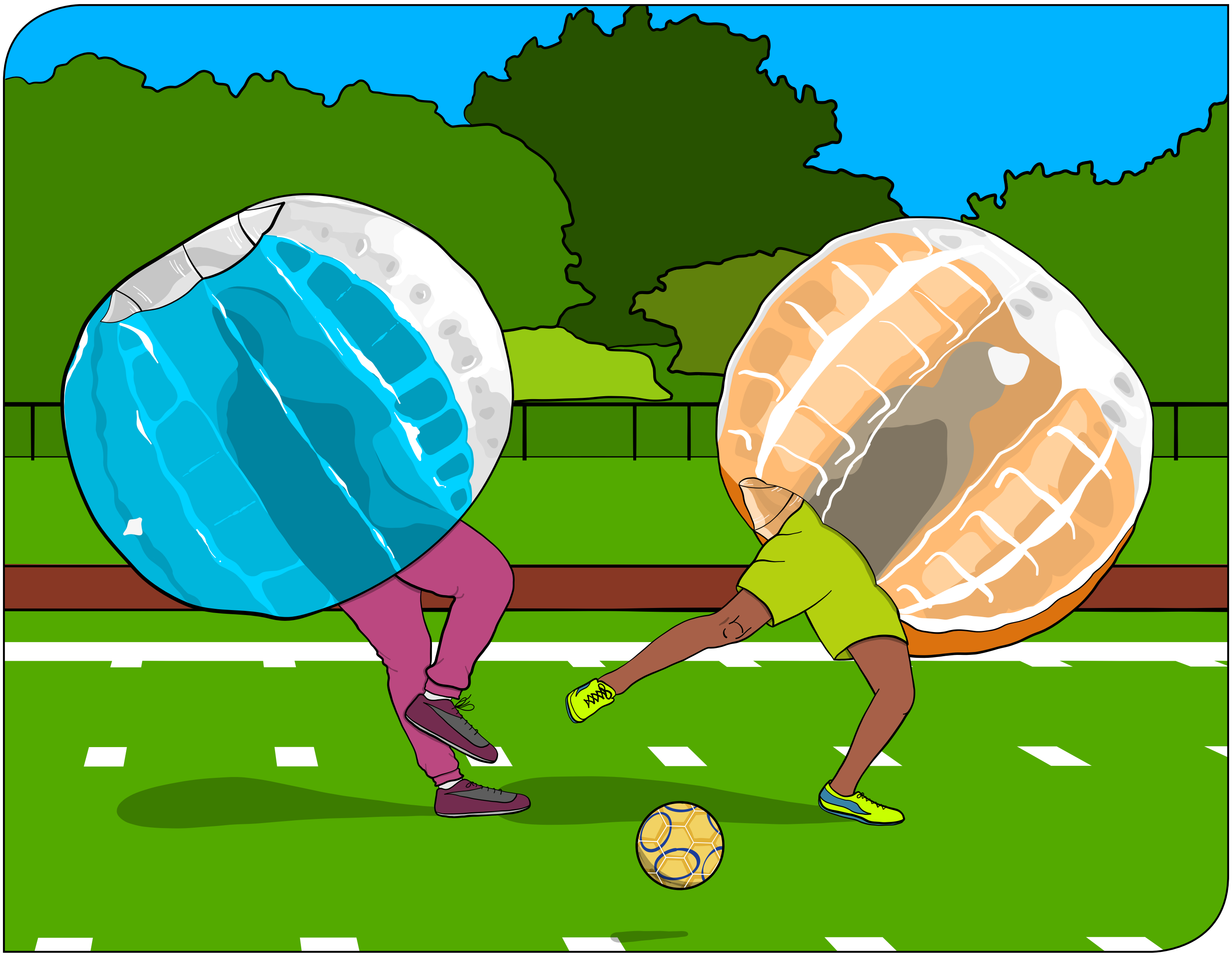
ENGINEERING DESIGN PROCESS



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

Student Journal
MS.PS.NGSS

Forces: Contact and Non-Contact
MSPNG1



A Middle School Unit supporting Next Generation Science Standards and Michigan Science Standards

Name:____________________________________

Name:______________________________

Date:_______________________________

Charlene is a very fast runner and loves to play soccer. But, when she plays bubble soccer, she keeps getting bumped and knocked away from the ball and out of play. When Charlene tries to run into other players with her bubble to bump them out of play, the opposite happens and Charlene goes flying in a different direction. How can we help Charlene keep on her feet and in the field of play? Write your ideas below:

1A ACTIVITY
Collisions on the Bubble Soccer Field

Name: ____________________

Date: ____________________

Draw, label, and write a model of what you think is happening when Charlene collides with another player on the bubble soccer field.

Name:________________________________

Date:________________________________

Station 1: Get the Balls Rolling: Same Force/Different Mass

1. Write the question you are investigating.

2. Measure and record the weight of each ball.
Steel Ball: ________________
Wooden Ball:________________
Marble Shooter:________________

3. Complete the data chart:

4. What did you find out?

5. How will your new information help in explaining the phenomenon and solving the problem?

Name: ____________________

Date: ____________________

Station 2: J-Track and Different Balls

1. Write the question you are investigating.

____

____

2. Measure and record the weight of each ball.
Steel Ball: ____________________
Wooden Ball: ____________________
Marble Shooter: ____________________

3. Complete the data chart:

4. What did you find out?

____

____

____

5. How will your new information help in explaining the phenomenon and solving the problem?

____

____

____

____

Name:______________________________

Date:______________________________

Station 3: Rolling on Ramps

1. Write the question you are investigating.

2. Measure and record the weight of each ball. Record the height of the ramp.
Steel Ball: ____________________
Wooden Ball:__________________
Marble Shooter:_______________

3. Complete the data chart:

4. What did you find out?

5. How will your new information help in explaining the phenomenon and solving the problem?

Name: ______________________

Date: ______________________

Station 4: Colliding Balls

1. Write the question you are investigating.

____

____

2. Measure and record the weight of each ball. Record the height of the ramps.

Steel Ball: ________________

Wooden Ball: ________________

Marble Shooter: ________________

3. Complete the data chart:

4. What did you find out?

____

____

____

5. How will your new information help in explaining the phenomenon and solving the problem?

____

____

____

____

Name:______________________________

Date:______________________________

Station 5: Lookout Below! Dropping Balls

1. Write the question you are investigating.

____

____

2. Measure and record the weight of each ball. Record the height from which you are dropping the balls.

Steel Ball: ____________________
Wooden Ball:____________________
Marble Shooter:__________________

3. Complete the data chart:

4. What did you find out?

____

____

5. How will your new information help in explaining the phenomenon and solving the problem?

____

____

____

6. Extension: What did you observe when all three balls were dropped from the same height at exactly the same time?

____

____

____

1C JOURNAL
Making Sense of Our Station Data

Name:______________________________

Date:______________________________

Your class visited four motion stations to explore the effect of mass on the motion of objects. Use your data from one of the stations to explain the effect of mass on motion.

Station #____________

Explain how your understanding of the effect of mass on the motion of an object will help to solve Charlene's problem on the bubble soccer field.