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Objective

Students will learn about changes in energy when objects collide through a hands-on investigation using marbles. Then, students will build fun "contraptions" that utilize collisions to transfer energy.

STEM Focus

Physical Science: When objects collide, energy can be transferred from one object to another, thereby changing their motion. When objects collide, the contact forces energy transfer so as to change the objects' motions.

Scientific Inquiry: Ask questions and predict outcomes about the changes in energy that occur when objects collide.

Science and Engineering Practices: Ask questions and define problems; construct explanations and design solutions; engage in argument from evidence.

Crosscutting Concepts: Patterns, cause and effect, energy and matter

Setup

For Introduction and Mini Challenge

- Collect 2 balloons for the demonstration.
- Students will be using the grooves on the backs of rulers to roll marbles in a straight line. *Note:* Have students roll marbles in the center of an open textbook if your rulers don't have a groove down the middle.

For Main Challenge

- Use materials you have on hand for this challenge. The more materials you supply, the more creative students can be!

Suggestions for Building Materials

* ***Things that roll:*** marbles, Ping-Pong balls, golf balls, small toy cars
* ***Things to make tracks:*** cardboard tubes, pipe insulation (split in half), funnels, yardsticks, dowels
* ***Containers:*** cups, cans, plastic tubs, boxes
* ***Things that can fall over:*** dominoes, pattern blocks, small boxes, erasers
* ***Things that provide structure:*** craft sticks, straws, pipe cleaners, paper plates, cardboard, cardstock or index cards
* ***Tools:*** scissors, different kinds of tape, string, rubber bands, staplers

Materials

Introduction and Mini Challenge

- *Marble Collisions* (page 30), one per group
- 2 balloons
- marbles, 5 per group
- music player
- rulers with grooves or textbooks (See Setup.)

Main Challenge

- *Collision Contraptions* (page 31), one per group
- *Reflections—Collision Contraptions* (page 32), one per student
- building materials and tools (See Setup.)

Time Frame

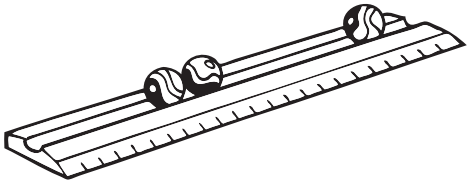
The Introduction and Mini Challenge can be completed in one class session of about 40 minutes.

The Main Challenge can be completed in about 45–60 minutes.

Follow up with Writing Reflection as time allows.

Vocabulary

collide
collision
contraption
energy
kinetic
potential
transfer

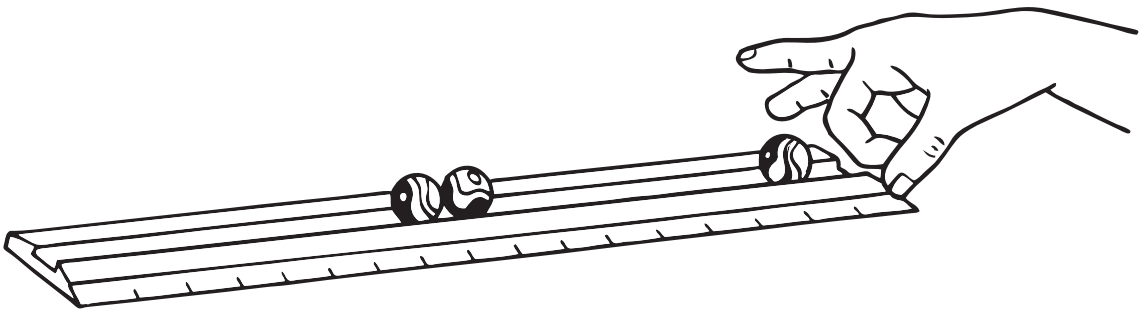


Collision Contraptions

Mini Challenge

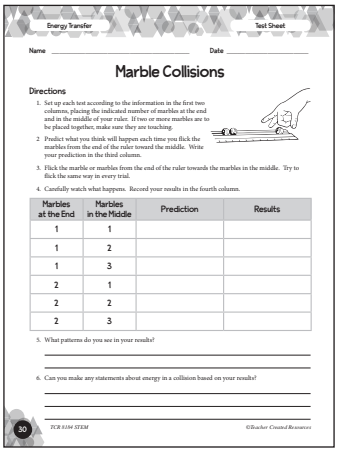
1. Tell students that they will now do an activity to find out more about changes in energy when things run into each other, or collide.

2. Place a ruler on a table and place a marble in the groove at one end. Demonstrate for students how to gently flick the marble so that it rolls down the groove of the ruler. Tell students that they are going to use a ruler and marbles to investigate what happens when objects collide.



3. Place students in groups of two or three. Distribute a copy of *Marble Collisions* to each group and give each group a ruler and five marbles.

4. Go over the test sheet with students, and make sure they understand the procedures. Have them decide how they will determine whose turn it is to flick the marbles.



Energy Transfer — Test Sheet

Name _____ Date _____

Marble Collisions

Directions

1. Set up each test according to the information in the first two columns, placing the indicated number of marbles at the end and in the middle of your ruler. If two or more marbles are to be placed together, make sure they are touching.
2. Predict what you think will happen each time you flick the marbles from the end of the ruler toward the middle. Write your prediction in the third column.
3. Flick the marble or marbles from the end of the ruler towards the marbles in the middle. Try to flick the same way in every trial.
4. Carefully watch what happens. Record your results in the fourth column.

Marbles at the End	Marbles in the Middle	Prediction	Results
1	1		
1	2		
1	3		
2	1		
2	2		
2	3		

5. What patterns do you see in your results?

6. Can you make any statements about energy in a collision based on your results?

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5. Circulate while students perform their tests. If students are having trouble with the marbles staying in place initially, have them check to make sure the ruler is on a flat, level surface.

6. Bring the class back together, and discuss the results. For each row in the chart, have one group share its results. If other groups got the same, or almost the same, result, they should raise their hands. If any group got a different result, ask them to share it. The class should discuss what might have caused any discrepancies.

7. Have groups share their answers to the last two questions.

Explain the Science

Students will most likely notice that the number of marbles flicked is the same as the number of marbles that move, and the marbles in between (mostly) stay still. The energy of the rolling marble(s) is transferred through the still marbles to the ones on the other side. They may also see that the faster the first marble is moving, the faster the last marble will move.

Collision Contraptions

Main Challenge

Define the Problem & Plan

1. Tell students that they will now build fun "contraptions" using the transfer of energy by **collision**. A **contraption** is a machine or a device that has lots of parts. The contraption doesn't have to have a purpose; it's just fun to watch it work!

✏ Write the word *contraption* and its defininition on the board.

2. Show students the materials available for this challenge. Have students brainstorm some ways to make items collide. For example, lining up dominoes or pattern blocks and tipping over the first one transfers energy from block to block as they knock each other down. Students can try having items knock each other over, fall on top of each other, roll into each other, or swing into each other.

3. Go over the Challenge Constraints for this challenge. Constraints tell engineers what they can and can't do. Write the constraints for the *Collisions Contraptions* challenge on the board or chart paper, or make copies for students to refer to throughout the challenge. If appropriate, add budget information. (See pages 8–10.)

Challenge Constraints

- Build a contraption that transfers kinetic energy through a collision in at least two ways.
- Create a fun ending where the motion stops.
- Use only the materials given. You do not have to use all of the materials.

4. Give a copy of the *Collision Contraptions* recording sheet to each group.

5. Have students gather building materials. Allot time for students to handle the materials, discuss, brainstorm, and plan their contraptions.

Build • Test • Improve

1. Review the *Engineering Design Process* (page 12) with students. Remind them that they can test, improve, and retest as much as they like in the time available. Their goal is to get their contraption working so that the energy transfers all the way through to the end.

2. Let students know how much time they will have to complete the challenge.

3. Circulate as students build and test their contraptions to observe and question for formative evaluation.

4. Give students a five-minute warning as they reach the end of the testing time so that they can wrap up.

Collision Contraptions

Main Challenge (cont.)

Analyze & Evaluate

1. Ask each group to demonstrate their contraption for the class.

✏ Have the class write down at least two ways they saw kinetic energy being transferred through a collision for each contraption.

2. Have the demonstrating group state the ways that they intended to transfer energy, and have the class raise their hands if they agree. Discuss any differences.

3. Ask the group to discuss their opinions and interpretations of their contraption, and then ask the rest of the class for their observations.

   —Did they find any patterns in the transfer of energy?

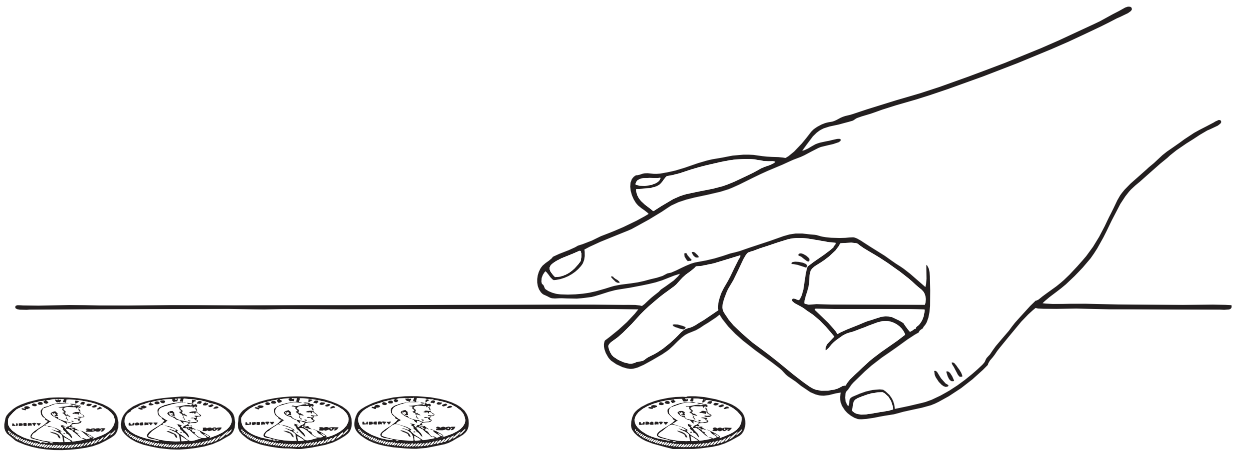
4. Encourage students to cite evidence in their answers. For example, "When two things are the same size and one hits the other one, it looks like all of the energy is transferred," or "If a little thing hits a big thing, the big one doesn't move."

Writing Reflection

✏ Have each student complete the *Reflections—Collision Contraptions* writing reflection individually.

Extension

- Have students try the Mini Challenge with pennies instead of marbles. They will need to practice flicking pennies on a flat surface.
- Have each group partner with another group and combine their contraptions into one, bigger contraption.
- Look up "Rube Goldberg machine" for some great videos showing cool, complicated contraptions.



Name _____ Date _____

Collision Contraptions

Directions: Plan a contraption that will transfer kinetic energy through a collision at least twice.

1. What are the two ways you will transfer kinetic energy through a collision?

   First way: _____

   _____

   Second way: _____

   _____

   ★ You can add more ways if you want to!

2. How will you connect the different parts so the motion continues from the beginning to the end?

   _____

   _____

3. Sketch your contraption.