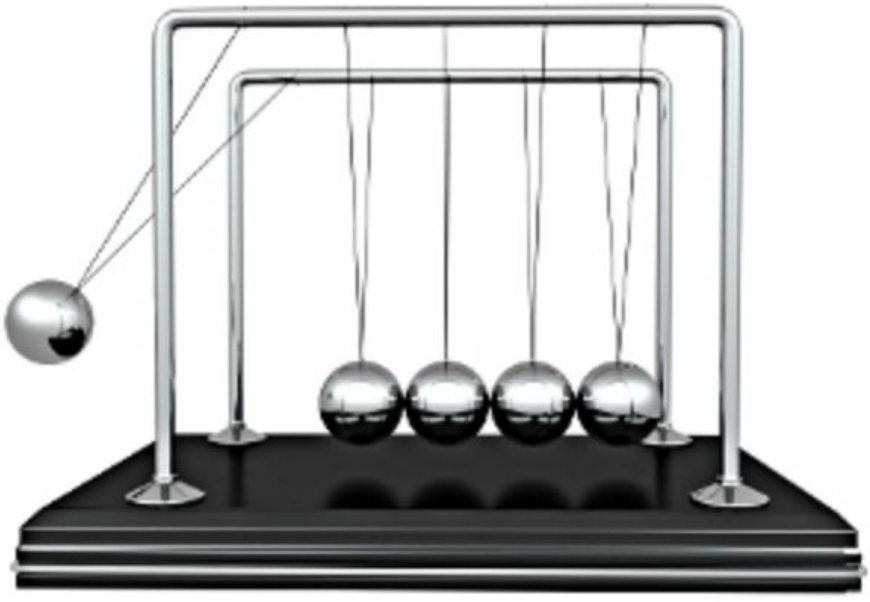
Accessing Prior Knowledge

Name: _____ Date: _____

Energy and Collision

If you were to pull the first ball back and let it go, what would happen? Brainstorm two similar scenarios from real life that could also demonstrate the concept of transfer of energy. Draw and label two examples in the blank boxes below.



Scope Phenomenon

Name: _____ Date: _____

Falling Dominoes

1. Describe the movement of energy in the video.

_____
_____
_____
_____

2. In the video, what caused the energy to change from a domino standing up to a domino falling down? Where did the energy come from?

_____
_____
_____
_____
_____
_____

3. What pattern can you observe in the video? Is this pattern predictable?

_____
_____
_____
_____

4. What would happen if two marbles that were the same size collided?

_____
_____

Explore

Why Do Basketballs Bounce?

Basketball Story

There are 30 seconds left on the clock, and you just stole the basketball from the other team. You are making a fast break down the court! The basketball is bouncing on the floor as you dribble it to the other end. All of a sudden, you ask yourself, “Why do we use basketballs to play basketball?”

Basketballs and similar balls have the ability to bounce. Not all things can bounce very well. Rocks and other harder things do not bounce well. They crack or make loud noises when they hit a surface.

Why do basketballs bounce? It has to do with energy. When you pick up a basketball, you use energy. The basketball then has potential energy, which means it has the potential to do something. When you drop the basketball, the potential energy changes to kinetic energy. Kinetic energy is the energy of motion.

A basketball is different from other items, like rocks, because when it hits the floor, the rubber material of the basketball stores energy as it slightly collapses. When the basketball’s side collapses, it has potential energy. The rubber stretches and bends, storing the energy for later. As the rubber goes back to its original shape and bounces back up, the basketball has kinetic energy.

A rock is different. It is not made of stretchy or bendable material. When a rock hits the floor it does not bounce; it cracks, breaks, and makes a loud noise. Rocks, or other items made of hard materials, would not be good to use for playing basketball.

Explore

What role does the floor play in all of this? The floor dents ever so slightly, storing the energy for just a moment. It then goes back to its original form, giving the energy right back to the basketball.

It's a good thing the energy returns to the basketball because you will need it. As you make it to the other end of the floor, you shoot the basketball at the hoop. It bounces off the backboard and goes in. Your team wins the game. Boy, aren’t you glad your basketball had the potential and kinetic energy to help you win the game for your team?

Explore Student Journal

Name: _____ Date: _____

Let's Bounce

Student Journal

Directions:

1. Place pinto beans, a pencil, a rubber eraser, and a rock on top of your table.
2. Use your ruler to measure 30 cm above the table. Hold the golf ball 30 cm above the table top and drop it so it lands close to (not on top of) the items on the table.
3. Record what happened to the items on the table in your data table.
4. Repeat these actions with the baseball or softball and the basketball.
5. Complete three trials for each ball.

	Trial 1	Trial 2	Trial 3
Golf Ball			
Baseball or Softball			
Basketball			

How do you think the falling ball made the object move?

_____

_____

_____

_____

_____

_____

Explore

Name: _____ Date: _____

Let's Bounce

Student CER

Prompt:
Write a scientific explanation for which ball transferred the least amount of energy to the table.

Claim:

_____
_____

Evidence:

_____
_____
_____

Reasoning:

_____
_____
_____

Explore

	2	1	0
Claim	Answers the question, and answer is based on accurate data.	Answers the question, but answer is based on inaccurate data.	Makes no claim or does not answer the question.
Evidence	Cites accurate data from data table.	Cites inaccurate data from data table.	Cites examples but does not use data from data table.
Reasoning	Cites the scientifically accurate reason and connects the reason to the claim. Uses accurate vocabulary and is able to accurately show they understand cause and effect stimulus response.	Cites a reason, but it is inaccurate or does not support the claim. Reasoning does not use scientific terminology or uses it inaccurately.	Offers no reasoning or simply restates the claim.

Explore

Energy and Collision

PBL Entry Document

Recently a new show, “The United States Got Skills,” debuted and caught the attention of the famous domino artist: “Mary the Magnificent.” In order to make it on the show, “Mary the Magnificent” needs a new setup to impress the judges. She is relying on you to come up with a fantastic new presentation so she can win over the judges!

Design a domino chain reaction that “Mary the Magnificent” will consider using to impress the judges on the show. The more difficult and elaborate the chain reaction is, the more the judges will be impressed. The energy used to knock over the first domino must be transferred through to the the end of the chain. As seen in the video of a Rube Goldberg machine, the transfer of energy can be quite intricate.

You will design a chain reaction using no less than 50 and no more than 100 dominoes. Dominoes should not be placed in a simple straight line. The chain reaction is not limited to, but must include these elements: one upward ramp, one pendulum, a target to be hit, a cup, wheels, a spherical object that travels at least 80 cm, and a sound resulting from the transferred energy. The end of your domino chain reaction should accomplish a simple task. The chain reaction must also remain within a 4 m^2 area.

On the first day, your team will be given 45 minutes to design a blueprint of your plan and gather needed materials. On the second day, your team will be given 45 minutes to construct, test, make adjustments to, and present your innovative domino chain reaction.

Divide your team up into the following four roles: design team expert, material engineer, architectural engineer, and mechanical engineer. Develop a list of what you know, begin sketching a design, and use the engineering design process. You should incorporate any redesign ideas into your presentation in order to completely communicate your solution.

Will your team’s innovative domino chain reaction be the one “Mary the Magnificent” chooses to use on the new show, “The United States Got Skills”?

Explore

PBL Expert Roles

Design Team Expert

As the design team expert, you will ensure your team successfully completes the task in the allowed amount of time. You will lead and keep track of all planning, encourage communication among engineers, and make sure all members of the team fully know and understand all parts of the plan. You and your team members will present your final project.

Material Engineer

As the material engineer, you will communicate with your team and find the materials requested for designing your domino chain reaction. You and your team members will present your final product.

Architectural Engineer

As the architectural engineer, you will ensure your team develops a design blueprint for your chain reaction with labels and measurements. Be sure to keep all blueprints in order to track changes that are made after testing. You will guide the team's activities to ensure all the required elements of the blueprint are included in your design and presentation. You and your team members will present your final product.

Mechanical Engineer

As the mechanical engineer, you will ensure your team includes scientific principles in the design process. You will guide the team's activities so all the required elements of the criteria and blueprint design are included in your final product and presentation. You will be responsible for testing your model. You and your team members will present your final product.

Explore

Energy and Collision

Individual 21st Century Skill Rubric in Problem/Project Based Learning Challenge

Innovation and Collaboration	Expert (4)	Competent (3)	Beginner (2)	Novice (1)
Creativity	Continuously applies creative ideas to make a real and useful contribution to the project.	Applies creative ideas to make useful contributions to the project.	Develops creative ideas but does not make a contribution.	Does not attempt to develop creative ideas.
Innovation	Embraces the idea that experimenting is an important part of the path of success and approaches opportunities with an understanding that every failed attempt is an opportunity to learn.	Understands that experimenting is an important part of the path to success but becomes frustrated with failed attempts.	Does not fully understand that experimenting will lead to success and is reluctant to take risks.	Does not understand how failed attempts are part of the process that leads to success and gives up easily.
New Ideas	Develops, implements, and communicates new ideas to others effectively in a variety of conditions.	Develops, implements, and communicates new ideas to others effectively.	Develops new ideas and attempts to communicate them to others, but is not always successful.	Develops few ideas, but does not effectively implement or communicate ideas with others.
Conclusion and Evidence	Is able to look at complex information, successfully draw conclusions, and apply the information to the situation.	Is able to look at information and draw conclusions with relative success.	Looks at information and is sometimes able to draw conclusions.	Looks at information, but is rarely able to draw a conclusion.
Collaborative Team Member	Encourages others to share ideas, helps make the ideas clear, and connects the ideas to the team's work.	Stays on task and keeps track of time for the group. Helps group to finish tasks.	Cooperates with the team but only does own share of the work.	Has to be reminded to complete their work.
Feedback	Gives specific feedback to the team to improve the quality of the product. Takes pride in work, accepts feedback graciously, and tries to apply it to the product.	Provides some feedback to the team about work. Works hard to have a good product and tries to accept feedback from others on the team.	Does not provide feedback to the team, but is willing to take the feedback offered and try to apply it to the product.	Does not provide feedback and is unwilling to apply feedback from the team to the product.

Explore

Domino Chain Reaction Key

Rubric for a Problem/Project Based Learning Challenge

Points Awarded	Expert (4)	Competent (3)	Beginner (2)	Novice (1)
Problem and Solution	Solution includes one upward ramp, one pendulum, a target to be hit, a cup, wheels, a spherical object that travels at least 80 cm, and a sound. A simple task is fulfilled by the chain reaction.	Solution includes one upward ramp, one pendulum, a target to be hit, a cup, wheels, a spherical object that travels at least 80 cm, and a sound.	Solution is missing one of the following: one upward ramp, one pendulum, a target to be hit, a cup, wheels, a spherical object that travels at least 80 cm, and a sound.	Solution is missing two or more of the following: one upward ramp, one pendulum, a target to be hit, a cup, wheels, a spherical object that travels at least 80 cm, and a sound.
Solution, Prototype or Plan	Drawing is neat and complete on blueprint. All parts are drawn, labeled with measurements, and within the required area. Meets time limits.	Drawing is neat, complete, and labeled. Missing one or two requirements, but is within the required area. Meets time limit.	The drawing is missing two or more criteria or is over the designated area. Slightly over time limit. Work is not neat.	The drawing is missing two or more of the criteria and is beyond the designated area. Well over time limit. Work is not neat.
Implementation of Design	Based on the designed plan, the chain reaction occurs successfully with all elements and stays within the required area.	Based on the designed plan, the chain reaction occurs successfully with some elements missing and occurs within the required area.	Based on the designed plan, the chain reaction occurs successfully but is missing two or more elements. Slightly outside of the required area.	Based on the designed plan, the chain reaction is unsuccessful, incomplete, and occurs outside the required area.
Materials Chart	Materials chart is complete. Reasoning is thorough and clearly states why materials were chosen in relation to each element used.	Materials chart is complete. Reasoning is clear but not thorough.	Materials chart is missing one or two pieces of information.	Materials chart is missing more than two pieces of information.
21st Century Skill: Innovation	Our solution is new or original. I have never seen this idea before.	Our solution is a new adaptation of a traditional solution. I probably haven't seen this idea before.	Our solution is a typical adaptation of a traditional solution. I have seen this idea before.	We did not solve the problem completely.
Collaboration	All team members are kind and respectful. The team makes decisions as a group. Everyone shares their ideas.	All team members are kind and respectful. The team makes decisions as a group.	All team members are kind and respectful.	Not all team members are kind and respectful.

Energy and Collision

Picture Vocabulary

Contact

A meeting or touching of surfaces

Energy

What is needed to do work or cause change

Force

A push or pull that causes an object to move, stop, or change direction

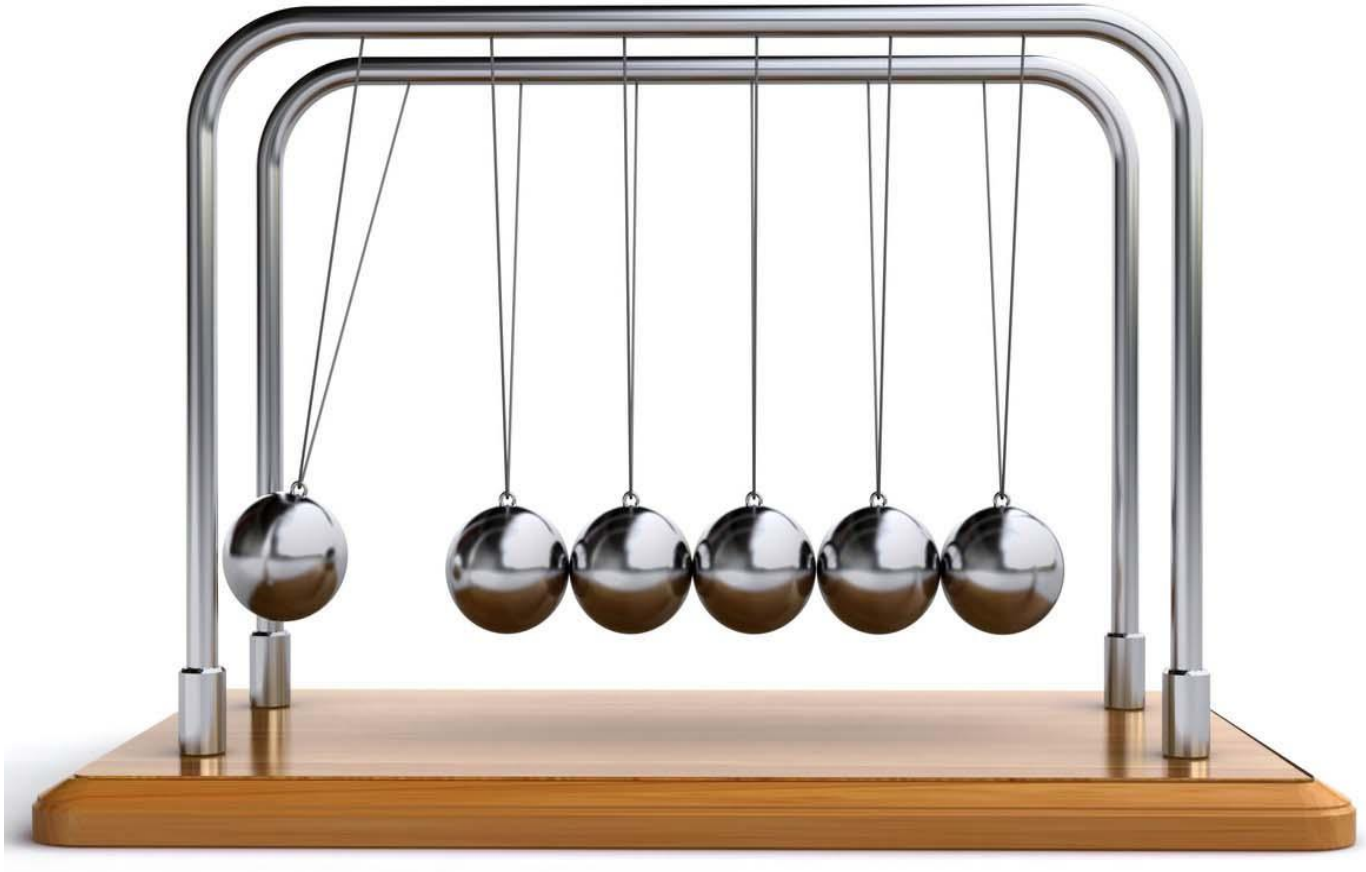
Motion

How an object moves from one place to another

Speed

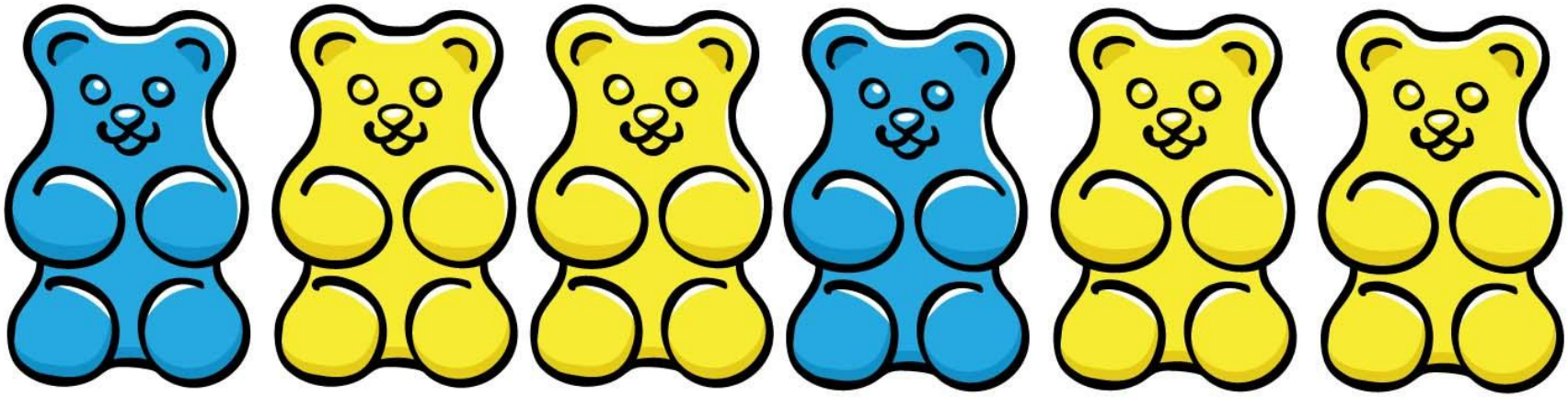
Rate of motion

Collision



A forceful impact when energy is transferred from one object to another

Pattern



A design or sequence that is repeated

Energy and Collision

Reflect

Shuffleboard is popular at parks and on cruise ships

What happens to objects when they collide? Objects have both energy and speed, whether they are moving or not. Energy cannot be destroyed, so during a collision, the energy has to go somewhere.

One game that relies on objects colliding is shuffleboard. In shuffleboard, a cue (fang) is used to push heavy metal discs (biscuits) down a court to slide into a space marked with a number. Opposing players try to knock each other's biscuits out of the scoring area. The player with the most biscuits inside the scoring area wins the round.

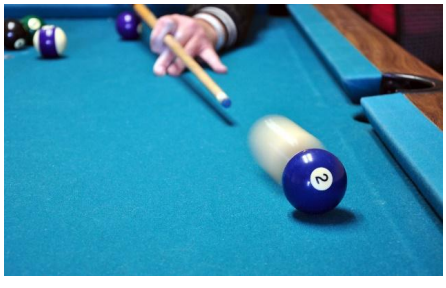
Each player has to figure out how hard to push the fang to get their biscuit into the scoring area. More importantly, pushing the other player's biscuits out of the scoring area without having your own biscuit also slide too far requires skill.

The biscuits colliding with each other changes both biscuits' energy and speed. As the moving biscuit collides with a biscuit at rest, it loses energy and speed, while the other biscuit gains speed and energy.

Don't sink the cue ball!
Billiards, or pool, is another game that involves objects colliding. As shown in the picture to the right, a cue stick is used to hit a white cue ball. The cue ball, in turn, collides with one or more of the numbered balls. The goal is to drop the numbered balls into a pocket without sinking the cue ball.

collision: The meeting of objects in which each exerts a force upon the other.

speed: how fast an object moves



What Do You Think?

What do you think would happen if you replaced the biscuits with wrapped pieces of candy? What about replacing the white cue ball with a balloon?

One important characteristic of baseball pitchers is how fast they can throw the ball. The speed of each pitch is measured and often displayed during the game. Balls moving faster have more energy.

Catcher's mitts are designed to protect the catcher's hand from the energy of the ball. Extra padding covers both the palm and the fingers. Other parts of the design such as the closed webbing make it easier for the catcher to hold onto the ball firmly and not drop it.

Catchers wear a mitt and other equipment to protect themselves from collisions with the ball.

Look Out!

Many people are in car accidents every day. When cars collide with each other, each car changes speed and energy quickly. The hoods and trunks of cars are designed to slow down this change of speed and protect the people inside each car.

Toy cars demonstrating the effects of a collision.

Try Now

What Do You Know?

In the table below, take a moment to think about the energy transfer that is occurring. Then decide which object is gaining energy and which object is losing energy in each situation.

Your World Real-life collisions	Gains Energy Which object is gaining energy?	Loses Energy Which object loses energy?
A cue stick is used to hit the cue ball in billiards.		
An asteroid hits the surface of Jupiter.		
A soccer ball is kicked into the goal.		
A child catches a football.		

Connecting With Your Child

Energy Transfer at Home
This activity will help you and your child explore the transfer of energy between colliding objects.

The materials you will need are a small toy car and a small ball, such as a tennis ball or a golf ball.

Find a spot where you child can roll the ball into the toy car and observe the car's speed. A smooth surface such as a wood floor or a concrete garage works well. Some sidewalks are also smooth enough.

Place the toy car some distance from the ball. Have your child kneel or sit near the toy car. Roll the ball gently so that it collides with the toy car. Have your child observe what happens to the speed of the toy car and the ball after the collision.

Repeat this as you roll the ball faster. Be sure not to roll it so fast that either the ball or the toy car flies off the ground!

Discuss the following questions with your child:

- Was the ball's energy greater when it was rolled fast or slow?
- What happens to the speed of the ball after it collides with the toy car?
- How does changing the speed of the ball change the speed of the toy car?
- What happens to the toy car's energy after the collision?
- When did the toy car gain the most energy: when the ball was rolled faster or slower?

Linking Literacy

Name: _____ Date: _____

Draw and Explain

Draw and label your picture.

Explain your picture below.

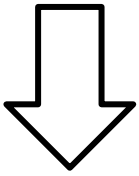
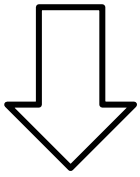
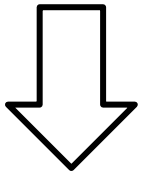
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Linking Literacy

Name: _____ Date: _____

Cascading Connections

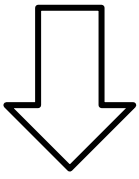
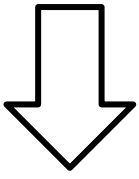
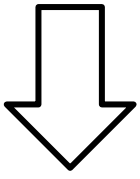
Main Topic

Contributing Factor

Contributing Factor

Contributing Factor

Result or Variable Impacted by Factors and Main Topic

Linking Literacy

Name: _____ Date: _____

Visualize and Apply

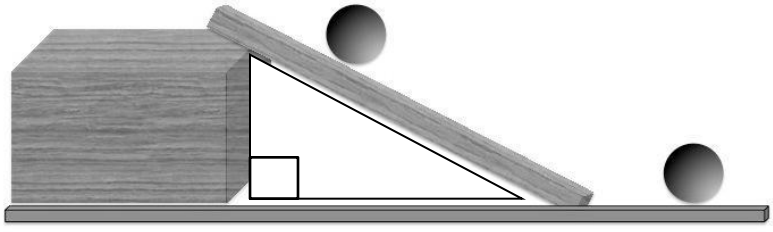
Word	Drawing	Application

Math Connections

Name: _____ Date: _____

Students are investigating how collisions affect an object's motion. The first experiment is shown in the diagram below. Ball A rolls down a ramp and collides with Ball B at the bottom of the ramp.

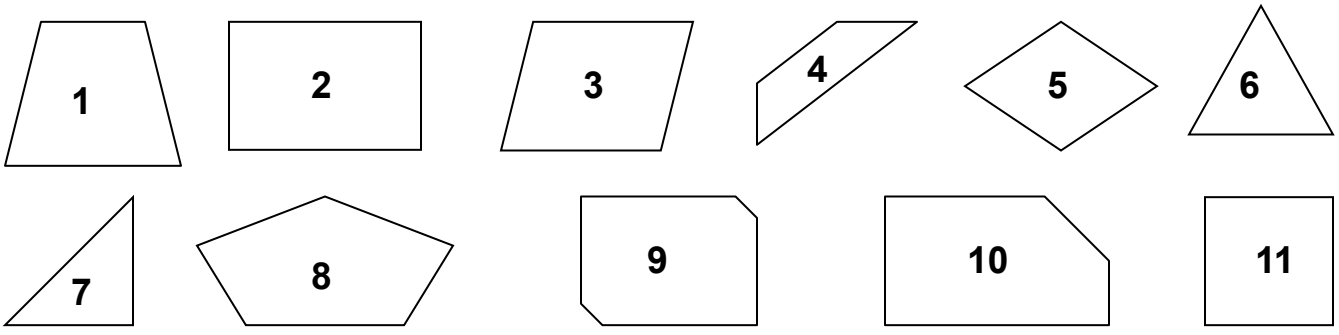
Use the diagram to answer questions 1 and 2.



1. Classify the shape that forms as the ramp leans against the wood block based on its angles and its sides. Explain your answer.

2. What will happen to the motion of Ball A and Ball B when the two collide?

In the second experiment, the students rolled a ball toward several different objects with various shapes. The students observed the motion of the ball as it collided with each object. The objects are shown below. You will use these objects to answer questions 3–6.



Math Connections

3. Complete the table below by writing the object numbers of any object that fits the characteristic.

Characteristic	Object Number(s)
At least one obtuse angle	
At least one right angle	
At least one acute angle	
At least one pair of parallel line segments	
At least one pair of perpendicular line segments	

4. Complete the table below by classifying each object based on whether it contains at least one right angle. Write the number of the object in the appropriate column.

Contains at least one right angle	Contains no right angles

Math Connections

5. Now look at the objects and determine a different way to sort all of the objects into two categories. Complete the table below, writing a title that describes the category at the top of each column. Then, write the numbers of each object in the category it belongs.

Title:	**Title:**

6. Draw a diagram showing the ball colliding with one of the objects. Your diagram should include your prediction of the motion of the ball after it collides with the shape.

Reading Science

Name: _____ Date: _____

A Winning Force

1 The world is always moving and changing. There is motion all around us. On a cool autumn day, the wind causes the leaves on a tree to shake and fall. Ocean waves lift a surfer and push her toward the shore. A baseball flies into the outfield after being hit by a batter. Forces cause objects to change their speed and direction.

2 Objects change direction when a force is applied. When you push a shopping basket, the basket moves in the direction of the force you used. It will continue to move as long as you push it. The greater the applied force, the farther or faster the basket will travel. Once you stop pushing the basket, it will stop moving. There is no longer a force acting on it to overcome the forces of gravity and friction, which act to hold the basket down in one spot.

3 When you ride a bike, you are changing your motion by accelerating. When you push down on the bike pedals, you apply a force that turns the wheels. As you push harder on the pedals, your bike speeds up. This is not the only example of acceleration. When you drop an object, the force of gravity pulls it toward the ground. The force of gravity acts on an object as long as the object is in the air. As the object falls farther and farther, it falls faster and faster. It accelerates.

4 An opposing force moves in the opposite direction of another force. It causes the object to slow down or stop. Think of a time when you were walking your dog. If your dog tries to chase a cat, they are pulling forward. When you pull on the leash, you are pulling backwards. Your pull is an opposing force that causes your dog to slow down or stop. There are also opposing forces in a tennis match. Both players try to keep the ball from going over the back line. They stop the forward movement of the ball by hitting it with their rackets. The swing's force makes the ball change direction and fly back over the net.

Reading Science

5 Think about forces the next time you are playing football, soccer, or tennis with your friends. If you apply a greater force to the ball, it will move faster and farther. Share this with your entire team, and you will be sure to win!

Reading Science

1 Complete the following analogy:

Pedaling your bike is to acceleration as pulling back on a dog's leash is to–

A energy.

B gravity.

C acceleration.

D deceleration.

---

2 Complete this sentence with one of the choices below:

The greater the force applied to an object, the farther or _____ the object will move.

A slower

B faster

C lower

D timer

Reading Science

3 Which of the following is the best example of an opposing force?

A Pulling on the dog leash when the dog starts running

B Kicking a football

C Pushing bike pedals

D Pushing a shopping basket at a grocery store

---

4 Accelerate means–

A to slow down.

B to push away.

C to pull toward.

D to speed up.

---

5 Which of the following is a force of nature?

A Your friend pushing a shopping cart

B Wind blowing leaves off a tree

C An athlete hitting a baseball with a bat

D An athlete kicking a football into the air

Content Connection Video

Name: _____ Date: _____

How to Build a Rube Goldberg Machine

1. What is a Rube Goldberg machine?

2. What kind of energy powers a Rube Goldberg machine?

3. In the first video activity, what were they investigating?

4. How did releasing the marbles from higher up on the ramp affect how much the position of the cup at the bottom changed?

Content Connection Video

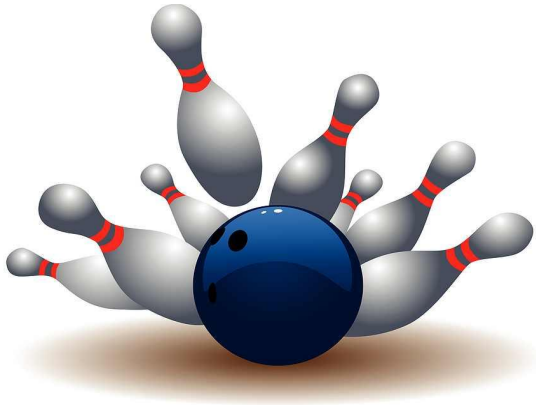
5. Regarding the Rube Goldberg machine at the end of the video, how does energy have the ability to create change?

Claim-Evidence-Reasoning

Name: _____ Date: _____

Scenario

The class took a field trip to a bowling alley. The students noticed that the pins moved and fell over when the bowling ball hit them, and that these falling pins knocked over other pins. Pins that were untouched by the bowling ball or other falling pins did not move.



Prompt

Write a scientific explanation for what happens when the bowling ball makes contact with the pins.

Claim:

_____

_____

Evidence:

_____

_____

_____

Reasoning:

_____

_____

_____

Claim-Evidence-Reasoning

Energy and Collision CER

Rubric for writing a scientific explanation

Points Awarded	2	1	0
Claim	Makes an accurate and complete claim.	Makes a claim that is inaccurate or incomplete.	Does not make a claim.
Evidence	Provides two or more accurate pieces of evidence, uses labels, and addresses variables.	Provides one or two accurate pieces of evidence.	Does not provide evidence or only provides inappropriate or vague evidence.
Reasoning	Evidence is connected to the claim and uses scientific principles and vocabulary.	Cites a reason, but it is inaccurate or does not support the claim. Reasoning does not use scientific terminology or uses it inaccurately.	Does not connect the evidence to the claim.

Open-Ended Response

Name: _____ Date: _____

Energy and Collision

1 What will happen to the ball when the soccer player kicks it?

_____

_____

_____

2 Have you ever bumped into someone? Describe the transfer of energy that happened and how your body changed directions.

_____

_____

_____

3 Observe the bowling ball as it collides with the pins. How are the pins changing position?

_____

_____

_____

Multiple Choice

Name: _____ Date: _____ Group: _____

1 When two moving objects collide, the motion of both objects will change. Why does this happen?

A Energy is transferred from one object to the other.

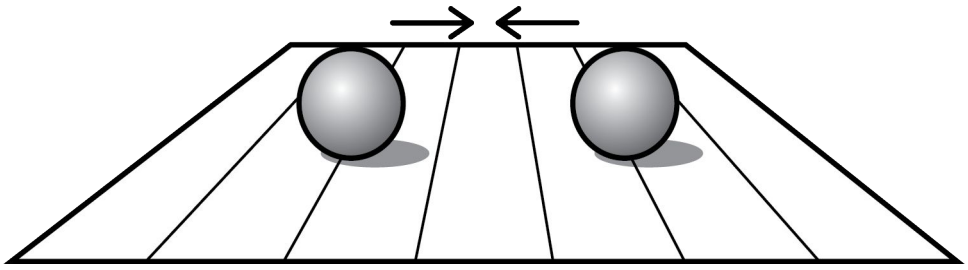
B Friction changes when moving objects collide.

C Objects lose mass when they collide, so they weigh less.

D The motion of all objects is changing all the time.

Multiple Choice

2 Two metal spheres roll across the floor toward each other.



After they collide, what about the spheres is most likely to change?

A Their mass

B Their state of matter

C Their motion

D Their shape

Multiple Choice

3 Students are interested in investigating how the motion of marbles changes when they collide. They decide to roll marbles on a flat surface and allow them to hit each other. What observations will be most important for the students in their investigation?

A How the marbles are moving before and after they collide

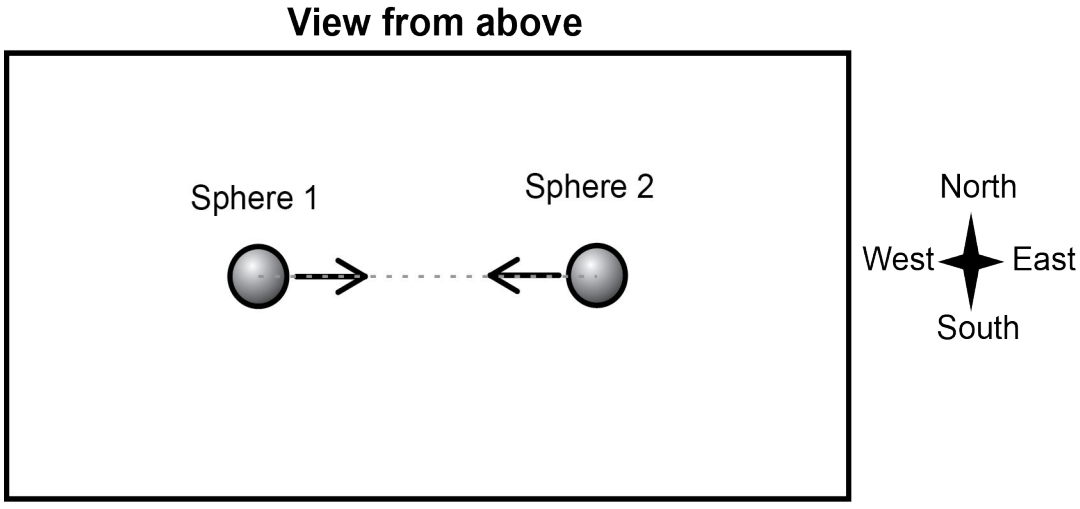
B The material the marbles are made of and their mass

C The diameters and the colors of the marbles

D The exact length and width of the surface the marbles roll on

Multiple Choice

4 This illustration shows the view, from above, of two identical spheres of rubber moving directly toward each other at the same speed. Sphere 1 is moving to the east. Sphere 2 is moving to the west.



After the spheres collide, what is the most likely motion for the two spheres?

A Both Sphere 1 and Sphere 2 will move to the east.

B Sphere 1 will move to the west, and Sphere 2 will move to the east.

C Both Sphere 1 and Sphere 2 will move to the west.

D Sphere 1 will move to the east, and Sphere 2 will move to the west.

Multiple Choice

5 Two moving objects will change their motion if which of the following is true?

A There is no friction on the objects.

B The objects collide with each other.

C One object is heavier than the other.

D The objects are moving in space.

Energy and Collision

Guided Practice

Note: Due to the nature of this element, not all sections of the activity can be completed and submitted online by students.

Description

Students will describe how the energy and speed of two objects changes after a collision.

Materials

2 Kick balls (per group)
Copy of Student Page (per group)

Procedure

1. Each group of students should have two kick balls.
2. Have students roll one ball quickly and one ball slowly. Students should then identify which ball had more energy.
3. Have students place one ball on the ground and roll the other ball toward it so that they collide. Have students share their observations about the energy and speed of each object before and after the collision. Repeat the collision if students miss the changes.
4. Have one student slowly roll one ball while another student rolls the second ball fast enough in the same direction so that it catches up with the first ball and collides with it. Students should observe and describe the energy and speed of the two kick balls before and after the collision. Repeat as necessary.
5. Have two students stand across from each other and slowly roll the two kick balls toward each other. Students should observe and describe the energy and speed of the two kick balls before and after the collision. Repeat as necessary.

Guiding Points

Be sure to check for understanding when listening to students' responses on how the energy and speed of the balls are changing as a result of each collision. During this intervention, be sure to label students' observations with appropriate vocabulary terms.

Guiding Questions

1. Which ball has more energy: the faster or slower ball?
2. When a ball collides with something, what happens to its speed and energy?
3. If a ball is hit by something, how does its energy and speed change?
4. What can happen to the speed and energy of objects when they collide?

Guided Practice

Name: _____ Date: _____

Check Understanding

Complete each statement using the word bank.

Word Bank					
energy	increase	collide	speed	less	decrease

1. A slower moving object has _____ energy than a faster moving object.

2. When two objects _____, the _____ and _____ of both objects will change.

3. If the speed of an object decreases after a collision, the energy of that object will _____.

Answer the question below. Use additional paper if needed.

4. Some students were playing soccer at recess. During the game, one student kicked the ball to pass it. Another student ran up behind the ball and kicked it in the same direction that it was already rolling. Describe what happened to the speed and energy of the ball when the second student kicked the ball.

_____

_____

_____

_____

_____