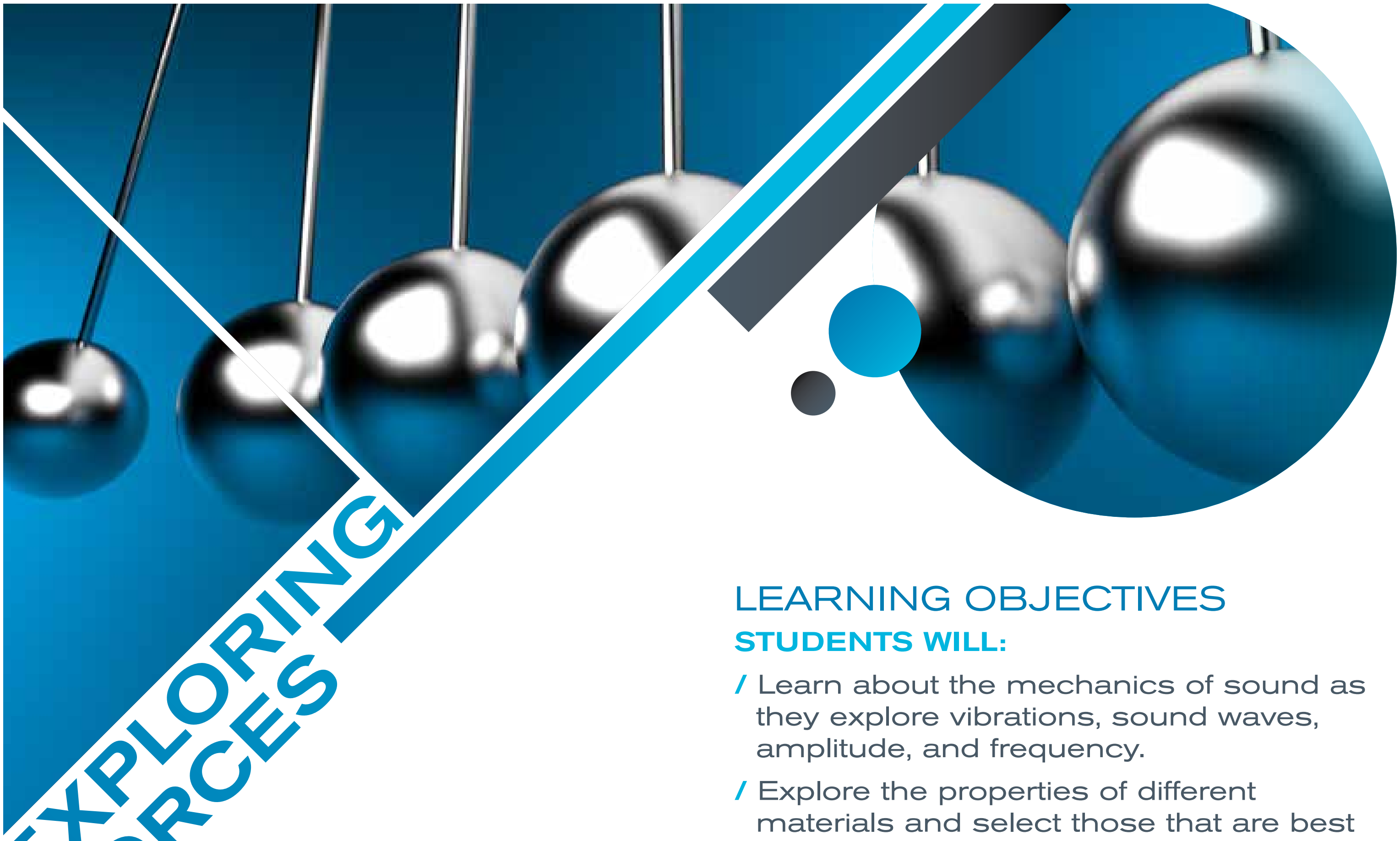
MIDLAND CENTER FOR THE ARTS

EDUCATION GUIDE
EXPLORING FORCES



EXPLORING FORCES

This guide introduces students to basic physics concepts through the use of hands-on, engaging experiments. Each activity encourages students to engage with inquiry-based learning strategies as they strengthen critical thinking and analytical skills. This guide can act as a standalone resource for you and or students or it can be paired with one of the following Alden B. Dow Museum of Science & Art programs:

/ Art and Science Connections Tour

/ Amazing Magnets

/ Science of Sound

/ Fantastic Forces

/ Fascinating Flight

The content can be adapted to fit a wide range of grade level expectations with minor adjustments.

LEARNING OBJECTIVES

STUDENTS WILL:

/ Learn about the mechanics of sound as they explore vibrations, sound waves, amplitude, and frequency.

/ Explore the properties of different materials and select those that are best suited for their purposes during design challenges.

/ Gain a basic understanding of forces (pushes and pulls) and their impact on the motion of an object

/ Learn more about magnetism and how magnets help solve problems in our everyday life

/ Gain a basic understanding of balanced and unbalanced forces

/ Learn about Newton's Laws and everyday applications

Curriculum Standards (GLCE) Introduced:

Grade K: K-PS2-2
Grade 1: 1-PS4-1
Grade 2: 2-PS1-2
Grade 3: 3-PS2-1, 3-PS2-4
Grade 4: 4-PS3-3
Middle School: MS-PS2-1

MAKING WAVES

ACTIVITY #1

Students will learn about sound and test a variety of materials as they make dancing oobleck and design their own instrument.

MATERIALS

- / Slinky
- / Cornstarch
- / Water
- / Thin plastic lid (from container like yogurt or sour cream)
- / Speaker with flat surface or subwoofer
- / Device to play music and connecting cable for speaker
- / Spoon
- / Food Coloring
- / Paper
- / Pencils
- / Recycled materials such as coffee cans, cardboard, shoeboxes, etc.
- / Arts and crafts materials such as string, yarn, tape, markers, pipe cleaners, etc.

PREP

Create oobleck ahead of time by adding 3 tablespoons of cornstarch and ½ tablespoon of water. Add food coloring and stir the mixture on the plastic lid.

WARM-UP

1. What is sound? Sound is a type of energy that is made by vibrations. We can feel those vibrations easily by laying our hand on our throat and speaking. Let's give it a try! Have students gently place their hand on their throat and say "hello." Did they feel the vibration?
2. Sound actually travels in waves. Demonstrate sound waves using a slinky. These waves at times compress or push together tightly, creating what we call high frequency waves. Sometimes they spread out further, creating lower frequency waves. When the wavelengths are close together, a higher pitch is produced and when they are farther apart and the frequency is low, a low pitch is produced. Have students practice making high and low pitches.
3. Let's take a look at how sound waves affect oobleck! Connect your device to the speaker and select a song. Make sure the volume is turned up! Place the lid on the speaker or subwoofer and hold it in place. Turn the volume of the music up and down. Sound waves don't just travel through air! They can also travel through liquids and solids.
4. What happens as the music plays? How does the oobleck move differently depending on the pitch of the song? What patterns do you see? How do changes in volume impact the oobleck? When you turn music up, you are increasing the amplitude (amount of movement or displacement of the sound wave). When you turn the music down, you are decreasing the amplitude.

DIVE DEEPER

1. Now that students have learned a bit about sound, it's time to create a musical instrument! Music is just organized sound and instruments are tools that enable us to create vibrations that may have the same or different frequencies, creating varying pitches.
2. In order to create their instrument, they should start with a sketch. As they design their instrument, they need to keep in mind that there must be an element that vibrates. Students should begin to brainstorm what materials they will use to make their instruments. They should also think about any variations in their materials that may allow for changes in frequency or pitch.
3. Have students select the materials they will use and test them to make sure that they will work for each component. They should identify some of the basic properties of their materials. Is their material hard or soft? Is it flexible or brittle? Strong or weak? Heavy or light?
4. Once students have selected their materials, they can build their prototype. Encourage students to build, test, and refine throughout the process.
5. Students can present their finished objects to the rest of the class.

ASSESSMENT AND REFLECTION

Have students create a journal entry, answering the following questions:

1. What is sound? How is it created?
2. How does amplitude affect how loud or soft something is?
3. How does frequency affect pitch?
4. What lessons did I learn when creating my instrument? What materials worked well? What materials did not work well? How did I alter my design throughout the process?
5. Think about an instrument you have seen in real life. Do you know what part of that instrument vibrates to create sound?
6. What do I still wonder about sound?

POWER OF MAGNETISM

ACTIVITY #2

Students will explore forces as they learn about magnetism.

MATERIALS

- Bar magnets with handles
- Paper plates
- Markers
- Scissors
- Paper clips
- Tape
- Scrap paper
- Clear plastic cups
- Total™ cereal
- Gerber Graduates® Arrowroot cookies
- Cheerios
- Rice Krispies
- Neodymium magnets
- Water
- Zipper seal sandwich bag
- Pencil
- Paper

WARM-UP

1. What is a magnet? Can you give examples of magnets you see around your house? Explain to students that a magnet is a rock or piece of metal that can pull certain types of metal toward itself. The force a magnet exerts is called magnetism.
2. What is a force? A force is simply a push or a pull.
3. Pass out bar magnets. Have students hold their magnet by the handle and turn to their neighbor. Have students push the magnets together. Then, have one student flip their magnet. Again, have students push the magnets together. What do they notice? They may notice that they felt but a pull and a push. They are feeling magnetism.
4. Now, we will use the force of magnetism to create a unique maze!
5. Have students begin by creating a small figure using scrap paper. They may choose to cut their figure into a specific shape or color their figure. After they have created their figure, they will use a small piece of tape to attach a paper clip to the top. Explain to students that paper clips are magnetic. They are made out of a type of metal that will be attracted or pushed towards their magnet.
6. Next, have students design a maze on their paper plate using markers.
7. Once they have finished, have students place their figure on top of their paper plate, on their maze, and place a bar magnet with a handle under their plate. Their goal is to guide their figure through their maze using the force of magnetism.

DIVE DEEPER

1. Did you know that some of the foods we eat are actually magnetic? Certain cereals are fortified with iron. Iron is a metal that is actually found in our body! It is an important mineral that plays a role in our energy metabolism, the formation of red blood cells, oxygen transportation and much more!
2. Give students one type of each cereal in a plastic sandwich bag. Label each bag A, B, C, or D, making sure to include the same type of cereal in each lettered bag for all students.
3. Have students squash each cereal so it is a powder. Students will need to add water and then let them mixture sit for one-two hours.
4. Next, pour each type of cereal into a labelled plastic cup. Have students hold one side of a neodymium magnet against the side of the up and observe the iron particles that collect on the side of the cup! Students should record what they see either through a written description, drawing, or both.
5. Have students repeat step four for each type of cereal.
6. When they are finished, reveal what cereal was in each bag/cup. What cereal contained the most iron? What cereal contained the least amount of iron? Any additional observations?

ASSESSMENT AND REFLECTION

Have students take a tour through their homes using a bar magnet with a handle. Have students record 3 magnetic items that they find in their home and 3 objects that are metal but are not magnetic in their home. Have students research what types of metal these objects are usually made out of. Have students record what they have researched. What types of metal are magnetic?

GREAT MAGNET CHALLENGE

ACTIVITY #3

Students will apply their understanding of magnetism to create a design solution.

MATERIALS

- / Cork
- / Box cutter or knife
- / Permanent marker
- / Large sewing needle
- / Water
- / Bowl
- / Paper
- / Pencil
- / Recycled objects (cardboard, bottle caps, boxes, etc.)
- / Arts and crafts supplies (pipe cleaners, yarn, tape, etc.)

PREP

Carefully slice a 1cm segment of the cork, creating a round disk. Push a large sewing needle through the side of the cork (rounded areas) so that you have a flat disk on the top and bottom. Label the cork with an N on one side of the top and an S on the other side of the top (where the end and tip of your needs are).

WARM-UP

1. Reinforce the concepts introduced in the previous less, including force and magnetism. Have students take a look around their classroom or home. How many items use magnets? How do magnets help solve a problem?
2. While we often think of magnets that hold pictures to the refrigerator door, there are actually many more magnets all around us! Many computers use magnets to store information, the small speakers in televisions and radios also use magnets that convert or change electronic signals into sound vibrations. Magnets in electric generators turn mechanical energy into electricity. Vacuum cleaners, washing machines, phones, door bells and even shower curtains all contain magnets!
3. One of the oldest uses for magnets is a compass. Did you know that the core or center of the Earth creates its own magnetic field? This enables us to use a tool called a compass in order to find our direction. A compass finds the Earth's natural magnetic fields. Our Earth has a North and South Pole, just like our magnet has a north pole and a south pole. The Earth's poles are located at the very top and bottom of the globe. A compass points to the magnetic North Pole (which isn't truly north). This enables you to use a compass to help find your direction.
4. We can actually make our own compass! Show students the cork and needle you assembled. Explain what you did.
5. Place the needle and cork gently into your bowl of water. What happens? You will notice that your compass will actually rotate until it aligns with the Earth's magnetic pole!

DIVE DEEPER

1. Now that students have explored some of the everyday ways we use magnets, they must invent a solution to a problem using magnets.
2. Present students with the following scenario:

   Jessica is the owner of a local junk yard. She sees many objects come to her business every day, both big and...HUGE! Jessica has hired you to invent a tool or machine that can help her move very large items like cars, refrigerators, and farm equipment from one area of her land to another. These very large items often have a lot of metal in them, metal that just happens to be attracted to magnets! You must sketch and build a prototype of a tool or machine that uses magnets and solves Jessica's problem.
3. First, have students sketch out their design. As they sketch, they must think about what materials will work best for the job, based on their properties. Their machines will need to be strong and durable.
4. After students have successfully sketched their designs, they will need to create their prototypes. They should use recycled materials and arts and crafts items.
5. Once students have finished their prototypes, have them present their designs to the class. They should talk about how their design functions, what materials they would use and why, and how their magnet works.

ASSESSMENT AND REFLECTION

Have students apply the principles they have learned during this activity to solve a problem at home. First, have students interview family members in order to find a problem. After they have written down their problem, have students sketch a solution that uses magnets. Have students present their design during their next class or they can even create a prototype to present.

COLLISION COURSE!

ACTIVITY #4

Students will learn about balanced and unbalanced forces along with Newton's Laws through hands-on exploration.

MATERIALS

/ Plastic cups
/ Water
/ Pennies
/ Index cards
/ One balloon
/ Two tennis balls
/ One ping pong ball
/ Device to show online video
/ Masking tape
/ Pipe cleaners
/ Plastic cups
/ Straws
/ Marbles
/ Pencils
/ Paper
/ Construction paper or cardstock
/ Scissors
/ Glue sticks
/ Miscellaneous objects found in classroom (as available such as books, blocks, dominos, etc.)

WARM-UP

1. Review the definition of a force with students. During this activity, students are going to apply some of the ideas they have learned about forces to motion. When a force is balanced, there is no motion! What forces are acting on your body right now? Gravity is a big one! Let's think about a book sitting on a table. Gravity is pulling the book closer to earth. However, the book doesn't just go crashing through the table. This is because the table is actually pushing up on the book, holding it in place. There is equilibrium.
2. What happens if forces are not balanced? If forces are unbalanced, motion occurs. Let's go back to our book. So, the book is sitting on the table in a state of equilibrium, there are balanced forces. What happens if I run up and push the book? The book would slide across the table. I would be exerting an additional, unbalanced force, causing motion! This idea relates to Newton's First Law which states that an object at rest remains at rest unless acted upon by an unbalanced force. According to this law, an object in motion will also stay in motion unless acted upon by an unbalanced force.
3. Pour about 1 inch of water into plastic cups. Haves students place their index card on top of the cup and a penny on to of the index card, making sure it is place in the center of the card.
4. What do students think will happen to the penny if they flick the index card? Where will the penny go?
5. After students have made a hypothesis, have them firmly flick the index card forward. What happened to the penny? Since an object at rest wants to stay at rest, the index card (which had an unbalanced force exerted on it) moved. However, the penny did not have an unbalanced force so it stayed at rest, falling straight down into the cup.

DIVE DEEPER

1. Now we have explored balanced and unbalanced forces, but what happens when objects collide? According to Newton's Third Law, for ever action, there is an equal and opposite reaction. That may sound a little complicated but let's think about a balloon. Blow up a balloon and hold it up for students to see without tying it. If you were to let of the balloon, what direction would the balloon travel in? What direction would the air shoot out of the balloon from? This is an equal and opposite reaction!
2. Now, let's think about this. What if I had two balls that were exactly the same and I rolled them towards each other with the same about of energy, once they collided, what direction would each ball travel it? Now, what happens if two objects collide and they are not the same mass? What happens if one ball is at rest and the other is in motion?
3. Demonstrate each of these scenarios and have students discuss what they observe. You may also try to apply different amounts of 'strength' or energy to see how this impacts the motion of the balls. Have students note that if forces are unbalanced, the object will accelerate in the direction of the net force.
4. Now that students have explored these concepts, they must use what they have learned about Newton's First and Third Laws to design a Rube Goldberg Machine. They will need to be very mindful about the collisions that will take place and the resulting affects.
5. Show students an example of a Rube Goldberg Machine on YouTube before they begin.

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6. Now, they must think about what their machine is going to accomplish. Will it move something? Turn on a light switch? After students have decided on the task their machines will accomplish, they should sketch their machine, paying careful attention to what materials they will use.
7. Once sketched, they can begin to build their machines. Give students ample time to experiment and encourage them to keep working, even if their machine does not work the first time!
8. After students have finished, they may present their machines to the rest of the class. Have students discuss the way their knowledge of Newton's Laws impacted their design.

VOCABULARY

Amplitude / the distance that a wave dips down or rises higher than its calm or flat surface.

Balanced Force / two forces of equal size that are acting on a body in opposing directions.

Force: a push or a pull.

Frequency / the number of waves that pass a fixed place in a given amount of time.

Gravity / the force that attracts a body toward the center of the earth or toward another body that has mass.

Magnet / a piece of iron that has its atoms ordered in such a way that it exhibits the properties of magnetism.

Magnetic Field / the space or region near a magnet in which a magnetic force acts on any other magnet, electric current, or moving charged particle.

Mass / the amount of something (matter) there is, and is measured in grams (or kilograms).

Net Force / the sum of all forces.

Newton's First Law / An object at rest tends to stay at rest, and an object in motion tends to stay in motion, unless acted on by an outside force.

Newton's Third Law / For every action there is an equal and opposite reaction.

Pitch / the quality of sound governed by the frequency of the sound wave.

Prototype / a first or preliminary model of something that will later be developed or copied.

Sound Wave / longitudinal pressure waves that travel through a material medium that create an audible sound.

Unbalanced Force / two forces acting in opposing directions on an object that are not equal in magnitude and in size.

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