Forces and Motion

Teacher Manual

3-PS2 Motion and Stability: Forces and Interactions

3-PS2 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. [Clarification Statement: Examples could include an unbalanced force on one side of a ball can make it start moving; and, balanced forces pushing on a box from both sides will not produce any motion at all.] [Assessment Boundary: Assessment is limited to one variable at a time: number, size, or direction of forces. Assessment does not include quantitative force size, only qualitative and relative. Assessment is limited to gravity being addressed as a force that pulls objects down.]

3-PS2-2. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. [Clarification Statement: Examples of motion with a predictable pattern could include a child swinging in a swing, a ball rolling back and forth in a bowl, and two children on a see-saw.] [Assessment Boundary: Assessment does not include technical terms such as period and frequency.]

3-PS2-3. Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other. [Clarification Statement: Examples of an electric force could include the force on hair from an electrically charged balloon and the electrical forces between a charged rod and pieces of paper; examples of a magnetic force could include the force between two permanent magnets, the force between an electromagnet and steel paperclips, and the force exerted by one magnet versus the force exerted by two magnets. Examples of cause and effect relationships could include how the distance between objects affects strength of the force and how the orientation of magnets affects the direction of the magnetic force.] [Assessment Boundary: Assessment is limited to forces produced by objects that can be manipulated by students, and electrical interactions are limited to static electricity.]

3-PS2-4. Define a simple design problem that can be solved by applying scientific ideas about magnets.* [Clarification Statement: Examples of problems could include constructing a latch to keep a door shut and creating a device to keep two moving objects from touching each other.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Asking Questions and Defining Problems
Asking questions and defining problems in grades 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships.
- Ask questions that can be investigated based on patterns such as cause and effect relationships. (3-PS2-3)
- Define a simple problem that can be solved through the development of a new or improved object or tool. (3-PS2-4)

Planning and Carrying Out Investigations
Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.
- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-PS2-1)
- Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (3-PS2-2)

Connections to Nature of Science

Science Knowledge is Based on Empirical Evidence
- Science findings are based on recognizing patterns. (3-PS2-2)

Scientific Investigations Use a Variety of Methods
- Science investigations use a variety of methods, tools, and techniques. (3-PS2-1)

Disciplinary Core Ideas

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. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.) (3-PS2-1)
- The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.) (3-PS2-2)

PS2.B: Types of Interactions
- Objects in contact exert forces on each other. (3-PS2-1)
- Electric, and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other. (3-PS2-3),(3-PS2-4)

Crosscutting Concepts

Patterns
- Patterns of change can be used to make predictions. (3-PS2-2)

Cause and Effect
- Cause and effect relationships are routinely identified. (3-PS2-1)
- Cause and effect relationships are routinely identified, tested, and used to explain change. (3-PS2-3)

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology
- Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process. (3-PS2-4)

Connections to other DCIs in third grade: N/A

Articulation of DCIs across grade-levels: **K.PS2.A** (3-PS2-1); **K.PS2.B** (3-PS2-1); **K.PS3.C** (3-PS2-1); **K.ETS1.A** (3-PS2-4); **1.ESS1.A** (3-PS2-2); **4.PS4.A** (3-PS2-2); **4.ETS1.A** (3-PS2-4); **5.PS2.B** (3-PS2-1); **MS.PS2.A** (3-PS2-1),(3-PS2-2); **MS.PS2.B** (3-PS2-3),(3-PS2-4); **MS.ESS1.B** (3-PS2-1),(3-PS2-2); **MS.ESS2.C** (3-PS2-1)

Common Core State Standards Connections:

ELA/Literacy –

RI.3.1	Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. *(3-PS2-1)*,(3-PS2-3)
RI.3.3	Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect. (3-PS2-3)
RI.3.8	Describe the logical connection between particular sentences and paragraphs in a text (e.g., comparison, cause/effect, first/second/third in a sequence). *(3-PS2-3)*
W.3.7	Conduct short research projects that build knowledge about a topic. (3-PS2-1),(3-PS2-2)
W.3.8	Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories. (3-PS2-1),*(3-PS2-2)*
SL.3.3	Ask and answer questions about information from a speaker, offering appropriate elaboration and detail. *(3-PS2-3)*

Mathematics –

MP.2	Reason abstractly and quantitatively. *(3-PS2-1)*
MP.5	Use appropriate tools strategically. *(3-PS2-1)*
3.MD.A.2	Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem. *(3-PS2-1)*

Core Idea PS2 Motion and Stability: Forces and Interactions

How can one explain and predict interactions between objects and within systems of objects?

Interactions between any two objects can cause changes in one or both of them. An understanding of the forces between objects is important for describing how their motions change, as well as for predicting stability or instability in systems at any scale. All forces between objects arise from a few types of interactions: gravity, electromagnetism, and the strong and weak nuclear interactions.

PS2.A: FORCES AND MOTION

How can one predict an object's continued motion, changes in motion, or stability?

Interactions of an object with another object can be explained and predicted using the concept of forces, which can cause a change in motion of one or both of the interacting objects. An individual force acts on one particular object and is described by its strength and direction. The strengths of forces can be measured, and their values compared. What happens when a force is applied to an object depends not only on that force but also on all the other forces acting on that object. A static object typically has multiple forces acting on it, but they sum to zero. If the total (vector sum) force on an object is not zero, however, its motion will change. Sometimes forces on an object can also change its shape or orientation. 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).

At the macroscale, the motion of an object subject to forces is governed by Newton's second law of motion. Under everyday circumstances, the mathematical expression of this law in the form $F = ma$ (total force = mass times acceleration) accurately predicts changes in the motion of a single macroscopic object of a given mass due to the total force on it. But at speeds close to the speed of light, the second law is not applicable without modification. Nor does it apply to objects at the molecular, atomic, and subatomic scales, or to an object whose mass is changing at the same time as its speed.

For speeds that are small compared with the speed of light, the momentum of an object is defined as its mass times its velocity. For any system of interacting objects, the total momentum within the system changes only due to transfer of momentum into or out of the system, either because of external forces acting on the system or because of matter flows. Within an isolated system of interacting objects, any change in momentum of one object is balanced by an equal and oppositely directed change in the total momentum of the other objects. Thus, total momentum is a conserved quantity.

Grade Band Endpoints for PS2.A

By the end of grade 2. Objects pull or push each other when they collide or are connected. Pushes and pulls can have different strengths and directions. Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. An object sliding on a surface or sitting on a slope experiences a pull due to friction on the object due to the surface that opposes the object's motion.

By the end of grade 5. Each force acts on one particular object and has both a 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. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.) The patterns of an object's motion in various situations can be observed and measured; when past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.)

PS2.B: TYPES OF INTERACTIONS

What underlying forces explain the variety of interactions observed?

All forces between objects arise from a few types of interactions: gravity, electromagnetism, and strong and weak nuclear interactions. Collisions between objects involve forces between them that can change their motion. Any two objects in contact also exert forces on each other that are electromagnetic in origin. These forces result from deformations of the objects' substructures and the electric charges of the particles that form those substructures (e.g., a table supporting a book, friction forces). Gravitational, electric, and magnetic forces between a pair of objects do not require that they be in contact. These forces are explained by force fields that contain energy and can transfer energy through space. These fields can be mapped by their effect on a test object (mass, charge, or magnet, respectively).

Objects with mass are sources of gravitational fields and are affected by the gravitational fields of all other objects with mass. Gravitational forces are always attractive. For two human-scale objects, these forces are too small to observe without sensitive instrumentation. Gravitational interactions are non negligible, however, when very massive objects are involved. Thus, the gravitational force due to Earth, acting on an object near Earth's surface, pulls that object toward the planet's center. Newton's law of universal gravitation provides the mathematical model to describe and predict the effects of gravitational forces between distant objects. These long-range gravitational interactions govern the evolution and maintenance of large-scale structures in the universe (e.g., the solar system, galaxies) and the patterns of motion within them.

Electric forces and magnetic forces are different aspects of a single electromagnetic interaction. Such forces can be attractive or repulsive, depending on the relative sign of the electric charges involved, the direction of current flow, and the orientation of magnets. The forces' magnitudes depend on the magnitudes of the charges, currents, and magnetic strengths as well as on the distances between the interacting objects. All objects with electrical charge or magnetization are sources of electric or magnetic fields and can be affected by the electric or magnetic fields of other such objects. Attraction and repulsion of electric charges at the atomic scale explain the structure, properties, and transformations of matter and the contact forces between material objects (link to PS1.A and PS1.B). Coulomb's law provides the mathematical model to describe and predict the effects of electrostatic forces (relating to stationary electric charges or fields) between distant objects. The strong and weak nuclear interactions are important inside atomic nuclei. These short-range interactions determine nuclear sizes, stability, and rates of radioactive decay (see PS1.C).

Grade Band Endpoints for PS2.B

By the end of grade 2. When objects touch or collide, they push on one another and can change motion or shape.

By the end of grade 5. Objects in contact exert forces on each other (friction, elastic pushes and pulls). Electric, magnetic, and gravitational forces between a pair of objects do not require that the objects be in contact—for example, magnets push or pull at a distance. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other. The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.

Lesson Sequence

Lesson 1- 6 days

4 1-hour blocks and 2 45-minute blocks

Lesson 2- 3 days

3 1-hour blocks

Lesson 3- 2 days

2 1-hour blocks

Lesson 4- 3 days

2 1-hour blocks and 1 45-minute block

Lesson 5-2-3 days

2-3 1-hour blocks

Unit Driving Question: What Makes Objects Move the Way They Do?

Students will build an understanding of the forces required for each type of motion (static, magnetic, kinetic).

ANCHORING PHENOMENA 1: Magnetic Slime

The following video demonstrates a more extreme example of magnetic slime but it is strongly recommended that students be able to experience a hands on version of this phenomenon. ***Magnetic Slime clip***

ANCHORING PHENOMENA 2: Can Can Go

The following video demonstrates multiple examples of static electricity including the Can Can Go but it is strongly recommended that students be able to experience a hands on version of this phenomenon. ***Static Electricity clip***

ANCHORING PHENOMENA 3: Kickball

The following video shows memorable missed field goals but it is strongly recommended that students be able to experience a hands on version of this phenomenon. ***Kicking Field Goals clip*** *Show time frame from 2:27-3:31*

Magnetic Slime Recipe

Supplies: White PVA Washable School Glue (Elmer's)
Water
Baking Soda
Iron Oxide
Saline Solution

Directions:

1. Thoroughly mix ½ cup glue and ½ cup water in a bowl (bowl will clean up nicely afterwards)
2. Add ½ tsp baking soda and stir
3. Add 1 tbsp of iron oxide powder and stir until color is uniform
4. Add 1 tbsp of saline solution. Stir vigorously until mixture forms a slimy ball.
5. Coat hands with a few drops of saline and knead slime to desired consistency

LESSON 1: 2 days

Time: 1 hour each day

MATERIALS NEEDED:

- Magnetic Slime in small containers for partners
- Magnets- 2 per group
- Trays
- Student Journals- Notice/ Wonder sheets

This is the first lesson in the unit.

1. You will introduce the anchoring phenomena to the students. You will encourage the students to discover things about it by making observations and asking questions about it. You can prompt them if they are having trouble coming up with questions but refrain from telling them any answers about it or to their questions.
    - Looking at already created Slime, students will generate driving questions based upon their observations.
    - Examples of student questions may include:
        - What is this?
        - How does it move?
        - What is this made of?
        - Why does this happen?
        - Is this a solid or a liquid?
        - What is ot's purpose?

    - Examples of teacher questions may include:
        - How can we use our observations to figure out what this is?
        - How does it behave? What is its purpose?

2. Ask students to observe the Slime with their hands and with the magnets.
    - What do you notice?
    - What happens to this substance if you put the magnet close?
    - What happens if you put the magnet far away?
3. Students share observations of the slime in small groups. In their journal on pg. 1, students record what they notice and wonder about the slime. Students can create individual drawn models of the phenomena and share in their groups, looking at similarities and differences.
4. Students share their models whole group. Allow students to share under the doc camera if possible. As a whole group, look for similarities and differences among the models.
5. On chart paper, the teacher, along with the students, creates a whole group consensus model of the slime. The whole group consensus model should show how the slime moves.

BREAK DAY 1

6. On a separate chart paper, make a list of related phenomena.
7. Create a driving question board (DQB). Each student should write at least one question on a sticky note that they want answered about this phenomenon. (These questions should come from what the students wondered about in their journals.) Teacher might need to prompt, referring back to the magnetic slime. Connect noticings to wonderings, asking how and why questions. Students put questions up onto chart paper. Read them aloud with class, then sort questions into categories of similarities. Give groups of questions headings.
8. Ask students ideas for investigations based on their wonderings. Teacher may need to lead students to investigations that will be planned.

LESSON 1: Days 3 and 4

Time-1-hour block over 2 days

Students start by exploring with magnets to develop a working definition of magnetic force.
Students will identify how strength, distance, and orientation of a magnet impacts the force it exerts on another object.

MATERIALS NEEDED:

- Magnet stations (Classroom magnet set-1 large horseshoe magnet, 6 Mag-Wands, 6 rectangular magnets, 3 floating magnet stands with 12 floating magnets, 29 jumbo magnetic marbles, 204 magnetic chips)
- Use each center cards as a placemat for each magnet station (you may want to laminate them for longevity). Students can keep track of observations on an *I notice, I wonder* sheet.

** Use any combination of these. You do not need to do them all.

When centers are completed daily:

Provide a forum for students to share their *I notice, and I wonder* responses for each station. You can record student findings on the anchor chart, or you can present the station placemats one by one and discuss student ideas and questions. As students share what they noticed help students to use the appropriate vocabulary. By allowing students to explore the magnets prior to this discussion students can use their experience to understand/describe the properties of magnets.

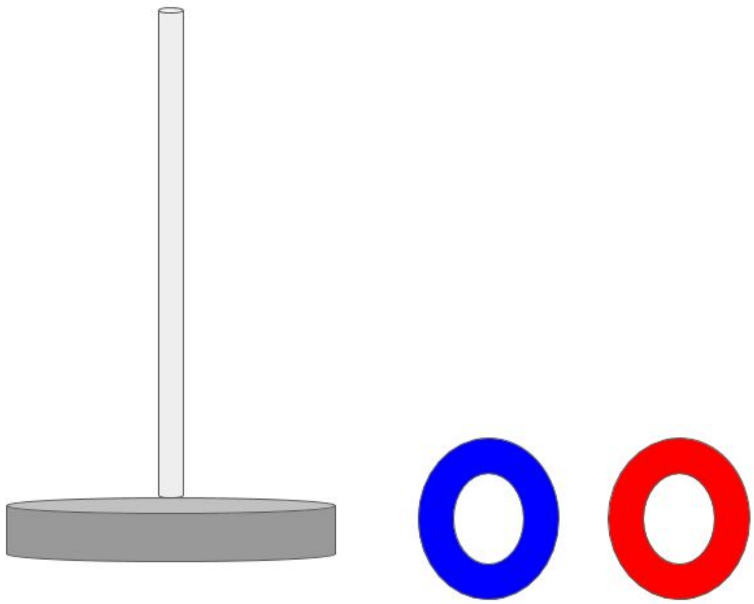
Refer back to the DQB. What questions have been answered? Move those to the side. Additionally, refer back to student ideas for investigations.

Station 1: Distance
Supplies: Magnet, 1 magnetic chip

Directions: Place the chip on the dot at the end of the ruler. Use the mag-wand to investigate how far the magnetic force can PULL the chip. Place the wand at different measurements along the ruler with each trial.

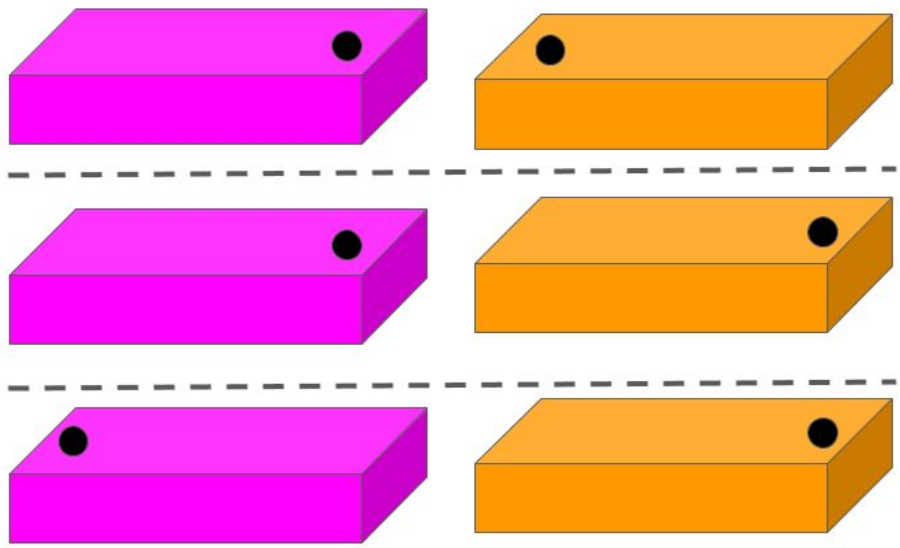
Station 2: Floating Magnets
Supplies: floating magnet stand, 4 ring magnets

Directions: Stack the magnets into different color arrangements. Observe the behaviors. Flip some magnets over and replace on the stand. How does the behavior of the magnets change?



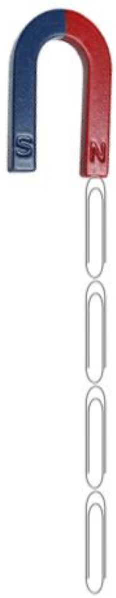
Station 3: Attraction or Repulsion
Supplies: 2 Rectangular Magnets (Decide if the dot is the North end of each magnet or South)

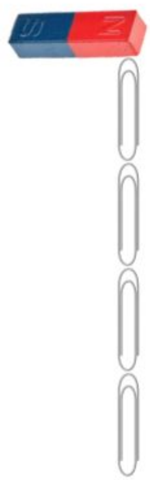
Directions: Place the magnets in the different orientations seen below and record your observations.



Station 4: Strength
Supplies: Horseshoe Magnet, rectangular magnet, round magnet, handle magnet, box of paperclips

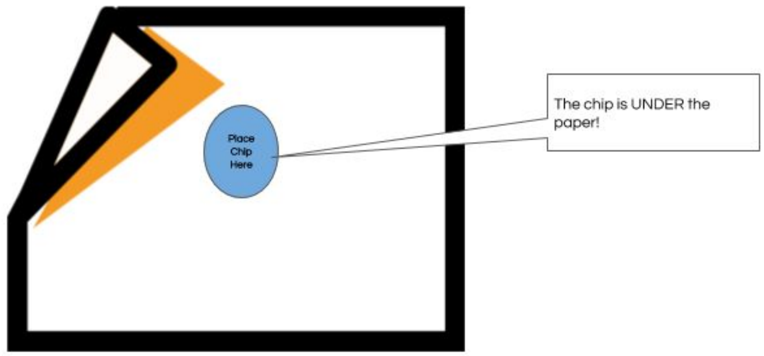
Directions: Hold your magnet high above the placemat. Make a paperclip chain from the bottom of the magnet. How many paperclips can you add to the chain before they fall off the magnet?





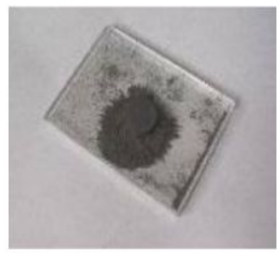

Station 5: Blocking a Magnetic Force
Supplies: Mag-wand, magnetic chip (1), 5 sheets of paper, cardboard, styrofoam plate,

Directions: Place the chip on the placemat, cover the chip with a piece of paper, hold the wand above the chip and paper. Does the chip attract to the wand? Can you lift the piece of paper up? Repeat with more sheets of paper, styrofoam plate, and cardboard. Did any of the materials block the magnetic force?



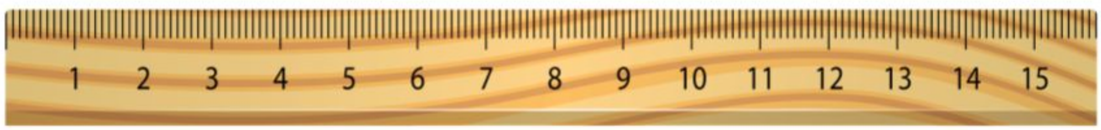
Station 6: Iron Filings
Supplies:: magnets, containers of iron filings

Directions: Place the magnet under the container of filings. Observe how the filings line up around the poles of the magnet.



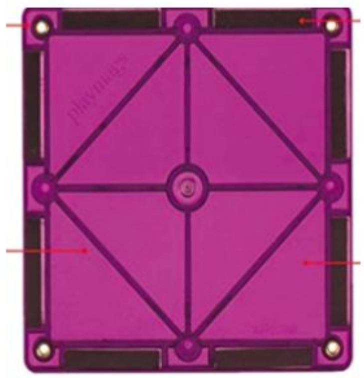
Station 7: Car Magnets
Supplies: car magnets, rulers, magnets of different forces

Directions: Place the car at the end of the ruler. Use the magnet to investigate how far the magnetic force can PULL the car. Place the magnet at different measurements along the ruler with each trial.



Station 8: Building with Magnets
Supplies: variety of magnetic blocks

Directions: Use magnetic blocks to build 3-D structures.



LESSON 1 Day 5

Time: 45 minutes

MATERIALS NEEDED:
- Magnetic slime
- Magnets
- Journals

Have magnetic slime available and allow the students to interact with the slime and the magnets. Ask the students to model (draw) the slime (in their journal) before the magnets are near and again when the magnets are close to show how the slime changes when the magnet is near. Ask students to add zoom out boxes to describe what is happening.

*At this point, students should understand that magnetic force is a push and a pull.

LESSON 1 Day 6

Questions about Magnets

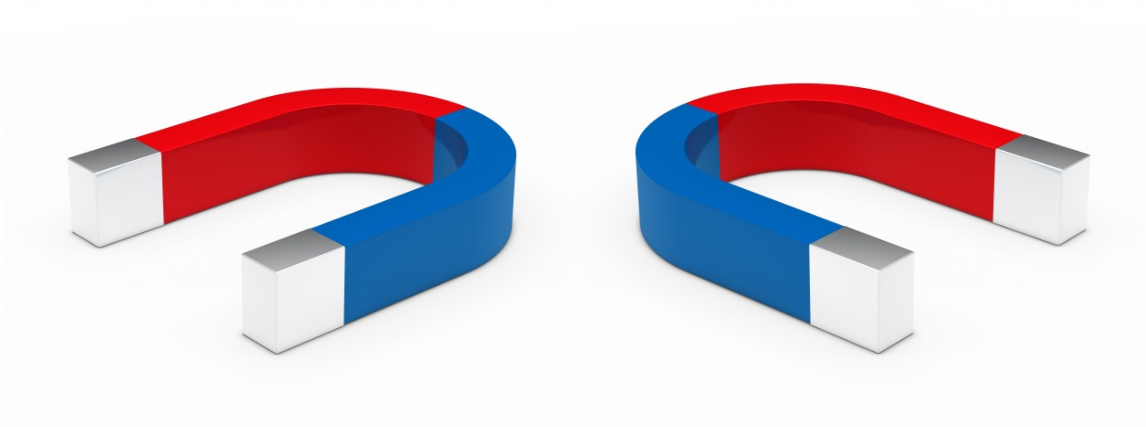


photo created by d3images - www.freepik.com

Billy has 2 magnets. They are the same shape, size and weight. He's wondering if one of them is stronger than the other.

What questions could Billy ask to help figure out if one of them is stronger? Write at least two questions that could be answered with investigations.

1. ____

____

____

2. ____

____

____

LESSON 2 Day 1

Time: 1-hour block

ANCHORING PHENOMENON 2:
Observing the interaction between a PVC pipe and a soda can, students will generate driving questions based on their observations.

Questions may include:

1. How does the can move without contact?
2. Why does the can move slow? Why does it move fast?
3. How can I change the direction/ speed the can is going?

TEACHER DEMONSTRATION:

1. Grab an empty soft drink can and a short piece of PVC pipe

2. Rub the PVC pipe on a woolen jumper or, if your hair is clean and dry, rub it on your head (it won't work if your hair is wet or if you've used a styling product).

3. Bring the PVC pipe near your soft drink can but without actually touching it, and the can will start rolling towards your wand.

4. Move the pipe to the opposite side of the can and it will slow to a halt before giving chase again in the opposite direction.

While the teacher is demonstrating the phenomenon:

1. Students observe and fill out their "I notice, I wonder" sheets in their journals.
2. Students then create individual drawn models of the phenomena and share in their groups, looking at similarities and differences.
3. Students share their models whole group. Allow students to share under the doc camera if possible. As a whole group, look for similarities and differences among the models.
4. On chart paper, the teacher, along with the students, creates a whole group consensus model of the phenomenon. The whole group consensus model should show how the can moves.
5. On a separate chart paper, make a list of related phenomena.

6. Create a driving question board (DQB). Each student should write at least one question on a sticky note that they want answered from this phenomenon. (These questions should come from what the students wondered about in their journals.) Teacher might need to prompt, referring back to the phenomenon. Connect noticings to wonderings, asking how and why questions. Students put questions up onto chart paper. Read them aloud with class, then sort questions into categories of similarities. Give groups of questions headings.
7. Ask students ideas for investigations based on their wonderings. Teacher may need to lead students to investigations that will be planned.

Lesson 2 Day 2

Time-1 hour block

Students start by exploring the centers to develop a working definition of static electricity.
Students will identify how strength, distance, and orientation of the charge impacts the force it exerts on another object.

MATERIALS NEEDED:

- Static Centers – 2 PVC pipes, 2 soda cans, 6 Styrofoam plates, 8 cloths, 4 balloons, 2 plastic bags, and several tiny paper pieces.
- Students can keep track of observations on their *I notice, I wonder* journal sheet.

When centers are completed:

Provide a forum for students to share their *I notice, and I wonder* responses for each station. You can record student findings on an anchor chart, or you can present the station placemats one by one and discuss student ideas and questions. As students share what they noticed help students to use the appropriate vocabulary. By allowing students to explore the centers prior to this discussion students can use their experience to understand/describe static electricity.

Refer back to the DQB. What questions have been answered? Move those to the side. Additionally, refer back to student ideas for investigations.

Station 1- The No Hands Can Race

Materials: 1 pipe and 1 soda can per pair of students
Directions: Lay the can parallel to the starting line. Rub the PVC pipe on your cloth. Hold your pipe close to the can without touching it. Observe what the can does. Now, line your cans back at the starting line and have a can race! The first person to cross the finish line without having touched the can wins!

Station 2- Hover Plates

Materials: 2 Styrofoam plates and 1 cloth per pair of students

Directions: Take 2 Styrofoam plates. Turn them upside down. Rub the bottom of each plate with the cloth. Turn one plate over and try to stack them on top of each other.

Station 3- Dancing Bag

Materials: 1 balloon, 1 cloth, and 1 bag per group of students
Directions: Rub the cloth over the balloon for 30-45 seconds. Rub the towel on the bag for 30-45 seconds. Hold the bag over the balloon.

Station 4- Paper Attraction

Materials: 1 balloon, 1 cloth, paper bits per group of students
Directions: Rub a balloon for 30-45 seconds with the cloth. Bring it close to the bits of paper on the tray. Observe what happens.

Lesson 2 Day 3

Time: 1-hour block

- Referring back to the magnetic and static centers, ask students to find similarities and differences between static and magnetic force.

- Allow for discussion in their small groups, referring back to their journals. Students should look for patterns and be using evidence to support their thinking.

- As a whole group, complete the Venn Diagram in the students' journals. Encourage the use of the following sentence starters:

- One pattern I observe is…
- Based on the pattern I observe, I can conclude…
- I would group ______________ and ______________ together because…
- One similarity I observe between ______________ and ______________ is…
- One difference I observe between ______________ and ______________ is…

Lesson 3 Day 1

Time: 1 hour

MATERIALS NEEDED: kickballs, student journals

ANCHORING PHENOMENON 3:

Description: This must occur outdoors or in a gymnasium.

- Prompt student thinking while holding a kickball: “How do I kick a ball to make it remain on the ground while it travels? How do I kick the ball differently so that the ball travels through the air? “
- Provide time for students to explore kicking differences to achieve both scenarios. Student groups should kick the ball 6 times and record (in their journals) where their foot hit the ball and how the ball traveled across the gym/school yard. Each student in the group will have a different job (1) recorder, (2) kick position identifier -where did the kicker make contact with the ball? (3) kicker, (4) ball retriever.
- To make sure students do not get hit by the ball, I would schedule kick times and ball retrieval times. In terms of time, you can provide students 20 minutes for the exploration-3+minutes per test. In that 3 minutes students can discuss their kick approach and execute the kick. Send all students to retrieve their groups balls at the same time, so no one is in the “firing zone”
- Allow students to compare their observations with their classmates. You could post all observations sheets and students could gallery walk and look for patterns in the data (For example pattern-if ball was hit on underside, it tended to arc; if the ball was hit on the side it traveled flat).
- Ask students to identify the forces acting on the balls that traveled flat. Then ask the students how the forces acting on the arced ball were different. You can collectively add key terms to each of the models to help students visualize the differences.
- A model template is provided in the students’ journal. You can present it and have students explain and label the difference forces acting on each.

Lesson 3 Day 2

Time: 1 hour

MATERIALS NEEDED: paper footballs, student journals

Activity Description: Paper football investigation and explanations.

- Students must construct a paper football (or you can have several ready to go). Review the previous lesson's discussion in which the students were asked to identify the differences in forces present on each of the ball trajectories. Ask students to further explore how a change in force strength and force direction could impact a paper football's path and distance.
- Allow the students time to flick the paper footballs 6 times. Students can record their observations on the observation sheet in their journals. Prompt students to make observations in terms of force strength and force direction.
- After sufficient time exploring the paper footballs, refer to journal. There is a model template to look at. Ask the students to make observations of the two finger flicks and predict which flick is more likely to end in a field goal. Encourage the students to make an evidence-based claim about which flick will end in a field goal (cause and effect). Use the following sentence starters:

- I think that ______________ caused ______________ because**...**
- The relationship between ______________ and ______________ is**...**
- I think ______________ and ______________ affect each other over time by**...**
- If we were to change ______________, I predict that**...**

Lesson 4 Day 1

Time: 1 hour

MATERIALS NEEDED: rulers, straws, feathers, paper towel pieces (3x3), wooden blocks, mass pieces, toy cars, student journals

Activity Description:

- “Can You Move It?” challenge- Let students know that they have a challenge that they need to solve. The challenge is to move all of the objects ONLY 2 inches using wind as the force. Tell students, “Engineers plan a solution (design) to a problem, test their designs, figure out what parts worked and what parts did not work, improve their design, and then re-test. Engineers continue this process until they get the results they want.”
- Provide students with a milkshake drinking straw. Let students know that they will have to incorporate force of air in their design solution. Prompt students to blow through their straws and feel the force that comes out the end. Ask students to think about the ways they can change the amount of force that comes out of the straw. Allow students in their cooperative groups some time to discuss and plan options for changing the amount of force. Some of the ideas should include:
  - ❏ blow softly on an object (weak force)
  - ❏ hard blow on an object (strong force)
  - ❏ if students all blow hard on the same object at the same time (stronger force)
- Provide a forum for students to share their ideas before showing them the variety of objects they will need to move with their straws. HAVE STUDENTS PUT STRAWS AWAY ...NO STRAWS FOR NEXT PORTION OF INVESTIGATION. Students can label their straws with tape and you can collect them if need be.
- Allow students time to explore the different objects they will need to move 2 inches with their straws: feather, paper towel (cut to 3X3), small wooden block, mass piece, and toy car. Prompt students to think about how they will get their object to travel ONLY 2 inches. Have students fill out their planning sheet in their journals, identifying the properties of the objects.
- Students will compare and contrast the properties of each object and how the property affects movement
  - Students will predict how close they would have to be to each object in order to get it to move 2” by blowing on it with a straw

- Once students have completed their planning, remind the students that good engineers keep their investigations controlled. That means they have to always place the straw in the same place and decide the difference between a strong blow and a week blow/puff. Allow students to work together to decide where they will place their straws and what will determine a strong or weak blow. If multiple students are placing straws at the same time to achieve a greater force, they should also think about where the all the straws will go. Remind students that they are to use only their straw in this investigation and that it is not healthy to share straws or blow air on others.
- Allow the students to collect and record data and observations. If the student group achieved the challenge for a specific object, they do NOT need to complete a second, third or fourth trial.
- Provide a forum for students to share their observations of the results of the five objects .
    - Which objects were they able to get to two inches successfully?
    - Which object were they unsuccessful with? What happened so that the object didn't meet the challenge? How might you change your approach in the future?
    - What properties of the object were important in deciding the amount of force needed to move the object only two inches?
    - How does air through a straw provide a force? How can you control that force?
    - Why don't all objects require the same amount of force to move the 2 inches?
- During the discussion and students sharing session, help students to develop their academic vocabulary and begin to understand the ideas that not all forces are visible (i.e. we could not see the air pushing (acting on the object), but its motion indicated that the force was present). Represent the students' findings on chart paper.

Lesson 4 Day 2

Time: 1 hour

MATERIALS NEEDED: Picture of Kicker

- Show the students the image and ask them "What's wrong with this image?"
- Allow the students to share their ideas with a partner.
- After a few minutes, have students share their ideas with the class. Ask students to provide a rationale for their ideas. A scientist doesn't just share their prediction, but they also share their reasoning. That reasoning then becomes something the scientist can investigate further. Do not provide students with any feedback about their ideas at this point in the learning.
- Introduce the driving question, "How does the direction of a force affect motion?"
- Tell the students that they will test various ways to push/pull to observe direction of movement

"Push Me-Pull You" experiment

- Students press their hands together (as if in prayer) and PUSH left. Observe the direction in which your hands move.
- Return to center and PUSH right. Observe the direction in which your hands move.
- Return to center and push equally hard in BOTH directions. Observe the direction in which your hands move.

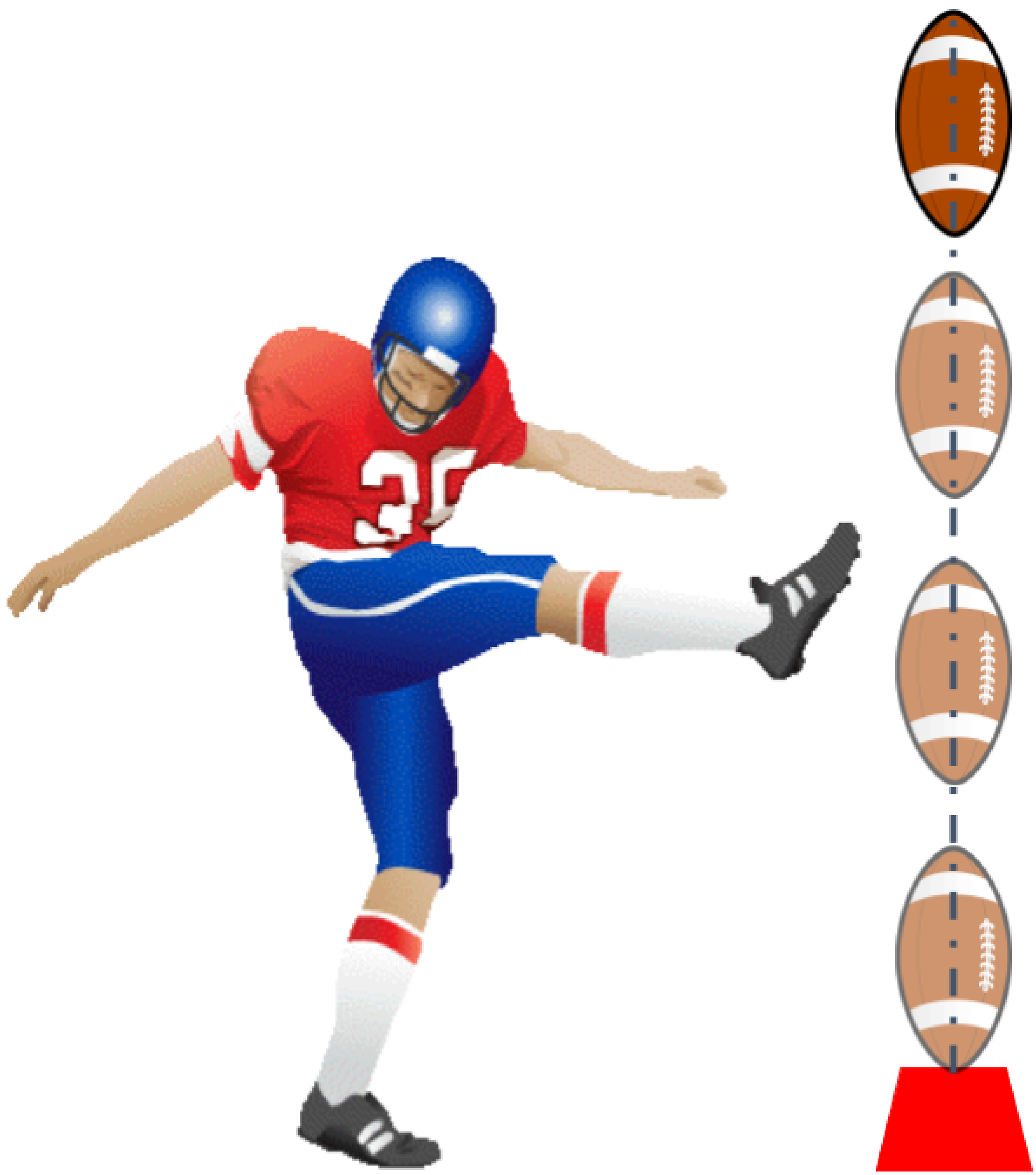
- Now, have students hook their hands together (fingers linked to fingers) and PULL their hands left. Observe the direction in which your hands move. Return to center and PULL right. Observe the direction in which your hands move. Return to center and pull equally hard in BOTH directions. Observe the direction in which your hands move.

- Teacher will intermittently ask: What did you notice? What should happen in the football picture based on your exploration? Again, allow students to share ideas without providing immediate corrective feedback

- Provide time for students to create an explanatory model in their jornals that describes the football kicker picture. Instruct students to include force strength and force direction in their models.

- After students complete their models, the teacher facilitates class discussion to consolidate student's ideas. As students share, help students to use appropriate vocabulary.
- By the end of the discussions and model sharing, the class should come to the conclusion that the direction of the force (push or pull) affects the movement of the object. The direction a force PUSHES is the direction the object moves. The direction a force PULLS is the direction the object moves.
    - Some students may observe that when they BOTH pulled and pushed at the same time, their hands didn't move. This is a great time to introduce that sometimes objects have multiple forces acting on them (a push and a pull at the same time). When an object has multiple forces acting on it, the strongest force will move the object. If the forces are the same strength (balanced forces) and in the opposite directions - there is NO movement.

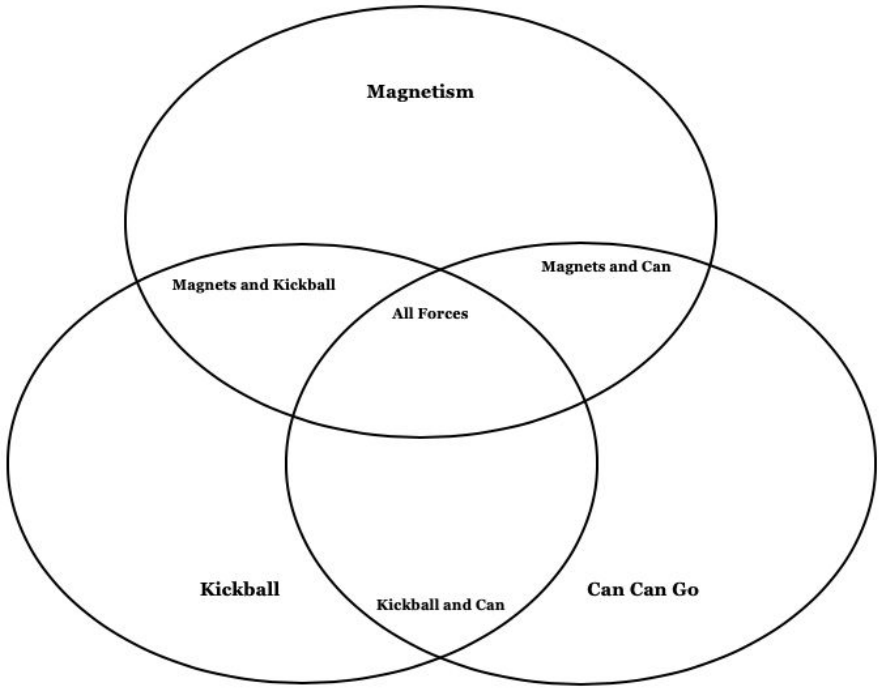
What’s wrong with this picture?



Lesson 4 Day 3

Time: 45 minutes

- Students need to expand their observations from the investigation to the anchoring phenomenon events. Provide time for students to work together to add to their journals. They are working to answer the question, “What new information can we use as evidence for explaining the cases of motion?
- You may need to review each anchoring phenomenon.
- Students will easily identify force strength in the football/kickball, but they may have a more difficult time identifying the forces in the static and magnetic scenarios. Help students to understand that we can see some forces, but others are unobservable. We only know they exist because of our observations.
- Work together to fill out the 3 circle Venn diagram. Be sure you have enlarged the diagram onto an 11” x 17” paper.
- Students are providing a working definition of force. They may do this with pictures and words.



Expand onto 11" x 17" paper

Lesson 5

Assessment

Magnetism Design Challenge-

Students will identify a simple design problem that can be solved by applying scientific ideas about magnets to develop or improve an existing object or tool. Students brainstorm with partners and share with the whole group. Allow students to walk around the classroom or school during this process.

Have student groups present at least three different ideas to the whole group. Record all of the student ideas on chart paper. Allow the students to choose one of the ideas you charted, it does not have to be their initial idea.

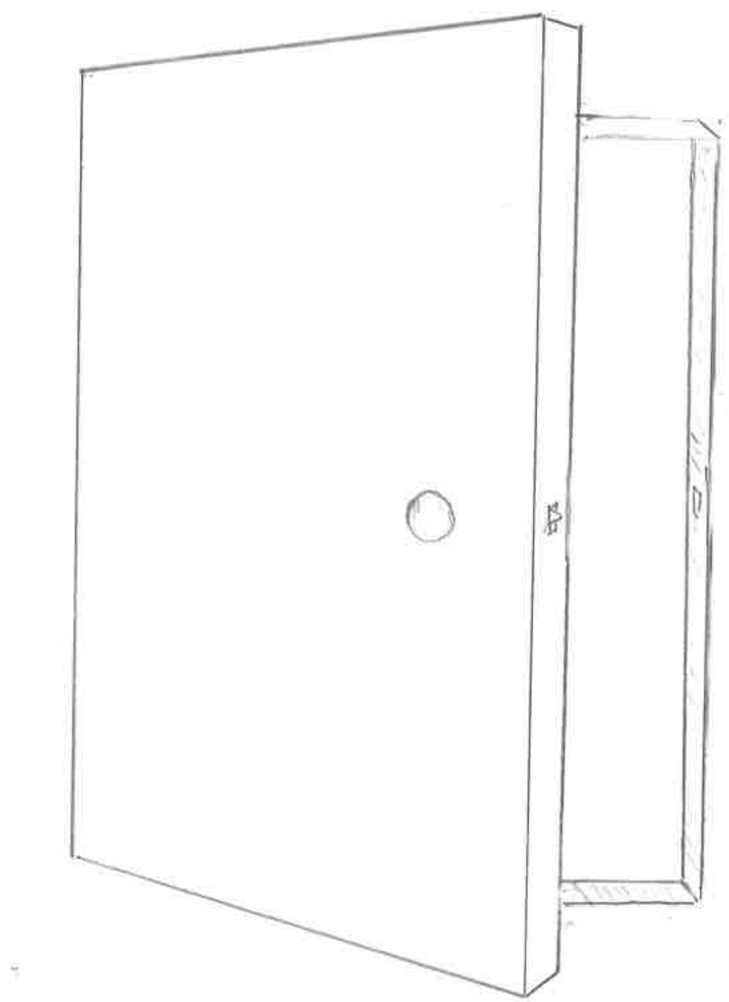
- In student journals, students will define the problem they intended to solve with magnets and then construct a model that demonstrates the solution. The model must include labels and explanations of how the device will work and solve the problem using the properties of magnets.
- After the students have devised their drafts, have them gallery walk and provide feedback to other students. Feedback can include recommendations, compliments and questions.
- Allow students to review their feedback and modify models.

Grade 3: Forces and Magnets

Mrs. O'Neil's classroom door sometimes slams shut. The door slam makes her jump and some of her students have complained about the loud noise.

Mrs. O'Neil is hoping that her students might help her by using what they've learned about magnets to help fix the problem.

Your challenge is to design a solution to Mrs. O'Neil's problem or a different problem that you know about. You can use the drawing below or your own drawing to show how your solution works. Please write about your solution to make sure that Mrs. O'Neil understands how your solution will work.



Define the problem you will solve using magnets:

How Does Your Solution Work?