Name: **Date:** **Class:**

Magnets and Magnetic Fields Worksheet Answer Key

Station 1: Parts 1a and 1b: Visualizing Magnetic Fields

Part 1a: Demonstrator guidance/teacher answer key:

- Magnetic field lines are closer together near the magnet and spread farther apart as you move away.
  - The ferrofluid's spikes are tightly packed when the magnet is close and more spread out when the magnet is farther away.
  - The fact that the spikes are larger when farther away from the magnet doesn't mean anything special; there are just fewer spikes, so there is more ferrofluid per spike available.
- Field lines curve smoothly from one pole to the other, bulging outward in the middle.
  - The ferrofluid forms a smooth, round blob that matches the shape of the magnetic field lines.
- You can show that a stronger magnet makes the magnetic field bigger and stronger by stacking several small magnets, which lets the ferrofluid react from farther away and form sharper, stronger shapes.
- Magnetic field pictures and ferrofluid spikes can make it look like magnetic fields are made of separate lines, but they aren't. Magnetic fields are smooth and continuous. The spikes are closer together where the magnetic field is stronger (e.g., near the poles.) The lines and spikes help us see the field, but the field itself is continuous.
  - Drawn lines on paper are a way to show the direction and shape of the field, like lines on a map.
  - Ferrofluid makes spikes because tiny particles line up and stick together in a magnetic field.

Part 1b: Demonstrator guidance/teacher answer key:

- If the field papers show a direction, you can explain that both magnetic fields point in the same direction, so they combine and strengthen each other.
  - Placing opposite magnet poles on each side of the bottle and moving them closer or farther makes the ferrofluid spikes stretch and jump between sides.
  - Watching the fluid move from one side to the other is impressive and enjoyable to see.
  - With careful control, the ferrofluid can form continuous lines connecting both sides of the container. It is much easier to form continuous strings of fluid connecting both magnets if the magnets are strong (e.g., using strong magnets or stacking several weak magnets).
- Same-magnetic poles repel each other, pushing each other's field lines away from each other.
  - If the field papers show direction, you can explain that the magnetic fields point in opposite directions, so they interfere and push each other apart.
  - If you put the same magnet poles on either side of the fluid jar, and are careful with distances, you can see ferrofluid spikes flatten out and get as far from the opposite side as possible. It is much easier to see the spikes flatten out when the magnets are strong, either by using strong magnets or by stacking several weak magnets together.
- When you move the magnets back and forth, the ferrofluid won't jump between sides and tends to stay separated. If the magnets are far apart, small bits can slip along the bottom, showing the repulsion is strongest near the center.

(optional) Station 1: Part 1c: Free exploration without adult guidance

Part 1c: Demonstrator guidance/teacher answer key:

Let students freely experiment with magnets and ferrofluid, and have them draw their own magnetic field shape diagrams based on what they observe.

- Skip Activities 1a and 1b and do not provide magnetic field line images at the start. Instead, allow students to experiment independently and draw their own magnetic field diagrams based on what they observe.
  - Students can explore magnetic fields using both a single magnet and multiple magnets, creating several diagrams that represent different magnetic field shapes and interactions.
  - After students have created their diagrams, reinforce the learning by drawing the magnetic field shapes on the board. At the end of the activity, show the official magnetic field images and explain that scientists used experiments similar to the ones the students conducted to determine the shapes and interactions of magnetic fields.
- If only a few ferrofluid bottles are available, students can work in small groups. Alternatively, you can prepare multiple CD cases with iron filings so students can work independently or in pairs.
- Use the magnetic viewing film to see magnetic fields. The film is a thin sheet filled with tiny nickel pieces that move when they are near a magnet. When the pieces line up, they make dark and light patterns. These patterns help you see the shape and direction of the magnetic field.
  - Dark areas show where the magnet's poles are.
  - Bright areas show where the magnetic field spreads out or connects between the poles.

Station 1: Part 2: Material Magnetic Interactions Experiment

Demonstrator guidance/teacher answer key:

This activity demonstrates, in a simple way, that different materials interact with magnetic fields differently. There are many possible materials, thicknesses, and variations that can be tested, each offering an opportunity to explore different and interesting effects. This activity allows for creativity and experimentation beyond the examples provided.

- Non-magnetic materials (paper, cardboard, plastic, concrete, stone, aluminum):
  - No visible change occurs; the magnetic field passes through unaffected.
    - Begin with paper, cardboard, and plastic.
    - Test aluminum next to challenge the misconception that all metals block magnetic fields.
- Thin magnetic materials (thin steel or iron sheets):
  - The ferrofluid spikes sag, indicating the magnetic field is weakened but still present.
    - Follow with thin steel to show partial interaction.
- Thick magnetic materials (thick steel or ferrite):
  - The ferrofluid collapses and falls to the bottom of the bottle, showing the magnetic field is strongly redirected or blocked.
    - End with ferrite to demonstrate strong blocking of the magnetic field.
- Magnetic fields pass through most solid objects with little interaction, which is why people cannot feel magnetism with their hands. Human bodies are not made of magnetic materials like iron, cobalt, or nickel, so magnetic fields largely pass through us unnoticed.
- Some animals, however, can sense magnetic fields using tiny magnetic crystals in their bodies. For example, homing pigeons use Earth's magnetic field to help navigate.
- Although humans cannot feel magnetic fields directly, there is a very small interaction between

magnetic fields and human tissues. This interaction makes MRI machines possible. MRI uses extremely strong magnets to detect these weak interactions and create images of the inside of the body. This technology exists because scientists carefully studied how magnetic fields interact with different materials.

- Even basic experiments like this reflect the same scientific processes used by researchers to understand and apply physics in the real world.
- Engineers use this same understanding when designing devices that use magnets. By choosing materials that block, redirect, or strongly interact with magnetic fields—such as ferrites—they can design technologies that work efficiently.

Station 2: Magnetic Field Treasure Hunt
Demonstrator guidance/teacher answer key:

- Some things are magnetic, some are not.
- Not all metals are magnetic. Only iron, cobalt, and nickel (and a few rare-earth metals) are magnetic.
- We can't feel magnetism with our hands, because human bodies are non-magnetic.
- Different materials have different properties, and those properties can be identified in different ways. Some properties are visible (such as color or size), while others cannot be seen and require tools or tests to detect, such as comparing weight, using a magnet, or feeling for temperature differences.
- Scientists and researchers spend their lives discovering how the world around them works, including things like magnetic properties.

Station 3: Magnetic Field Strength Curling Game
Demonstrator guidance/teacher answer key:

- The closer the small disks are to the launcher magnet when they are released, the greater the repelling magnetic force. This causes the disks to move faster and travel farther across the playing field.
- Magnetic fields are strongest near their source—in other words, the closer you are to a magnet, the stronger its magnetic field.
- For older students, you can introduce the idea that magnetic fields follow an inverse-square relationship, meaning the field strength decreases rapidly as distance increases. For example, the magnetic field is four times weaker when you move twice as far away from a magnet source. This same relationship applies to other phenomena such as light, sound, gravity, and heat.
  - This game demonstrates an important and interesting principle of physics: Intensity increases as one gets closer to the source, and quickly disperses farther away from a source.
  - The inverse-square relationship (or the fact that magnets are strongest near their poles) can also be demonstrated by trying to bring opposite poles of moderately strong magnets together. It is easy to get them very close, but surprisingly difficult to make them touch completely due to the rapidly increasing force as the distance decreases.
- Scientists have discovered and measured this property of magnetic fields and use it regularly in real-world applications. For example, electric motors and generators are designed so that their internal magnets are as close together as possible. Keeping the gaps small increases efficiency and performance. Although assembling components with such precision can be challenging, the improved efficiency makes it worthwhile.

Station 4: Magnet and Paperclip Play

Demonstrator guidance/teacher answer key:

- This activity overlaps with other magnet lessons but emphasizes the importance of play and free exploration as a way to learn.
- Different magnets have different strengths and abilities to interact with magnetic materials, such as how a strong magnet can lift more paper clips, or how the magnets have a stronger attraction and repulsion to each other.
- Magnetic fields can temporarily turn some materials into magnets. When a magnet touches a paperclip, the paperclip becomes a temporary magnet and can attract additional paperclips, forming a chain that extends the magnetic effect beyond the magnet itself.
- This activity can introduce how magnets work at a deeper level. In magnetic materials such as iron, cobalt, and nickel, atoms can align with a magnet's field, causing the material to behave like a magnet. Repeated contact or rubbing can align the atoms more strongly, sometimes making the material permanently magnetized.
- Magnets have two poles, and opposite poles attract while like poles repel. Magnetic field strength increases as you get closer to the magnet, which can be observed when magnets attract or repel objects more strongly at short distances.
- Care should be taken not to leave magnets attached to paperclips for long periods, as this can magnetize them unintentionally. Magnets should also be handled carefully, especially with younger students, as snapping magnets together can cause them to chip or break.