resource area For teaching

Topics Magnetism, Energy, Momentum, Coordinates

Materials

- ✓ CD holder/spindle
- ✓ Foam block or equivalent platform
- ✓ Magnet sheet
- ✓ Straw, regular size
- ✓ Binder clip, medium
- ✓ Wooden stir stick
- ✓ Paper clips, medium
- ✓ Pill magnets, 3/8" diameter
- ✓ Scissors
- ✓ Clear tape
- ✓ Printed grids, pg. 3

Learning Standards

NGSS: Physical Science, Forces & Motion, Magnetic interactions, Fields; Engineering, Comparing and Testing Design Solutions

Magnetic Perturbations

Create Endless Variations of "Perturbed" Motion!



Explore the interactions of magnetic fields as a swinging magnet weaves an intricate path influenced by the variable placement of other magnets on a coordinate grid.

To Do and Notice

- 1. <u>Base Platform:</u> Cut the magnet sheet so that it fits atop the foam block but leave 1" uncovered.(see image below, left).
- 2. Poke a hole with a pen/pencil through the foam in the uncovered 1" wide space, centered. Insert the post of the CD holder/spindle through the hole until the foam rests on the circular base of the CD spindle (below, right).





- 3. Cut out the paper grids from page 3 of this project guide. Choose one and tape it onto the magnet sheet as shown at the top of this page.
- 4. <u>Swinging Arm Assembly:</u> Cut the straw in half. Insert the top of the game pawn into one straw half. It should be held firmly in place. Use tape if needed (see below).
- 5. Attach a pill magnet to the bottom of the game pawn and secure with tape.



- 6. Insert the wide loop of a paper clip partway into the opposite end of the straw with the pawn (see below).
- 7. Slip a different paper clip onto the end of the wood coffee stick. Attach the straw with game pawn onto the stir stick as shown. It should freely dangle.



- 8. Attach the swinging arm to the base platform using a binder clip around the post and coffee stick, as shown. Angle the arm so the swinging magnet is about 1" above the platform.
- 9. <u>Magnetic Explorations</u>: Bring a separate pill magnet near the one on the swinging arm. Turn the magnet until the two magnets repel each other. Keep the pill magnet's orientation and place it on the grid.
- 10. Position additional pill magnets in a similar manner but in different places. You may need to space them apart, so they don't attract or move one another.
- 11. Move the swinging arm a few inches outward from the center and release it. Observe the path that the swinging magnet arm sweeps out as it moves.
- 12. Move the magnets around to different places on the grid and repeat.
- 13. Switch the paper grid with the other grid, if possible, and repeat the exploration.
- 14. Try finding relationships between the amount of pull on the arm and/or the positions of the magnets and the swinging pattern of the magnet.
- 15. Predict how to make the arm move in certain patterns (e.g. in a "figure 8") and test your predictions.

The Science Behind the Activity

Most magnets have a pair of **magnetic poles**, the places where the magnetic attraction is the strongest, located on opposite sides of the magnet. Pill magnets usually have a pole on the top and bottom. The poles are identified as being a north or a south depending on which direction the pole faces when the magnet is suspended, and can pivot freely, from point midway between the poles. **Like poles (south – south and north – north) of two magnets will repel each other equally**. The repelling force becomes greater as the like poles of the magnets are brought closer together. **Opposite poles (south-north) of two magnets will attract each other equally**. The attraction becomes stronger as the opposite poles of the magnets are brought together.

When the swinging magnet is pivoted and raised toward the post, the magnet gains height (gravitational **potential energy**). When the magnet is released, the potential energy is transformed into motion (**kinetic energy**) and a small amount of heat. As the magnet swings back upward most of the kinetic energy is transformed back into gravitational potential energy. With each back and forth (**oscillation**) conversion of potential energy and kinetic energy a small amount of energy is "lost" to the friction of the magnet and the straw moving through the air, slightly heating both. When the like (same) magnetic poles of 2 magnets approach each other the **momentum** of the motion is opposed by the force of magnetic **repulsion** of the like poles. The pivoting magnet is forced to change direction. The interplay of the gravitational and magnetic forces will cause the pivoting magnetic to move in a continually changing pattern for a relatively long time, depending on the placement of the magnets, as only a little energy is lost during each swing of the magnet.

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Polar Grid

Linear Grid

