Curriculum topics:

- Magnets
- Magnetism
- Patterns

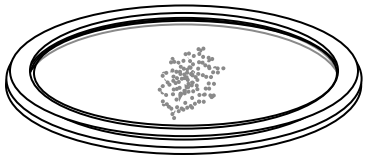
Subjects:

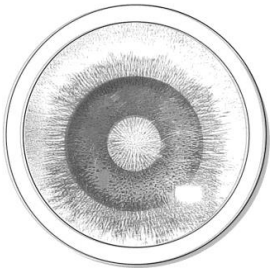
Physical Science, Earth/Space Science

Grade range: 2 – 12

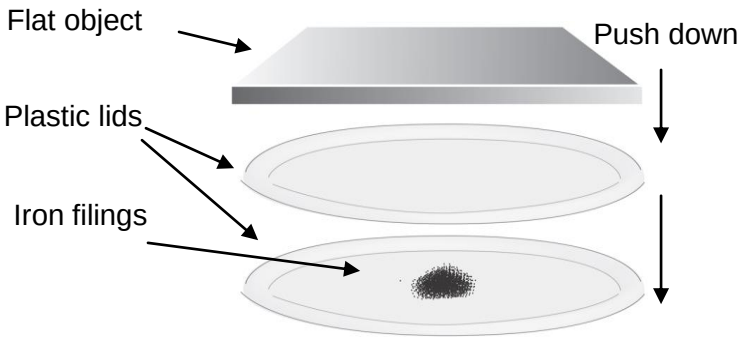
MAGNETIC FIELD LINE VIEWER

Make the invisible detectible





This easily-made device allows a magnet's unseen magnetic field to become "visible" in 3 dimensions. Iron filings are contained between a pair of clear lids joined at the rims and held apart by a trapped bubble of air. This simple tool can reveal the patterns due to invisible forces created by magnets.



Who we are:

Resource Area for Teaching (RAFT) helps educators transform the learning experience through affordable "hands-on" activities that engage students and inspire the joy and discovery of learning.

For more ideas and to see RAFT Locations

www.raft.net/visit-raft-locations

Materials required

Per Viewer:

- 2 clear, non-vented, plastic lids for beverage cups (Dart 12CL, 20CL or equal) (non-venting means the lid has no hole)
- Iron filings, the finer (smaller) the better
- Flexible refrigerator magnet, at least 2.5 x 5 cm (1" x 2")
- Donut magnet
- Optional: Paper towel
- Optional: 0.6 ml (1/8-teaspoon) measuring spoon
- Optional: Disposable dust mask
- Optional: Flat object (e.g.- book, board, or equal)
- Optional: Glue to ensure a tight seal
- Optional: Additional magnets of different shapes and types

How to build it

Teaching tip – Iron filings can be messy to clean up if spilled. Measure the iron filings over a sink, tray, waste receptacle, or surface covered with a paper towel to make clean up simpler and easier.

1 Place a clear, non-vented lid on a flat surface, topside upward. See figure 1.

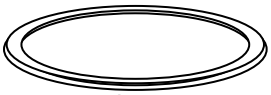


Figure 1

2 Place 0.6 ml (1/8-teaspoon) of iron filings in the center of the lid. See figure 2. Using fewer filings is better than more filings. Do not overfill - extra iron filings will cause clumping when a magnet is brought near, obscuring the patterns created by the magnetic field lines.

Figure 2

3 Place a 2nd lid over the first, topside upward, and align the rims. See figure 3.

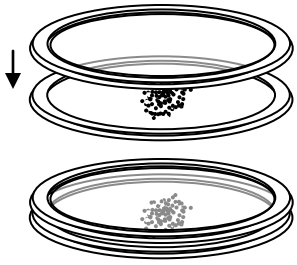


Figure 3

4 Lay a flat object such as a book or board on the top lid and push down quickly and firmly to secure the rims together. See figure 4. The goal is to trap air between the two lids to leave space for the iron filings to later create 3 dimensional patterns.

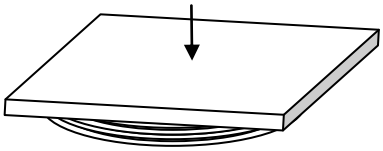


Figure 4

5 Inspect the edges of the lids. The rims of the lids should be sealed together very tightly all the way around. If they are not pressed together tightly enough, then use fingers or the flat object and press the rims more tightly together.

Teaching tip – To ensure a tight seal, some lids might need glue added to the inner groove of the rim of the 2nd lid before pressing the lids together.

To do and notice

1. Hold the viewer over a white surface, such as a paper towel. Shake the sandwiched lids to evenly distribute the enclosed iron filings.
2. Bring a donut magnet near the center of the bottom lid.
3. Tap or shake the lids to move the iron filings nearer the magnet.
4. Pull and rotate the magnet into different positions. Notice the patterns and angles formed by the iron filings and how the pattern changes when the magnet is moved.
5. Repeat with other shapes and types of magnets. Explore the magnetic fields of a flat, flexible "refrigerator" magnet by placing the viewer on the dark brown side (unprinted side) of the magnet. Pull the magnet from side to side, noticing the patterns and angles.

Note: While the plastic lids are made to be fairly durable, the plastic may crack or separate over time. The lids should be checked periodically for defects that might allow the iron filings to escape.

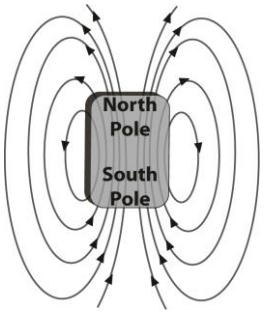
The science behind the activity

Background Information:
Scientists have observed that all material (**matter**) is a combination of 100+ basic building blocks called **elements**. Every element (such as gold) has a unique combination of properties.

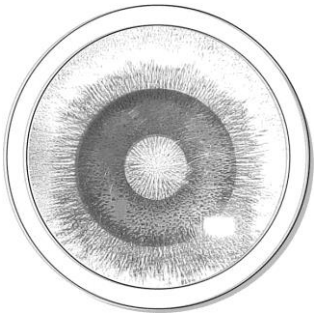
The smallest piece of an element that still possesses its properties is an **atom**. Every atom is made up of 3 types of smaller particles: **electrons** spin around a tightly-packed core (nucleus) which contains **protons** and neutrons. Two or more atoms can combine to form **molecules** - the smallest pieces of more complex types of matter.

Electrons and protons have an electrical property called **charge**. Charges can be positive (+) or negative (-). When a charged particle moves, a **magnetic field** is created around the particle. The magnetic field is conceptualized as a pattern of loops going out from the particle, looping into space, curving back to enter the particle on the opposite side. Individual loops **(magnetic field lines**) are continuous (unbroken) and do not cross. In an atom or molecule, the magnetic field lines are usually oriented in many different directions, and so there is little or no overall magnetic field. These materials are considered to be non-magnetic. Iron, nickel, cobalt, and many materials made from them are magnetic. Magnets which contain the rare earth elements neodymium or samarium have particularly strong magnetic fields.

Magnetic field lines of a bar magnet →



What are the magnetic field lines for this donut magnet? →



Key Content:
A magnetic field can pass through non-magnetic materials such as plastic. The iron filings, being a magnetic material, will become **magnetized** when a magnet is brought nearby. The iron filings nearest to the magnet will align to the magnetic field lines of the magnet. The iron filings will align to the magnetic field lines of the original magnet as much as is possible within the gap between the 2 lids. The groupings of iron filings that are most perpendicular to the magnet and most concentrated will point to one of the magnet's poles. The filings will seem to "bridge" or drape when following the magnetic field lines between the magnetic poles of one or a pair of magnets. If the iron filings are fine enough then flat, flexible refrigerator magnets will create a pattern of rows.

Curriculum Standards:

Properties of materials (Next Generation Science Standards: Grade 2, Physical Science 1-1 & 1-2; Grade 5, Physical Science 1-3)

Electric or magnetic interactions between objects not in contact with each other (Next Generation Science Standards: Grade 3, Physical Science, 2-3; Middle School, Physical Science, 2-5)

Magnets (Next Generation Science Standards: Grade 3, Physical Science, 2-4, Middle School, Physical Science, 2-3)

Science and Engineering Practices (Next Generation Science Standards Grades 2 – 12)

Additional standards at: http://www.raft.net/raft-idea?isid=203

Learn more

- Draw or create a model of the 3-D image of a magnet's magnetic field.

Related activities: See RAFT Idea Sheets:

Amazing Magnetic Worms –
http://www.raft.net/ideas/Amazing Magnetic Worms.pdf

Digging for Buried Treasure –
http://www.raft.net/ideas/Digging For Buried Treasure.pdf

Floating Compass –
http://www.raft.net/ideas/Floating Compass.pdf

Floating Garden of Magnets –
http://www.raft.net/ideas/Floating Garden of Magnets.pdf

Getting in Touch with the Unseen –
http://www.raft.net/ideas/Getting in Touch with the Unseen.pdf

Magnetic Exploration File Pile –
http://www.raft.net/ideas/Magnetic Exploration File Pile.pdf

Magnetic Explorer –
http://www.raft.net/ideas/Magnetic Explorer.pdf

Magnetic Maze –
http://www.raft.net/ideas/Magnetic Maze.pdf

Magnetic Perturbations –
http://www.raft.net/ideas/Magnetic Perturbations.pdf

Mini Magnet Wands –
http://www.raft.net/ideas/Mini Magnet Wands.pdf

Where is the Magnet? –
http://www.raft.net/ideas/Where is the Magnet.pdf

Resources

Visit www.raft.net/raft-idea?isid=203 for "how-to" video demos & more ideas!
See these websites for more information on the following topics:

- **Bar/solenoid** – http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/elemag.html#c2
- **Below are simulations of the iron filing patterns around and between bar magnets** –
  http://micro.magnet.fsu.edu/electromag/java/magneticlines/index.html
  http://micro.magnet.fsu.edu/electromag/java/magneticlines2/
- **Videos on Electricity and Magnetism from the Khan Academy –**
  https://www.khanacademy.org/science/physics/electricity-and-magnetism