Iron Filings and Magnetic Field Lines

Middle School Grades

Lesson Summary
Students use iron filings to observe the 2 and 3-D field lines around a magnet.

Prior Knowledge & Skills
Completed the lesson:
- *The Earth as a Magnet: Exploring Interactions in Geospace*

AAAS Science Benchmarks
The Nature of Science
Scientific Inquiry
The Physical Setting
Forces of Nature

NSES Science Standards
Science as Inquiry
Abilities to do Scientific Inquiry
Understandings of Scientific Inquiry
Physical Science
Motions and Forces
History and Nature of Science
Science as a Human Endeavor

Teaching Time: One 25-minute period

Materials (for each 3D visualizer)
- Clear plastic container
- Bar or cow magnet, 100 mm x 7 mm
- Sheet of paper
- 2 oz of iron filings

Advanced Planning
Preparation Time: 10 minutes
1. Review the instructions
2. Gather the necessary supplies.
3. Group students into pairs or teams.

Exploring Magnetism, pp. 14-21, UC Berkeley (2004)
http://cse.ssl.berkeley.edu/impact/magnetism/flash/mag_flash.html

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Activity 2: Iron Filings and (2-3D) Magnetic Field Lines- back to top -

[These activities are optional or they can be demonstrated in front of the class by the teacher instead of done by the students. If done as a demonstration, the iron filings should be sprinkled on a transparency that lays on top of the magnet(s) on an overhead projector.]

!! WARNING !! Iron filings are messy and will stick to magnets. It is important to have paper or transparencies between the filings and the magnets.

1. Give groups of 2-4 students iron filings and several thin sheets of paper. Have the students place the paper on top of one of their bar magnets, trace the outline of the bar magnet and mark which end is North and which is South. Lightly sprinkle the iron filings uniformly over the paper and then give the paper some gentle taps to make the filings align with the magnetic field, as shown in the photographs in Figure 1.3.

2. Have the students record their observations on Worksheet 1.3. Ask some probing questions to get the students to think about what they are seeing. Can they explain what is happening? Have them form some ideas (hypotheses) about what could be the explanation for what they observe. Do they see the same shape as they did with their compass tracings on paper around the bar magnets? The students should write down their answers to the questions on Worksheet 1.3. If you haven't already discussed how the filings act like tiny magnets, maybe now some students will be able to deduce this fact.

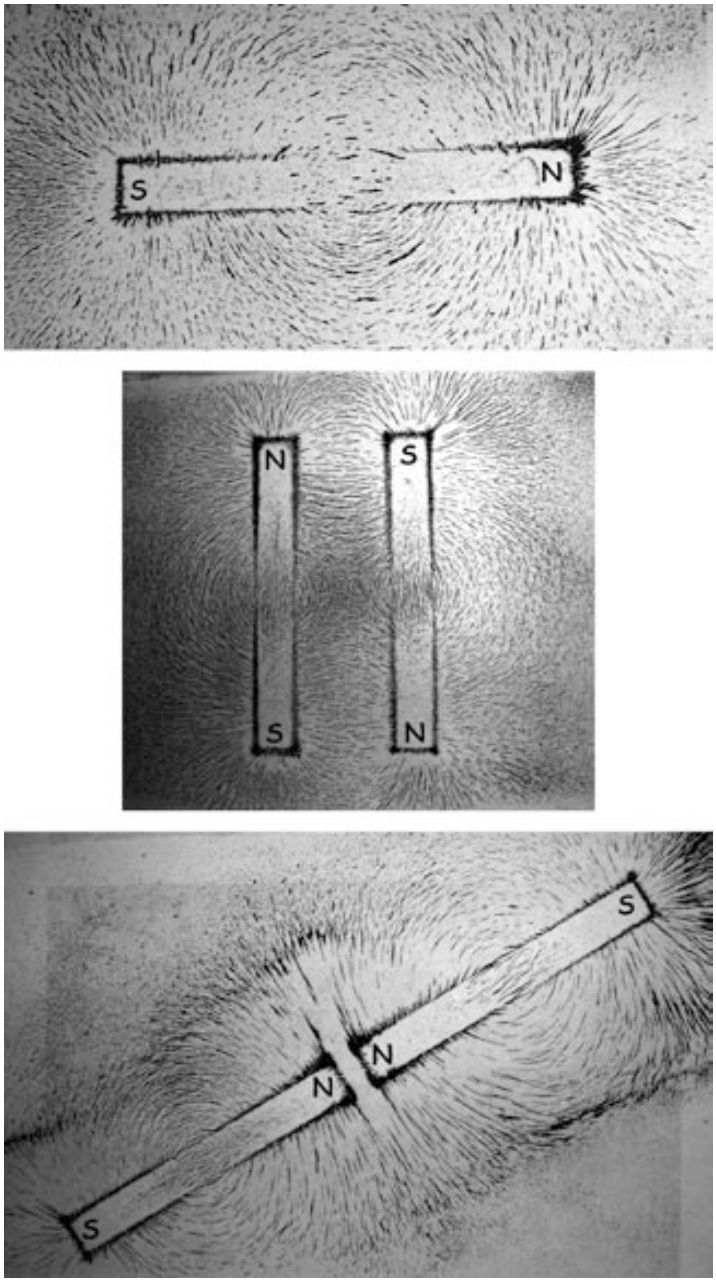

Figure 1.3 Iron filings on thin sheets of paper over bar magnets.

3. Lift up the paper carefully so as to not spill any of the filings, and funnel them back into your filings jar. Have the students place two magnets in some configuration of their choosing. On Worksheet 1.3, have students record a drawing of what they hypothesize the magnetic field will look like, then place the paper on top of the magnets and sprinkle some iron filings over it, tapping gently the paper to get the filings to align with the magnetic field. Now what do they see? Make sure they record their observations carefully by making drawings of their results and compare them to their predictions

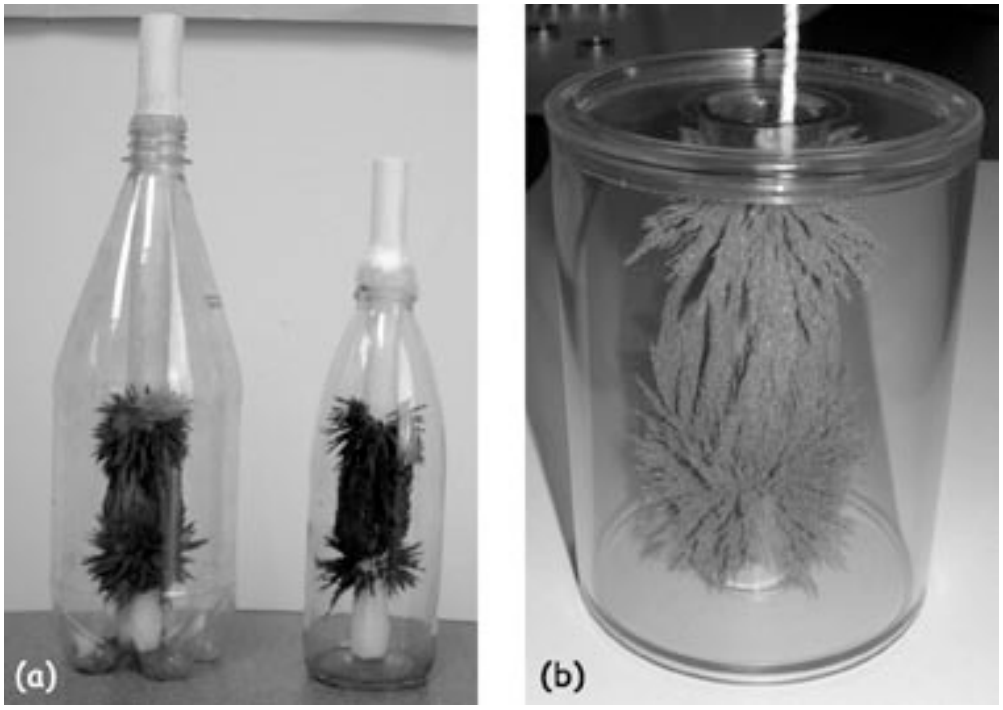

Figure 1.4 Visualizing the 3D magnetic field around a cow magnet using a 3D magnetic field visualizer made with simple materials (a), and purchased commercially (b).

4. For this step the teacher may simply do a demonstration for the class, or if you have enough materials, each group could build a 3-Dimensional (3-D) magnetic field visualizer. As the name suggests, you will construct (or buy if you have the funds) a device to visualize the 3-D structure of a magnetic field around a cow magnet.

5. To construct your visualizer obtain a clear plastic or glass bottle, small/medium sized (i.e. a 20 oz. soda or water bottle). Clear away any labels on the bottle.

    - Cut a manila folder so that you can roll it up tightly into a tube about the diameter of your cow magnet and a length slightly longer than your bottle. Tape the tube to keep it rolled up.

    - Seal one end of the tube with tape and stuff some paper into that end from the open end so that when you insert the cow magnet into the tube it will not go all the way to the bottom of the tube.

    - Pour some iron filings into the bottle; enough to coat the bottom with a layer ¼ inch thick should be fine.

    - Insert the tube into the bottle and use paper and tape to seal up the bottle opening around the tube.

Now, drop your cow magnet into the tube. Use a pencil to hold it in place and then shake the bottle. The iron filings will then stick to the outside of the tube and take the form of the magnetic field surrounding the magnet. Have students hypothesize the shape of the field before you actually do this.

You can remove the cow magnet by turning the bottle over and shaking it out (it will resist as the magnetic force of the filings will act to hold it in). Or you can fish it out of the tube by tying a string to a large paper clip and dropping it down into the tube and then pulling the magnet out. It's a neat effect to watch the filings be dragged up the tube until the magnet disappears and the filings drop away like dust. You can also purchase a pre-made, sealed tube with iron filings inside and a cow magnet for about $13 at most science classroom supply stores online (see resource list). For examples of the home-made tubes, see Figure 1.4a), and of a manufactured tube, see Figure 1.4b).

An optional method of viewing the 3-D field of force surrounding a magnet is to fill a bottle with mineral oil and a couple of table spoons of iron filings. Seal the bottle and shake it up. As the filings begin settling place a magnet (the stronger the better, and cow magnets are stronger than bar magnets of the same size generally) against the side of the bottle. Hold the bottle up to the light and you will see the filings moving along the magnetic lines of force. You should be able to see full loops of force from one pole to the other. If you have a horseshoe magnet (a bar magnet that has been bent into the shape of a horseshoe such that both poles are near each other) it can yield the most dramatic demonstration of the magnetic loops.

6. After completing the preceding activities the teacher should discuss with the students some of their observations, and have them explain their ideas and conclusions. Make sure to bring out the idea of like poles repelling and opposite poles attracting and that the magnetic force field has a direction. Also make note that the magnet would attract metals but not other kinds of materials. Perhaps bring out the idea that the iron filings were like tiny bar magnets that were aligning their poles with the attraction of opposite poles and repelling of like poles. Worksheets 1.1, 1.2, and 1.3 can be used as are appropriate and you can develop your own question and answers.

Worksheet 1.1

Name:_____

Date _____

1. What do you notice about the interaction of the bar magnets you were given?

2. What materials interact with the magnets and how do they interact?

   Interacts with magnets:

   Does not interact with magnets:

   What do all the materials that interact with the magnets have in common?

3. What happens when you bring a compass near a magnet? How does it depend on where you place the compass? (Use the back of this sheet if you need more space)

Worksheet 1.2

Name_____

Date:_____

Draw what you hypothesize the magnetic field will look like around a single bar magnet. Include arrows that point in the direction the compass points north (red by convention).

1. Draw how it looks from your measurements with the compass.

2. Draw what you hypothesize the magnetic field will look like around two bar magnets in a configuration (or configurations) of your choice.

3. Draw how it looks from your measurements with the compass:

Worksheet 1.3

Name: _____

Date: _____

1. What did you observe when you sprinkled the iron filings over the paper covering the bar magnet? Draw what you observed.

2. Can you explain why the iron filings behaved that way?

3. Do you see the same patterns as you did with the compass tracings?

4. Draw what you expect to see when you sprinkle iron filings over two bar magnets in a new configuration.

5. Draw what you did, in fact, see with your two magnets in the new configuration. How were your expectations the same or different?