Scope, Sequence & Coordination

A National Curriculum Development and Evaluation Project for High School Science Education

SS
&C

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Scope, Sequence & Coordination

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National Science Education Standard—Physical Science

Motions and Forces

Electricity and magnetism are two aspects of a single electromagnetic force. Moving electric charges produce magnetic forces, and moving magnets produce electric forces. These effects help students to understand electric motors and generator

Teacher Materials

Learning Sequence Item:

945

Magnetism

March 1996
Adapted by: Bill G. Aldridge, John Craven, and Charles Hunter

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Electromagnetism: Moving Charges, Magnetic Forces, and Changing Magnetic Fields. Students should observe that an unmarked bar magnet suspended at its midpoint revolves to align with an approximate north-south direction, and that this is the basis for calling a pole north (seeking). Students should observe properties of permanent magnets—they have poles, and like poles repel and unlike poles attract—and with iron filings and small compasses observe that we can visualize something called magnetic lines of force. (*Physics, A Framework for High School Science Education, p. 25.*)

Contents

This micro-unit was adapted by: **Bill G. Aldridge** (SS&C Project Director)**,**
John Craven (University of Iowa, Iowa City), and **Charles Hunter** (Yates High School, Houston).

945
Learning Sequence

Electromagnetism: Moving Charges, Magnetic Forces, and Changing Magnetic Fields. Students should observe that an unmarked bar magnet suspended at its midpoint revolves to align with an approximate north-south direction, and that this is the basis for calling a pole north (seeking). Students should observe properties of permanent magnets—they have poles, and like poles repel and unlike poles attract—and with iron filings and small compasses observe that we can visualize something called magnetic lines of force. (Physics, A Framework for High School Science Education, p. 25.)

Science as Inquiry	Science and Technology	Science in Personal and Social Perspectives	History and Nature of Science
Which Way Is North? **Activity 1** A Strange Rock **Activity 2** The Swinging Needle **Activity 3** The Floating Needle **Activity 4** Test Tube Magnet **Activity 5** Invisible Lines of Force **Activity 6** How Do Magnets Interact? **Activity 7** Magnets **Assessments 1, 2, 3** Compasses **Assessment 4**	Natural Magnets **Assessment 5**		Natural Magnets **Assessment 5** Earth's Heart Beats with a Magnetic Rhythm **Reading 1**

Suggested Sequence of Events

The inquiry activities of this micro-unit can best be accomplished in the order that they occur. If time is limited, the activities could be limited to 1, 2, 3, and 7.

Event #1

Lab Activity

1. Which Way Is North?

Event #2

Lab Activity

2. A Strange Rock

Event #3

Lab Activity

3. The Swinging Needle

Event #4

Lab Activity

4. The Floating Needle

Event #5

Lab Activity

5. Test Tube Magnet

Event #6

Lab Activity

6. Invisible Lines of Force

Event #7

Lab Activity

7. How Do Magnets Interact?

Event #5

Readings from Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives, and History and Nature of Science

Reading 1   Earth's Heart Beats with a Magnetic Rhythm

Readings can be found in the student version of this publication.

Assessment items are at the back of this volume.

Assessment Recommendations

This teacher materials packet contains a few items suggested for classroom assessment. Often, three types of items are included. Some have been tested and reviewed, but not all.

1. Multiple choice questions accompanied by short essays, called justification, that allow teachers to find out if students really understand their selections on the multiple choice.

2. Open-ended questions asking for essay reponses.

3. Suggestions for performance tasks, usually including laboratory work, questions to be answered, data to be graphed and processed, and inferences to be made. Some tasks include proposals for student design of such tasks. These may sometimes closely resemble a good laboratory task, since the best types of laboratories are assessing student skills and performance at all times. Special assessment tasks will not be needed if measures such as questions, tabulations, graphs, calculations, etc., are incorporated into regular lab activities.

Teachers are encouraged to make changes in these items to suit their own classroom situations and to develop further items of their own, hopefully finding inspiration in the models we have provided. We hope you may consider adding your best items to our pool. We also will be very pleased to hear of proposed revisions to our items when you think they are needed.

Teacher Sheet

Science as Inquiry

Which Way Is North?

Materials:

none needed for naked-eye observations

optional:

camera with time-exposure control

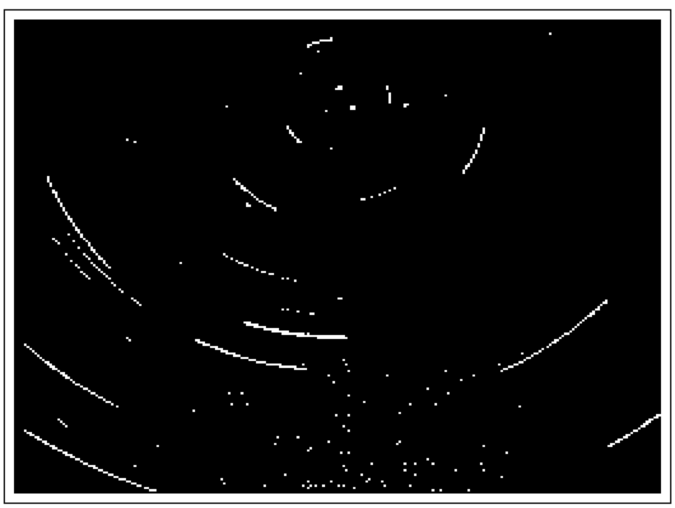
camera tripod

film (low speed)

Procedure:

This activity must be done on a clear night. On such a clear night, with the stars in view, have students set up a camera on a tripod so that they can take time-exposure pictures of the night sky. They should aim the camera in several directions and take several pictures. This should be done in a way that gives pictures of the entire night sky, straight up and toward the horizon in increments of 90 degrees. The best pictures will be roughly two-hour time exposures, so students will need the right film speed and correct aperture for the light from the stars.

For each picture taken, students should note which way the camera is facing relative to some arbitrary horizontal line. This could be expressed as a certain number of degrees from that line. If students are careful, one of their photographs of the night sky will look like that shown here.



If a student does not have access to a camera, he or she can just observe the pattern of stars in the night sky. Students can then draw their own pictures of certain patterns they see, and they can watch those patterns of stars over an hour or two.

Background:

With its background of stars, Earth's rotation appears to be with its axis pointing toward the North Star. The experience underlying this fact is ancient. People observed that the patterns of stars appeared to rotate about a point in the sky, and a star very close to that point was seen. This star, the North Star, was located by means of patterns of stars, including the Big and Little Dippers, and served for many centuries as a way of determining direction.

Obviously, in the Southern hemisphere, you cannot see the North Star. The students are being asked how they would do a similar thing in that hemisphere. You may want to discuss the Southern Cross (Crux), and how it would be used to find the direction, South, from which North could be inferred.

Science as Inquiry

A Strange Rock

Materials:

lodestones
iron filings or small paper clips
steel sewing needles

Procedure:

Students make general observations of a lodestone. They then make a small permanent magnet by stroking the needle along a pole of the lodestone. They should verify that they have created a magnet by picking up iron filings or small paper clips.

Background:

Lodestone (magnetite) is a naturally occurring magnetic material. Even though a lodestone does not have a regular shape, it does have both a north and a south pole. Students will discover the stronger regions (poles), but they will not, at this point, be called magnetic poles. Stroking the steel needle along one direction will align magnetic domains in the needle, thus creating a magnet. It is important at this point *not* to try to explain what is happening, but rather to have students make these simple observations.

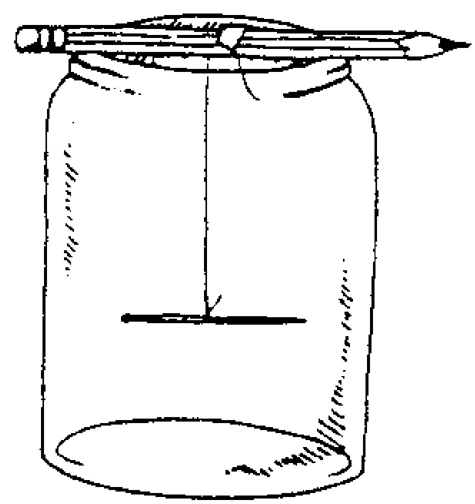
Science as Inquiry

The Swinging Needle

Materials:

a large sewing needle
bar magnet
sewing thread
glass quart jar
pencil

Procedure:



Have students magnetize a sewing needle by stroking one of the poles of a bar magnet a few times. They then tie the magnetized sewing needle to a sewing thread. They should lay a pencil across the jar opening and tape the free end of the thread to it, allowing the magnet to swing freely. They then swing the magnet gently to try to point it in a different direction.

Have students compare the direction of one end of this needle with the direction of the North Star that they found in Activity 1.

Background:

The ends of the magnet point in the directions of north and south. The glass jar protects the magnet from air currents. The north pole of such a magnet is actually defined as the north-seeking pole. The earth acts as a giant magnet, with a force field coming out of the south end and moving toward the north end, where it enters (this direction follows from our definition of magnetic north). The force field of the magnet, when it is allowed to swing freely, aligns itself with the magnetic field around the earth. The north pole of the magnet, when it is swinging freely, points approximately north. Earth's North Pole, from the standpoint of magnetism, must therefore be a south (seeking) magnetic pole.

Teacher Sheet

Science as Inquiry

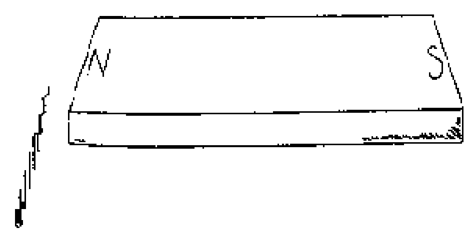
The Floating Needle

Materials:

large sewing needle
bar magnet
sponge (cube about 1/2" ∞ 1/2" ∞ 1/2")
bowl or container filled with water

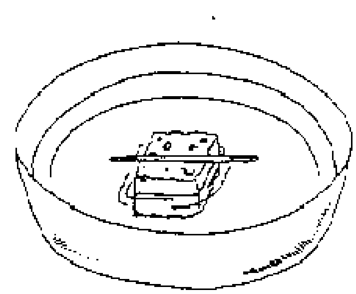
Procedure:

Have students stroke a steel needle along one end of a bar magnet several times. They then place a small block of sponge in a water-filled bowl on a nonmetallic tabletop, and not near any metal objects. They should put the needle on the sponge as shown below.



Background:

Materials that are attracted to a magnet can themselves become magnets. The normally random directions of some magnetic domains inside the needle are altered by the interaction with the bar magnet. A somewhat ordered set of domains along the length of the needle creates a weak but permanent magnet. By placing this magnet on the sponge floating on water, it is easily rotated in its magnetic interaction with Earth's magnetic field. What is important here is that this gives a clear indication of how one could create a magnetic compass.



Science as Inquiry

Test Tube Magnet

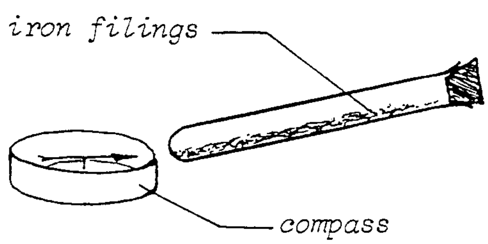
Materials:

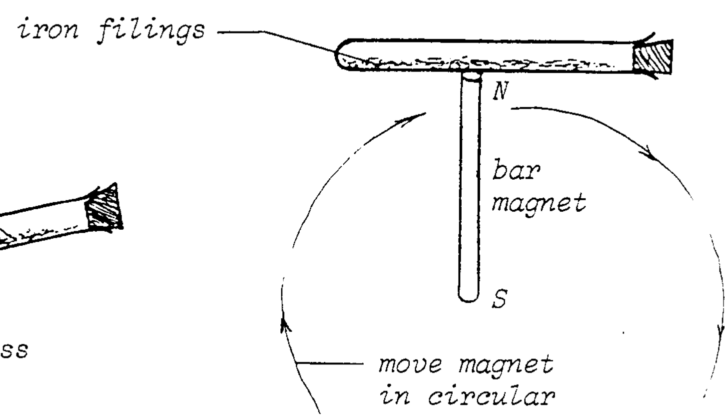
a test tube and fitting cork
a strong magnet and iron filings
a small compass (or needle compass)

Procedure:

Have students place some iron filings in a test tube, cork it, and shake the filings while holding the tube horizontally. By bringing the end of the tube close to the compass, they will discover that the compass needle is not or is very little attracted. They should also note that the same end of the compass needle is attracted to the test tube, no matter which end of the tube approaches the needle.

Students should now take the bar magnet and magnetize the iron filings in the test tube by stroking the bottom side of the horizontally held tube with one pole of the magnet in a circular motion. After stroking the tube with the magnet about five or six times, have students move each of the two ends of the tube near the compass. The test tube acts as a regular bar magnet.





Background:

A bar magnet is made up of many very tiny particles that have very weak magnetic dipoles called domains, consisting of millions of atoms of iron, many of which are aligned or partially aligned along the length of the magnet. In iron filings, domains are initially aligned in random directions.When iron filing domains are partially aligned by stroking with a strong magnet, the filings become like domains themselves, and the collection of test-tube filings becomes like a magnet. When the tube is shaken after it is magnetized, the iron particles, even though acting themselves like little magnets, have their directions redistributed randomly again, and no net magnetism is left in the tube. This is a very nice way to model the behavior of domains.

Science as Inquiry

Invisible Lines of Force

Materials:

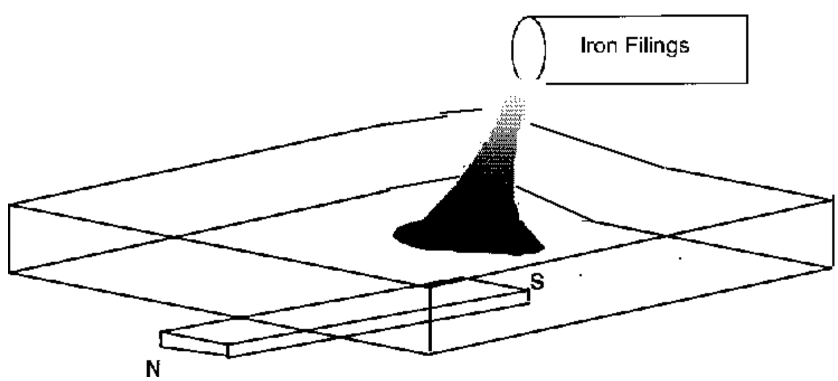
magnets (bar magnets, electromagnets, and horseshoe magnets)
large (14 ∞ 17) thin sheet of white paper
fine iron filings

Procedure:

Have students fold the paper like a tray, so that small flaps facing up along the edges will help contain the iron filings. They should then lay the magnet underneath the sheet of paper and carefully pour the iron filings onto the paper.

A gentle tap on the paper sheet will equally disperse the filings.

Have students observe and describe the pattern.



Background:

The pattern of the magnetic field surrounding a magnet is always bipolar. There is no such thing as a one-pole magnet.

Science as Inquiry

How Do Magnets Interact?

Materials:

two bar magnets, with masking tape covering the N and S labels
one steel or iron bar with the same shape and size as the magnets
thread

Procedure:

Students have seen how a magnet can be made and they understand now what we mean by the north and south poles of a magnet. What they have not yet investigated is how magnets interact with each other.

To carry out this investigation, students should be been given two metal bars. First they should see if each metal bar will attract bits of iron. If so, then they know that they are both magnets. They next suspend each magnet by thread tied around the middle of the bar, and observe which end aligns with north. They mark that end as N and the other end as S. This can be done by writing on masking tape placed on the ends of each magnet. When they finish, they should leave the thread attached to one of the magnets so that they may suspend it again for another part of this investigation.

When students have determined in this way the poles of each magnet, they are ready to carry out an important investigation. They will determine how magnets interact with each other. To do so, they should hold one magnet by the thread so that the magnet is suspended. Then they bring the north pole of the other magnet near the north pole of the suspended magnet and make an observation. Next they bring the south pole of the magnet they are holding next to the south pole of the suspended magnet. Again they make an observation. Finally, they bring the north pole of the magnet in their hand up close to the south pole of the suspended magnet. They make another observation.

Background:

This experiment allows students to discover for themselves the basic interaction of magnetic poles—like poles repel and unlike poles attract. They should formulate these relationships in their own words after having carried out the experiments described above.

Science as Inquiry

Magnets

Item:
A bar magnet whose ends are labeled N and S is brought close to an unidentified piece of metal whose ends are labeled X and Y. When the N end of the magnet is brought close to the X end of the metal it attracts, and when the N end of the magnet is brought close to the Y end of the metal it attracts. What can you conclude about the piece of metal?

A. It is a magnet with a north pole at X and a south pole at Y.
B. It is a magnet with a north pole at Y and a south pole at X.
C. It is a metal such as iron that is capable of being magnetized.
D. It is a metal such as copper that is not capable of being magnetized.

Justification:
Explain your reasoning in selecting your answer.

Answer:
C. The metal was attracted to both ends of the magnet. Since like poles repel each other the metal could not be a magnet. Choices A and B are the same, so these are not the answer.

Science as Inquiry

Magnets

Item:
A bar magnet whose ends are labeled N and S is brought close to an unidentified piece of metal whose ends are labeled X and Y. When the N end of the magnet is brought close to the X end of the metal it repels, and when the N end of the magnet is brought close to the Y end of the metal it attracts. What can you conclude about the piece of metal?

A. It is a magnet with a north pole at X and a south pole at Y.
B. It is a magnet with a north pole at Y and a south pole at X.
C. It is a metal such as iron that is capable of being magnetized.
D. It is a metal such as copper that is not capable of being magnetized.

Justification:
Explain your reasoning in selecting your answer.

Answer:
A. It is a magnet with a north pole at X and a south pole at Y. Like poles repel and unlike poles attract. Since the metal behaved as a magnet when close to the bar magnet, it is assumed to be one.

Science as Inquiry

Magnets

Item:

A piece of metal whose ends are labeled X and Y is brought close to a second piece of metal whose ends are labeled A and B. A attracts X and B attracts Y, but A repels Y. What can you conclude about the pieces of metal?

A. One is a magnet with a north pole at A and a south pole at B; the other is not a magnet.
B. One is a magnet with a north pole at X and a south pole at Y; the other is not a magnet.
C. Both are metals which are capable of being magnetized, but neither is a permanent magnet.
D. Both are magnets but the information does not enable one to tell which pole is which.

Justification:

Explain your reasoning in selecting your answer. What further experiments could you suggest to confirm your conclusion and identify both metals?

Answer:

D. Repulsion can be seen only between two magnets; a magnetizable material will be attracted to both poles. However there is no way to tell which is N and which is S of either magnet. To identify the poles, suspend the magnet by a thread and compare with a compass needle, or check repulsion/attraction against a known magnet.

Science as Inquiry

Compasses

Item:
When Admiral Perry attempted to reach the North Pole he used a magnetic compass to set his course. When he got near the North Pole his compass was no longer useful in directing him. Explain why this happened.

Answer:
Since the Earth's N pole (a south-seeking magnetic pole) is not on the surface, within Earth the compass esentially begins to point downwards, giving difficulties to a balanced needle often because of friction. More significantly, the N magnetic pole is not at the geographic North Pole of the Earth, but is off quite a distance. It even moves slowly and has been known to reverse polarity in paleomagnetic days (see Reading 1). Perry might have found the magnetic pole with a magnetic compass, but not the geographic pole. For the latter he must rely on observations of the stars.

Science and Technology/
History and Nature of Science

Natural Magnets

Item:

About 500 years ago, there was a great deal of interest in Europe in the idea that natural magnets, if supported at their center, would rotate and point in a certain direction. Natural magnets, called "lode-stones," may have been discovered in China many hundreds of years earlier.

Explain the practical use of this device, especially the advantages of using it rather than alternative methods. Why was there so much interest in the last 500 years?

What other application in nature is there of natural magnetic properties that does not involve people?

Answer:

Navigation was vital in the days of expanded exploration of the oceans and continents by Europeans. Sailors needed to find their way even in the dark, in fog, or in cloudy conditions, when methods using stars or sight of land would have been ineffectual.

Scientists have carried out experiments with pigeons and other birds, and even some other species, that indicate that small magnetic particles lined up in sensor organs may be used for navigational purposes.