Magnetic or Nonmagnetic — That's the Question!

Various materials are surveyed to determine if they are magnetic or nonmagnetic.

Application Magnetism • Magnets

Theory Although many people associate magnetism with metals, only three (pure) metals are in fact magnetic: iron, cobalt and nickel. Certain alloys of these elements are also magnetic. A magnetic object will be attracted to a magnet. A magnet is a material that induces a force of attraction on magnetic materials. Magnets can be man-made or naturally occurring, such as the mineral magnetite.

It is believed that magnetism is caused by the spin of the electrons of an atom. Spinning electrons create a magnetic field, similar to the magnetic field created by the spinning Earth. In most atoms, electrons occur in pairs. The magnetic fields between the electron pairs in these atoms cancel each other out making the material nonmagnetic.

Magnets are composed of atoms that have unpaired electrons. Normally these atoms are arranged randomly and the magnetic fields extend in many different directions—essentially canceling each other out. However if placed in the presence of a magnetic field, the atoms rearrange themselves along magnetic field lines. With the magnetic fields of the individual atoms pointing in the same direction, the fields are compounded and the material is considered magnetized. If the inducing magnetic field is removed, the magnetized material will retain its magnetism for a short period as the atoms return to their original random state.

Materials

Magnet

Samples of iron, nickel and cobalt

Samples of other shiny metals: aluminum, copper, zinc, manganese, gold

Samples of magnetic objects: paper clips, staples, scissors, nails, etc.

Samples of nonmagnetic objects: coins, plastic, wood, etc.

Safety Precautions Always follow laboratory safety rules while performing demonstrations.

Demonstration Ask students to name examples of materials that will be attracted to a magnet. Most likely some students will say that metals are attracted to magnets. Show students that not all metals are attracted to magnets by trying to pick up samples of aluminum, copper, zinc, and gold. Test other substances in the room to determine if they are magnetic. Tell students that if the substance is magnetic it most likely is contains some amount of iron, cobalt and/or nickel.

Disposal Save samples for next time.

North or South?

The North and South ends of a magnet are identified.

Application Magnetism • Magnets • Dipole

Theory To differentiate between the ends of a magnet the names "North" and "South" poles have been assigned. If allowed to hang freely, the "North" pole of a magnet will point north, and the south pole will point south. Two magnets brought close to one another will exert a force. If the poles are opposite, the force will attract or pull the magnets together. If the poles are alike, the force will repel the two magnets.

Materials Bar magnet, 3

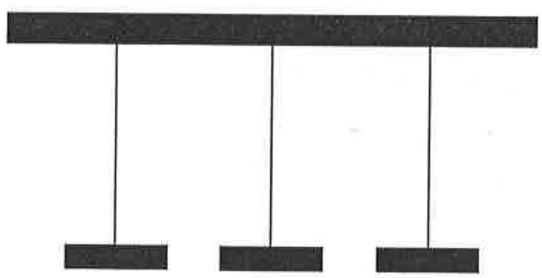
String, 1-m, 3

Hook on ceiling, 3

Safety Precautions Always follow laboratory safety rules while performing demonstrations.

Demonstration Suspend three bar magnets horizontally from hooks on the ceiling. Keep the magnets far enough apart so that they do not affect each other. Spin the magnets gently. They should all come to rest pointing in the same direction.

Disposal None required.



Force Fields

The magnetic field lines of a magnet are demonstrated.

Application Magnetism • Magnetic Field

Theory A magnetic field is an invisible force that extends beyond the surface of a magnet. This force field has the ability to move atoms in magnetic objects. Although the magnetic field of a magnet is strongest at its poles, it extends from one pole to the next. The three-dimensional magnetic field of a round bar magnet is viewed by placing it within a viscous suspension of iron filings. The iron filings will align themselves along the magnetic field lines.

A cow magnet is used to create the magnetic field in this demonstration. Cows have a tendency to eat almost anything—including nails and pieces of wire fence. Sharp metallic objects can easily rip the lining of the cow's digestion system. A dairy or cattle farmer will have their cows ingest a cow magnet to protect the cow's digestive system. Once swallowed, the magnet settles into the cow's first stomach and collects any magnetic objects the cow mistakenly swallows. Only the lining of the cow's first stomach is strong enough to withstand these foreign objects. Metal pieces the size of a baseball have been known to be removed from cows upon slaughter.

Materials

Glass soda bottle, 355-mL (12-oz)
Graduated cylinder, 500-mL
Acetone, 10 mL
Mineral oil, 500 mL
Iron filings, 10 mL
Funnel
Test tube (must fit snugly into the bottle)
Cotton ball
Hot melt glue gun or epoxy putty
Cow magnet

Safety Precautions Always follow laboratory safety rules while performing demonstrations.

Preparation Fill a 355-mL glass soda bottle with water. Gently slide a test tube into the bottle—causing some of the water to be displaced. Remove the test tube and measure the water remaining in the bottle, using a graduated cylinder. This is the volume of mineral oil that will be added later.

Thoroughly wash the soda bottle. Allow it to dry. Rinse the bottle with 10 mL acetone to remove any remaining water. Place 10 mL iron filings in the bottle. Use a funnel to pour in the volume of the mineral oil needed. Carefully slide the test tube into the bottle. A test tube that just fits into the bottle should be selected. Seal the test tube to the bottle using hot melt glue or epoxy putty. Pad the bottom of the test tube with a cotton ball.

Demonstration

Shake the apparatus to disperse the iron filings. Slide the cow magnet into the apparatus. The iron filings should immediately arrange themselves along the magnetic field lines of the magnet.

Disposal

None required.

Cling-on Wire

A current flow produces a magnetic field.

Application Magnetism • Electromagnetism • Current

Theory The study of the relationship between electricity and magnetism is called electromagnetism. As electricity flows through a wire the current produces a magnetic field. In this demonstration, a wire from a simple circuit is placed over a dish of iron filings. As the current flows through the wire, the induced magnetic field causes the iron filings to cling onto the wire, indicating the presence of a magnetic field.

Materials

Bell wire

Lightbulb with socket, 1.5 V

Knife switch

Battery, 6 V

Petri dish

Iron filings

Overhead projector & screen

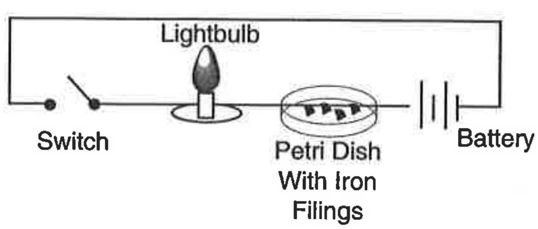
Safety Precautions Always follow laboratory safety rules while performing demonstrations. Do not allow the battery to remain shorted out for more than a few minutes. Batteries have been known to leak acid or even explode when shorted out for prolonged periods of time.

Preparation Connect the lightbulb, battery, and switch in series.

Demonstration Scatter a teaspoon of fine iron filings in a Petri dish. Place the dish on an overhead projector and project the image on the screen. Place the wire of the circuit over the Petri dish. Be sure that the wire is visible on the screen. Close the circuit. Iron filings should cling to the wire. The lightbulb confirms that the circuit is closed.

Open the circuit. The iron filings should fall from the wire. The lightbulb confirms that the circuit is open.

Disposal Recycle the iron filings.



Make a Magnet

A temporary magnet is made.

Application

Magnetism • Magnets • Magnetic Field • Magnetic Induction

Theory

A temporary magnet can be created by placing a material that conducts a magnetic field within a magnetic field. In time, the magnetic filed of the magnet will cause some of the atoms within a magnetic material to realign their individual magnetic fields (or domains) along the magnetic field lines of the magnet. The material will become magnetized and acts as a magnet. Such a magnet is considered a "soft" magnet since it loses its magnetic alignments quickly. These magnets are said to be made by magnetic induction. Only materials that are attracted to magnets can be used for making magnets. A pin (made of iron) left on a permanent magnet for a few minutes will become magnetized. The magnetized pin will attract other pins to itself.

Pins, nails and other similar objects can be quickly magnetized by stroking the material with a magnet. Each stroke of the magnet literally "pulls" the atoms of metal on the surface of the objects into alignment.

A permanent magnet is created by placing a molten (or extremely hot) sample of magnetic material in the presence of a strong magnetic field. If allowed to cool, while in the field the final product will consist of atoms arranged as a dipole—making it a magnet. Since the atoms are literally "frozen in place", the magnet is considered permanent.

Materials

Bar magnet

Stick pins or small finishing nails

Paper clips

Overhead projector & screen

Safety Precautions

Always follow laboratory safety rules while performing demonstrations.

Demonstration

Spread a pile of pins in the middle of an overhead projector. Project an image of these pins on a screen. Slowly remove one or two pins from the pile. Show that the pins are not attracted to one another. Place these pins on a bar magnet for a minute or two. Test the magnetized pins by bringing one close to the pile of pins. Pins from the pile should be easily pulled away by the magnetized pin.

Hold a second pin between your fingers and stroke the other end of the pin lengthwise along one end of a bar magnet. Each stroke must be in the same direction. After about ten strokes, try picking up a few paper clips.

Electricity Can be Attractive

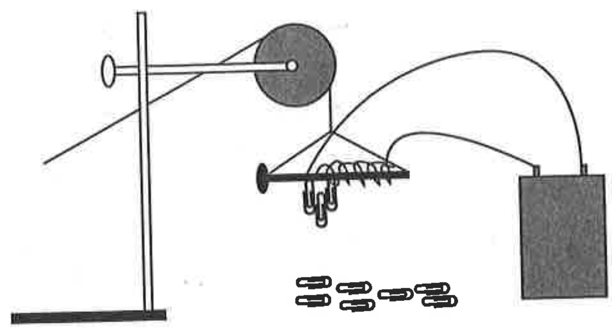
An electromagnet is produced.

Application Magnets • Electromagnetism • Magnetic Induction

Theory The relationship between electricity and magnetism is called electromagnetism. As electricity flows through a wire the current produces a magnetic field. If this wire is coiled around a magnetic object, such as an iron rod or nail, the current flowing through the wire induces a magnetic field in the nail. The strength of the magnetic field is increased by increasing the electric current or by increasing the number of turns in the coil.

Materials

Lantern battery, 6-V
Iron nail, size: 20d
Bell wire, 1.5 m
Paper clips
Pulley & clamp
Ring stand
String
Paper clips



Safety Precautions Always follow laboratory safety rules while performing demonstrations.

Preparation Remove the insulation from both ends of a 1.5-m piece of bell wire. Starting in the middle of the wire, wind the wire around the nail about five times. Hang the nail from a pulley as indicated in the diagram.

Demonstration Place a pile of paper clips under the electromagnet. Connect the wire of the electromagnet to a 6-V lantern battery. Pick up the paper clips by lowering the electromagnet onto the pile. Count the number of paper clips picked up.

Detach the electromagnet from the pulley system. Wind the wire around the nail an additional five times—for a total of ten. Determine how many paper clips are picked up with this electromagnet.

Disposal None required.

Distance Makes It Less Fonder

The relationship between the force of attraction and the distance between magnets is explored.

Application Magnetism • Forces • Newton's Second Law

Theory The force of attraction between two magnets diminishes as the distance between the magnets increases. In this demonstration, the weight (force) of the masses added to the system act to balance the force of attraction between two magnets.

Materials

Neodymium magnet or other strong magnets, 2

Pulley & clamp

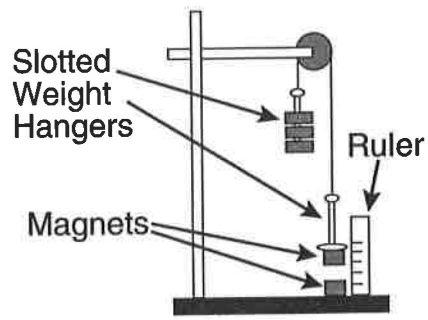
Ring stand

Slotted weight hangers, 2

Mass set

Metric ruler, 15 cm

Modeling clay



Safety Precautions Always follow laboratory rules while performing demonstrations.

Preparation Set up materials as illustrated in diagram. Use the modeling clay to support a 15-cm ruler upright. The magnets should be arranged with opposite poles facing one another. If iron mass holders and a ring stand are not available, use hot melt glue to secure the magnets in position.

Demonstration Hold the lower mass hanger about 10 cm away from the neodymium magnet mounted on the base of the ring stand. Add enough masses to the other mass holder to balance the apparatus. (If a mass set is not available, use fishing weights.) Have students note the position of the hanging magnet and the mass necessary to keep the system in balance. Now add another mass to the mass holder. Bring the magnets closer together to keep the system in balance.

The closer the magnets are the more mass is necessary to keep the system in balance proving that the further the distance between the magnets the less the force of attraction.

Disposal None required.

Magnetic Levitation

A strip of metal is raised using magnetic levitation.

Application

Magnetism • Magnetic Field • Right Hand Rule

Theory

As electricity flows through a wire the current produces a magnetic field. If the wire is coiled, the magnetic field is compounded. A coil of wire, carrying a current is called a solenoid. The right hand rule says that a current running through a solenoid induces a magnetic field perpendicular to the direction of the current. If two solenoids are arranged such that the currents running through them are parallel, the coils will attract each other. Two coils running with opposite currents will repel each other.

In this demonstration, two solenoids will repel each other as in a magentic levitation. Magnetic levitation is of great interest to society. Presently scientists are working to employ this technology to create alternative modes of transportation, including magnetically levitated trains.

Materials

Aluminum pie plate or heavy aluminum foil

Scissors

Bell wire

Lantern battery, 6-V

Overhead projector

Safety Precautions

Always follow laboratory safety rules while performing demonstrations. Do not allow the battery to remain shorted out for more than a few minutes. batteries have been known to leak acid or even explode when shorted out for prolonged periods of time.

Preparation

Cut the aluminum pie plate or heavy aluminum foil into two 2-cm × 10-cm strips. Wrap a piece of insulated bell wire around each strip about 20 times. Leave about 15 cm of wire at either end. Strip the ends of these wires.

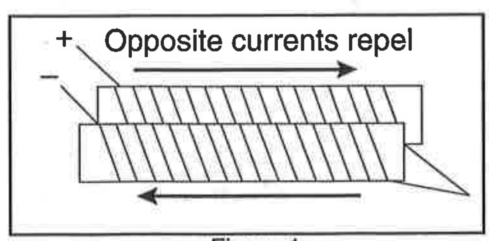


Figure 1

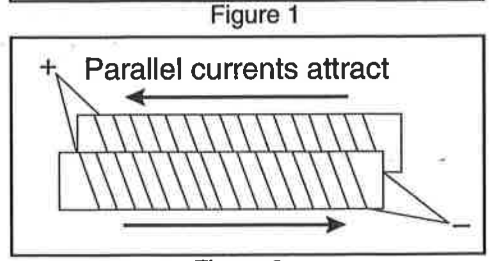


Figure 2

Demonstration

Place the coils on an overhead projector. Stand the two coils upright on their sides such that the coils are arranged in the same direction. Connect the two wires at one end of the coils together. Connect the remaining wires to the terminals of a 6-volt lantern battery. The circuit is in series (See Figure 1). Since the currents through the coils are in opposite directions, the coils will repel one another driving the aluminum plates apart.

Now connect the ends of the coils together. One end is connected to the positive terminal of the battery while the other wires are connected to the negative terminals of the battery (the circuit is in parallel). Since the currents are parallel, the strips move toward one another.

Disposal

None required. Keep apparatus for next year.

Magnetic Codes

The codes on magnetic media are developed.

Application Magnetism • Magnetic Media • Communication • Electromagnetic Induction

Theory For years people have utilized magnetic recording devices to encode information for later use. Magnetic media include audio tapes, videotapes, computer disks, ATM cards, credit cards, hotel key cards, etc. Tapes, disks and cards are coated with a thin layer of iron oxide or chromium oxide that can be permanently magnetized at will. Magnetic recording devices such as tape recorders, computer disk drives or magnetic card recorders encrypt magnetic codes on the surface of these media using an electromagnetic recording head. A tape recorder, for example, converts sound into electrical signals or current. As sound varies the current in the tape player, the current varies the magnetic field in the electromagnetic recording head. Then the recording head glides across the surface of the magnetic media (the tape) the magnetic field created in the electromagnet induces a permanent magnetic field in the tape. Essentially the sound is converted into an electrical code, which in turn, is converted into a magnetic code that is stored on a strip of magnetic media. Information is stored in the same way on ATM cards and computer disks.

The "code" on a strip of magnetic media can be made visible by spraying it with a suspension of powdered magnetite or extremely fine filings from a permanent magnet. The code visible on a developed magnetic strip of a key card or ATM card is made of a series of lines resembling that of a UPC symbol.

The difference between high density and low density computer disks becomes apparent when comparing developed high density disks to regular disks. The sectors of information on a high density computer disk are smaller because they are more tightly packed. High density disks utilize a coating of finer grains of iron oxide allowing more information to be stored per unit area.

Materials

Formatted high density computer disk

Formatted low density computer disk

Non-formatted low density computer disk

Scissors

Credit card or key card

Strip of videotape

Kyread® Magnetic Tape Developer

Note: Kyread® Magnetic Tape Developer is available from Kyros Corporation, P.O. Box 406, Madison, WI 53701.

Safety Precautions

Kyread contains 1,1 difluro-1chloroethane. Use only with adequate ventilation and avoid inhalation or skin contact. Avoid exposure to hot surfaces and open flames. Keep magnets and magnetic sprays away from all forms of magnetic media and magnetic recording devices. Magnetic media that is developed using magnetic spray must not be placed into a magnetic reading/recording device. Always follow laboratory safety rules while performing demonstrations.

Demonstration

Use a pair of scissors to open the computer disks. Spray the surfaces of the unformatted and formatted low density disks with the magnetic spray. Have students compare the design that develops on the surfaces. The series of bands will be visible on the surface of the formatted disk while the unformatted disk remains blank. Formatting a disk creates sectors (visible as small boxes) in which is inserted information in the form of a magnetic code. Blank disks are free of magnetic coding.

Spray a high density computer disk with the magnetic spray. The bands on a high density disk are smaller and tightly packed, compared to those on a low density disk.

Spray the magnetic strip on an ATM card or key card. Direct students' attention to the series of lines on the strip.

Disposal

Developed magnetic media may be disposed of in a trash container. Do not place developed magnetic media into a magnetic media reading/recording device.