The Video Encyclopedia *of* Physics Demonstrations™

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Chapter 47

Magnetism and Magnetic Fields

Demo 19-01 Magnetic Attraction/Repulsion

Two magnets, one of which is mounted on a bearing stand, are brought into close proximity so that the forces between like and unlike magnetic poles can be studied.† Using the apparatus of *Figure 1* it is observed that the force between like poles is repulsive and the force between unlike poles is attractive. For ease in identifying the poles, north poles of magnets have been painted red and south poles white.

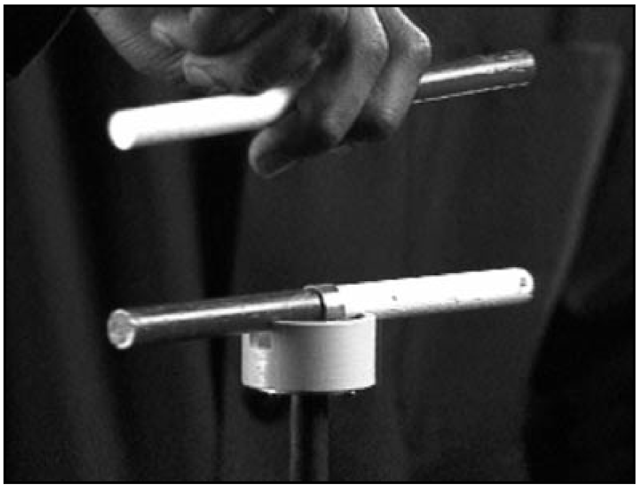

Figure 1

† Freier and Anderson, *A Demonstration Handbook for Physics*, Demonstration Er-2, Interaction Between Bar Magnets.

These two bar magnets will be used to show magnetic attraction and repulsion.

One of the magnets is placed on a bearing stand, and the other brought nearby, first with unlike poles together.

The magnets are attracted to one another.

Now with like poles together.

This time the magnets repel one another.

Equipment

1. Two large magnets.
2. Low friction-bearing pivot stand.

Demo 19-02 Lodestone

A lodestone is shown to be a magnet with two poles just like a bar magnet by substituting the lodestone for one of the bar magnets in Demonstration 1.† One end of the lodestone behaves as a south pole and one end as a north pole, as shown in the video, so the ends of the lodestone are identified as shown in *Figure 1*.

Figure 1

† Sutton, *Demonstration Experiments in Physics*, Demonstration E-77, Natural Magnets.
Freier and Anderson, *A Demonstration Handbook for Physics*, Demonstration Er-5, Lodestone.

This lodestone is a rock composed of naturally occurring magnetic ore. When we hold a bar magnet near the lodestone, it reacts just as if it were another bar magnet, showing attraction between unlike poles

and repulsion between like poles.

Equipment

1. Lodestone.
2. Copper wire suspension cradle.
3. Length of string.
4. Support system.

Demo 19-03 Dip Needle

A dip needle is a compass needle that is allowed to move in a vertical plane.† When oriented parallel to the magnetic lines of force of the earth, the dip needle will align itself parallel to the magnetic lines, as shown in *Figure 1*, which is taken from the accompanying graphics.

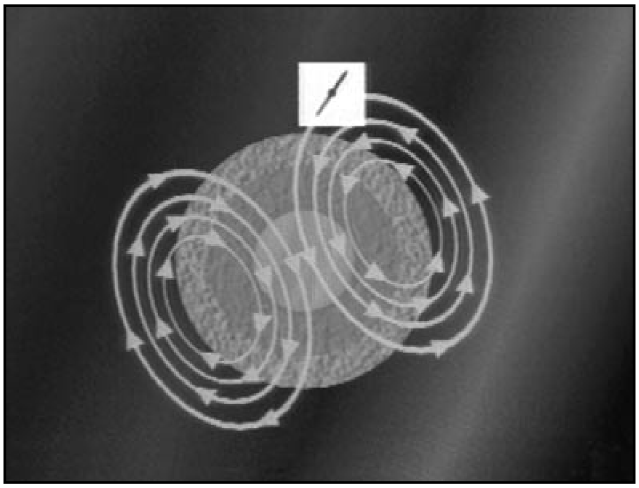

Figure 1

† Freier and Anderson, *A Demonstration Handbook for Physics*, Demonstration Er-7, Dip Needle.

We all know that a compass points to magnetic north. But the actual magnetic pole is far below the surface of the Earth. We'll demonstrate that using this compass as a dip needle, by turning it on its side and allowing it to come to rest.

The dip needle comes to rest pointing down at a very steep angle, known as the dip angle of the Earth's magnetic field.

This animation shows the dip needle aligning itself at various points with the magnetic field lines that surround the Earth.

Equipment

Dip needle.

Demo 19-04 Magnetic Fields Around Bar Magnets

The magnetic field around a bar magnet can be studied using iron filings, as shown in *Figure 1*.† The iron filings become magnetized and act as small magnets aligning with the magnetic field lines of the larger magnet to indicate the field lines around the magnet, as shown. This demonstration also shows the fields of two bar magnets in various configurations.

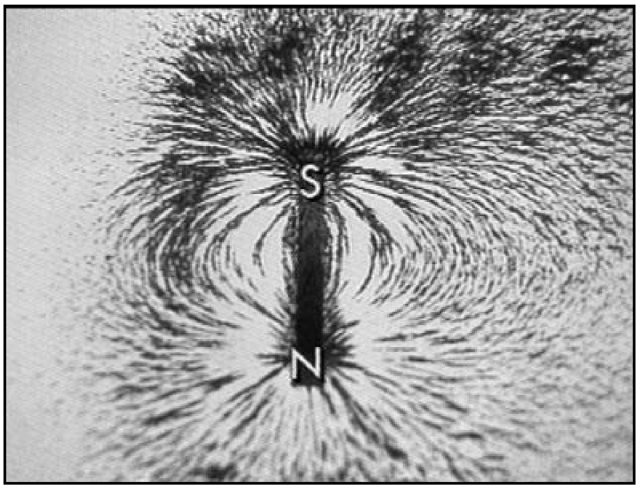

Figure 1

† Sutton, *Demonstration Experiments in Physics*, Demonstration E-89, Magnetic Fields Shown by Iron or Permalloy Filings.
Freier and Anderson, *A Demonstration Handbook for Physics*, Demonstration Er-4, Field of a Magnet.

Here is a single bar magnet. If we sprinkle iron filings on a glass sheet sitting on top of the magnet, the filings fall into a pattern which shows the shape of the magnetic field.

Here are two magnets with like poles facing.

Here are two magnets with unlike poles facing.

Here are two parallel magnets with like poles facing.

Here are two parallel magnets with unlike poles facing.

Equipment

1. Two bar magnets.
2. Glass cover sheet with bonded shims along opposite edges.
3. Supply of iron filings.
4. Overhead projector and screen.
5. AC power.

Demo 19-05 Broken Magnet

When a bar magnet is broken into two shorter pieces, new poles will be formed so that each of the smaller bars is a complete bar magnet with both north and south poles.† Using the apparatus of *Figure 1*, this behavior is shown by comparing the interaction of the two broken pieces with the interaction previously observed between two similar bar magnets.

Figure 1

† Sutton, *Demonstration Experiments in Physics*, Demonstration E-93, Breaking a Magnet. Freier and Anderson, *A Demonstration Handbook for Physics*, Demonstration Er-12, Forming New Magnetic Poles.

This bar magnet has a north pole on one end, and a south pole on the other, as shown by this compass.

If we break the magnet in half, will each side contain only one magnetic pole?

Each half of the magnet still has both north and south poles.

Equipment

1. Previously broken bar magnet.
2. Large compass needle on a pivot stand.

Demo 19-06 Lowest Energy Configuration

In this very interesting demonstration the interaction between a number of identical magnets is shown, illustrating how the magnets form minimum energy configurations. Identical magnets mounted vertically on floats are placed in a water bath within a current loop, as shown in *Figure 1* for an array of six magnets. The final configuration reached in each case, that with the least energy, is shown clearly in the video.

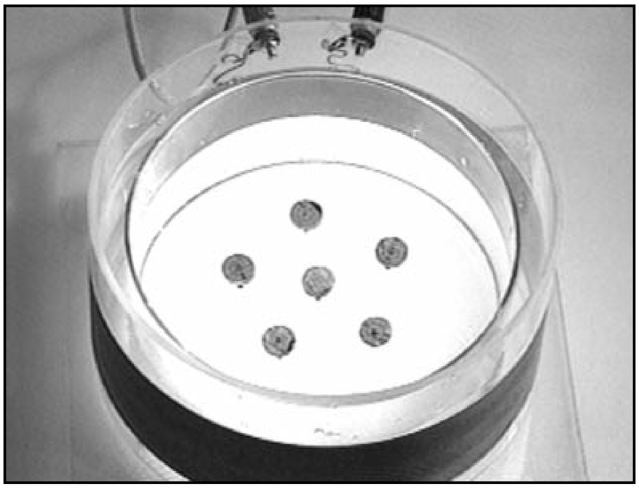

Figure 1

These small floating magnets repel one another and try to stay apart.

We'll use them to show how a system moves to the lowest available energy state.

A single magnet is first floated in the small dish of water, which is surrounded by a coil of wire. With no current running through the coil, the floating magnet is stable at any position in the dish.

When a current is run through the outer coil, the magnet moves to the center of the dish. Moving to the spot where the field is weakest lowers the energy of the system.

When two magnets are put in with the field off, they move to opposite sides of the dish. When the magnetic field is turned on, they move into symmetric positions around the center of the dish.

Now we'll add a third magnet.

And a fourth.

And a fifth.

When a sixth magnet is added, the ring structure becomes unstable, and one of the magnets moves to the center of the dish.

That produces a lower energy state than six magnets in a circle.

When the field is turned off, the magnets separate as far as possible.

Equipment

1. Large crystallization dish half filled with water.
2. Coil wrapped with fine copper wire on a plastic cylinder whose diameter is just a little larger than that of the dish.
3. Two electrical leads.
4. Battery eliminator.
5. AC power.
6. Collection of very small bar magnets, each of which has its own cork disc collar that enables the small magnets to float in a vertical orientation.
7. Plastic rod.
8. Overhead projector and screen.

CHAPTER 48

MAGNETIC FIELDS FROM CURRENTS

Demo 19-07 Right Hand Rule

The right-hand rule for magnetic field around a current-carrying wire is illustrated in this demonstration. When the right hand encircles the wire with the thumb pointing in the direction of the positive current, the fingers will point around the wire in the direction of the magnetic field lines, as shown in *Figure 1*.

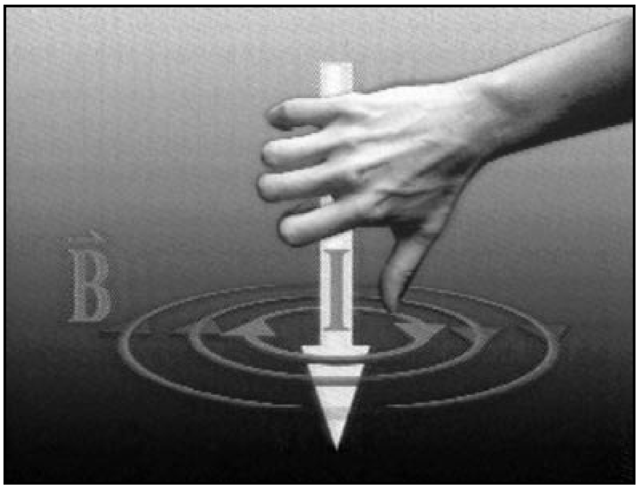

Figure 1

We'll use this vertical copper wire to demonstrate the right-hand rule of magnetic field production.

A small compass near the wire reacts when a current runs upward in the wire. As the compass is moved in a circle around the wire, the needle shows the magnetic field is tangential to the circle at all places, and points in the direction the fingers of a right hand would curl if the thumb were pointing in the direction of the current through the wire.

Reversing the direction of the current leaves the shape of the pattern unchanged, but the field lines now point in the opposite direction,

as predicted by the right-hand rule.

Equipment

1. Length of copper wire passing through the center of a clear horizontal plastic plate and then having its ends attached to the opposite edges of the plate at terminal posts.
2. Appropriate electrical leads.
3. Heavy-duty switch.
4. DC power.
5. Transparent compass needle.
6. Overhead projector and screen.
7. AC power.

Demo 19-08 Oersted's Needle

The classical demonstration called "Oersted's needle" shows that the magnetic field of a long straight wire is perpendicular to the wire and encircles it.† A bar magnet on a bearing stand placed under a current-carrying wire, as shown in *Figure 1*, responds to current in the wire by rotating so that it is perpendi-caular to the wire.

Figure 1

† Sutton, *Demonstration Experiments in Physics*, Demonstration E-121, Oersted's Experiment. Freier and Anderson, *A Demonstration Handbook for Physics*, Demonstration Ei-8, Magnetic Field around a Long Wire.

This straight wire and a bar magnet in a rotation stand make up a demonstration known as Oersted's needle.

When we start a current flowing in the wire, the magnet moves until it is perpendicular to the wire. If we move the wire, the magnet remains approximately perpendicular to the wire at all times.

Equipment

1. Same pivoted magnet as in Demonstration 19-01.
2. Length of heavy-duty lamp cord with the wire therein joined at both ends.
3. Heavy-duty switch.
4. Source of DC power.

Demo 19-09 Magnetic Fields Around Currents

The magnetic field around various geometries of conductors can be observed using iron filings.† While the current is running through the wire, iron filings are sprinkled onto a plastic sheet through which the wire runs, and the plate is gently tapped, producing the iron filing configuration which illustrates the magnetic field in the plane of the plastic sheet, as in *Figure 1* for the case of the solenoid.

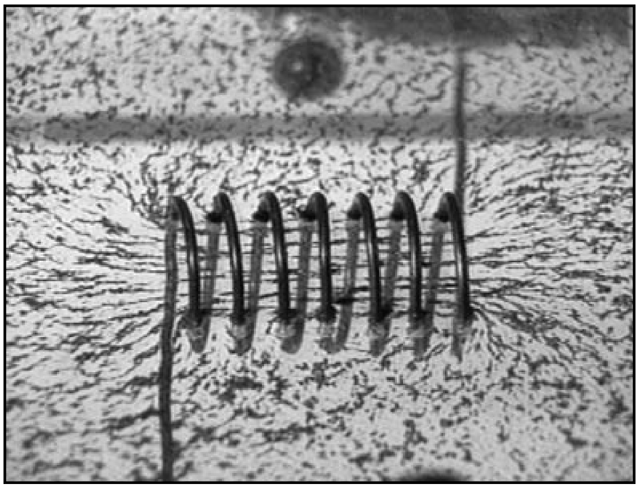

Figure 1

† Sutton, *Demonstration Experiments in Physics*, Demonstrations E-122, Magnetic Field Due to Current in a Long Straight Conductor, and E-123, Magnetic Field about Various Conductors. Freier and Anderson, *A Demonstration Handbook for Physics*, Demonstrations Ei-9, Magnetic Field Around a Wire, and Ei-10, Field of a Solenoid.

We'll use these wire forms and some iron filings to show the shape of the magnetic field around various current carrying wires.

This is a simple straight wire arranged vertically. We'll turn the current on, and sprinkle filings around the wire to show the shape of the magnetic field.

Here are two wires carrying currents in opposite directions.

This is a five-turn loop of wire.

Here is a solenoid.

Equipment

1. Same set up at Demonstration 19-07.
2. Supply of iron filings.
3. Field board similar to step one in Demonstration 19-07 but with the same wire passing through the plate twice.
4. Field board similar to step one in Demonstration 19-07 but with several turns of copper wire pressed together to approximate a single turn coil.
5. Field board with a solenoid.

Demo 19-10 Solenoid Bar Magnet

A long current-carrying solenoid produces a magnetic field (similar to that of a long bar magnet).† This behavior is shown by holding a small bar magnet near the ends of the solenoid as in *Figure 1*, so that the attraction between like poles and the repulsion between unlike poles can be readily observed. The effect is strengthened by inserting an iron core into the solenoid.

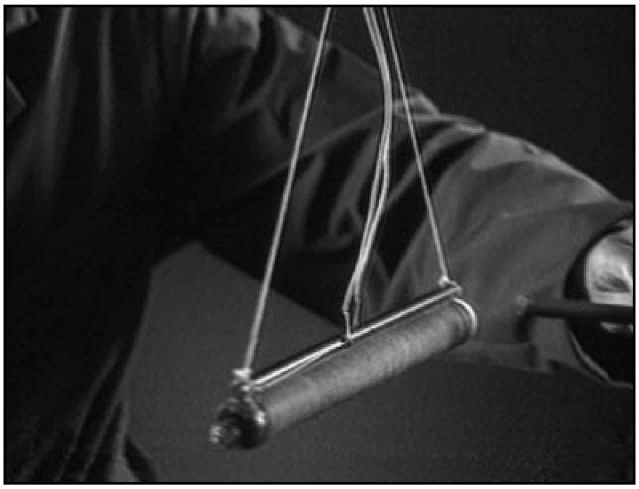

Figure 1

† Sutton, *Demonstration Experiments in Physics*, Demonstration E-122, Magnetic Field due to Current in a Long Straight Conductor.

This hanging solenoid can act like a bar magnet.

With no current in the solenoid, it doesn't react to a bar magnet brought nearby. Turn on the current, and it is attracted to and repelled by the bar magnet just as though it were another bar magnet.

An iron core placed in the solenoid increases the strength of the effect.

Equipment

1. Suspended solenoid with removable iron core.
2. Support system for the solenoid.
3. Telegraph-type switch.
4. Heavy-duty battery.
5. Appropriate electrical leads.
6. Bar magnet.

Demo 19-11 Large Electromagnet

A large electromagnet is formed from a multi-turn coil in which a soft iron core has been located.† The electromagnet attracts nails or other ferrous items that are thrown in its vicinity, as illustrated in *Figure 1*.

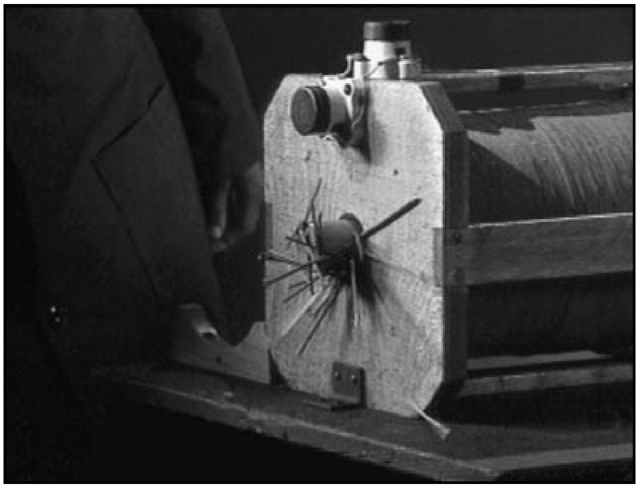

Figure 1

† Sutton, *Demonstration Experiments in Physics*, Demonstration E-126, Electromagnet.

We've all seen large electromagnets used to transport heavy metal objects. But how do they work?

This large electromagnet has approximately 3000 turns of wire and carries 25 amps of current. The strong magnetic field it produces can pull in nails and other iron objects with a large force.

Equipment

1. Large electromagnet with an iron core.
2. Nails.

Demo 19-12 Electromagnet with 1.5 V Battery

A surprisingly strong electromagnet can be created using only a 1.5-volt battery as its source of power.† This magnet is used to support considerable weight, as shown in *Figure 1*. When the iron core is removed, the magnetic field is reduced to a very low magnitude, and can support almost no weight, as shown in the video.

Figure 1

† Freier and Anderson, *A Demonstration Handbook for Physics*, Demonstration Es-11, Magnetic Holding with a Small Battery.

This small wire coil, a battery, and an iron core form a powerful electromagnet. If we put the coil inside the core and hook up the battery, a strong force clamps this iron cap to the core.

We can hang heavy weights from the electromagnet.

But when the battery is disconnected, the weights fall.

If we remove the coil from the iron core and hook up the battery, how much weight will the field from the coil be able to hold up?

Without the core, the coil cannot even hold up this cap.

Put the coil back into the iron core, and the magnet's strength returns.

Equipment

1. Small, but powerful, battery-driven electromagnet.
2. Support system to suspend the electromagnet.
3. Weight hanger.
4. Collection of slotted weights.
5. Drop pad to protect equipment and the tabletop.

Demo 19-13 Pinch Wires

A series of wires in which identical currents can flow either parallel or antiparallel can be used to illustrate the force between parallel current-carrying conductors.† Six wires carrying currents in the same direction are attracted, and "pinch" together. If the current in three of the wires is reversed, each three wires with their currents in the same direction will pinch together, but the two groups of three with opposing currents will be repelled from each other, as seen in *Figure 1*.

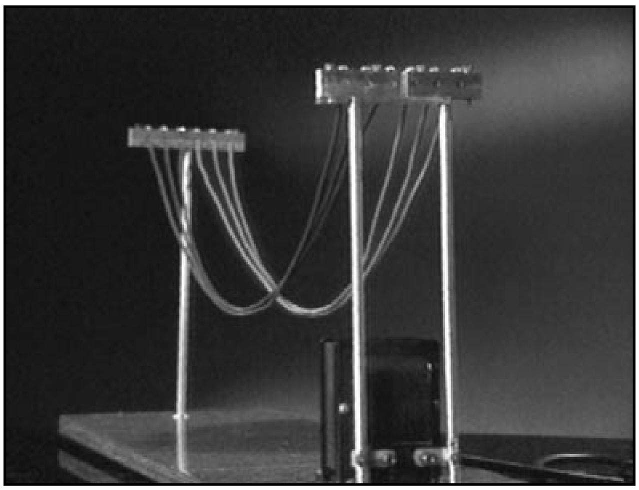

Figure 1

† Sutton, *Demonstration Experiments in Physics*, Demonstration E-148, Forces on Parallel Conductors.
Freier and Anderson, *A Demonstration Handbook for Physics*, Demonstration Ei-1, Force Between Parallel Wires.

This set of wires is hooked together so that current can flow through each wire in the same direction.

When we set the currents flowing in the wires they pull together.

In this set of wires three of the currents flow in the same direction while the other three currents flow in the opposite direction. Each set of three wires pulls together but the two sets repel one another and remain separate.

Equipment

1. Six parallel wires are loosely suspended from common end connections, and appropriately wired along with a heavy-duty transformer on a common base.
2. Switched connection to AC power.
3. Another punch wire setup where a trio of loosely draped wires stand parallel to another trio of wires, but carry the current back in the opposite direction. The two sets of three are wired in series.

Demo 19-14 Biot-Savart Law

The Biot-Savart law, discussed in most elementary physics textbooks, describes the magnetic field of a current element and how these fields of current elements add together to produce the fields of various current configurations. This graphics demonstration, shown in *Figure 1*, illustrates how the Biot-Savart Law works in the production of the magnetic field of a circular current element along the axis of the loop.

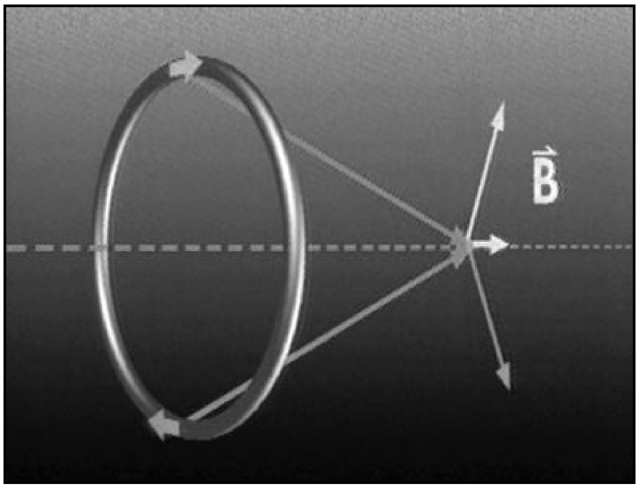

Figure 1

This animation shows a single loop of wire carrying a current in the direction shown by the arrows. We'll use the law of Biot-Savart to determine the direction of the resulting magnetic field along the axis of the loop. To find the magnetic field at point A, we first divide the wire into small sections, each carrying the same current. Each section of current contributes a magnetic field at A which is at right angles to both the current and to the vector drawn from that section to point A, and whose magnitude is proportional to the current in that section.

The total magnetic field at point A is equal to the sum of the magnetic fields created by all the sections of current.

The magnetic field contribution from each of the current sections has a component at right angles to the axis of the loop and a component parallel to the axis.

Since each current section has a corresponding current section on the opposite side of the loop, and since their components at right angles to the axis are equal and opposite, they cancel out. The components of their magnetic fields parallel to the axis add together, producing a net magnetic field along the axis of the loop.

The magnitude of the field is proportional to the magnitude of the current in the coil, and inversely proportional to the square of the distance from the center of the loop.

Equipment

This demonstration is an animation.

CHAPTER 49

MAGNETIC PROPERTIES OF MATTER

Demo 19-15 Magnetizing Iron by Contact

This demonstration shows how an iron nail can be magnetized by "stroking" it with one pole of a stronger magnet.† The magnetized nail is able to pick up iron filings, as seen in *Figure 1*.

Figure 1

† Sutton, *Demonstration Experiments in Physics*, Demonstration E-78, Magnetization by Contact.

We'll use these iron fillings and an iron nail to demonstrate magnetizing by contact.

The nail is initially unmagnetized, and will not pick up the iron filings from the pile.

If we stroke one end of this permanent magnet repeatedly along the nail in one direction, the nail becomes magnetized and will pick up the filings.

Equipment

1. Supply of iron filings.
2. Nail.
3. Bar magnet.

Demo 19-16 Magnetic Domain Model

An array of compasses is used as a model of magnetic domains.† When a magnet is brought near the previously well-organized array of compasses, shown in *Figure 1,* they will flip in a random manner, as would the domains in a piece of iron subjected to an external magnetic field. This demonstration serves as a model for the Barkhausen effect, Demonstration 19.

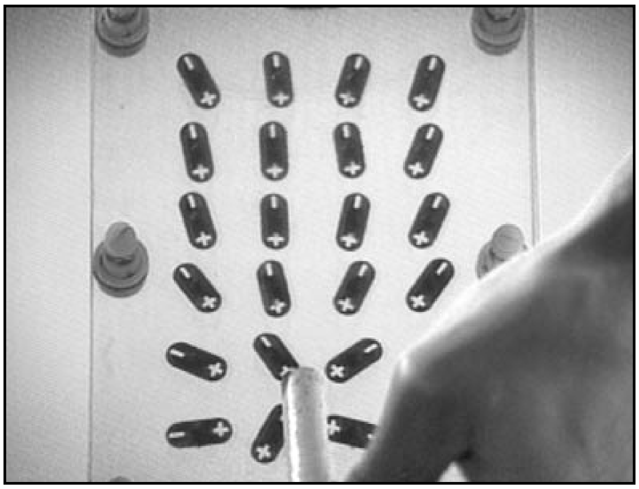

Figure 1

† Freier and Anderson, A Demonstration Handboom for Physics, Demonstration Es-2, Magnetic Domains.

These small compasses on pin bearings are models of the magnetic domains present in iron and other magnetic materials.

Like real domains, these compasses can be oriented randomly, or they can be aligned by the presence of an external magnetic field. When a bar magnet is passed slowly over the model, the domains line up in the same direction.

A rapidly changing magnetic field like the one from this oscillating bar magnet can randomize the domains.

Equipment

1. Magnetic domain model.
2. Bar magnet.
3. Overhead projector and screen.
4. AC power.

Demo 19-17 Magnetizing Iron

A long iron bar can be magnetized by placing it inside a high current solenoid, as shown in *Figure 1*, and turning the current on and off, producing large magnetic field impulses. This procedure aligns some of the magnetic domains.† The existence of magnetic poles on the magnet thus created is shown in the video by its interaction with a compass on a bearing stand, as in Demonstration 1.

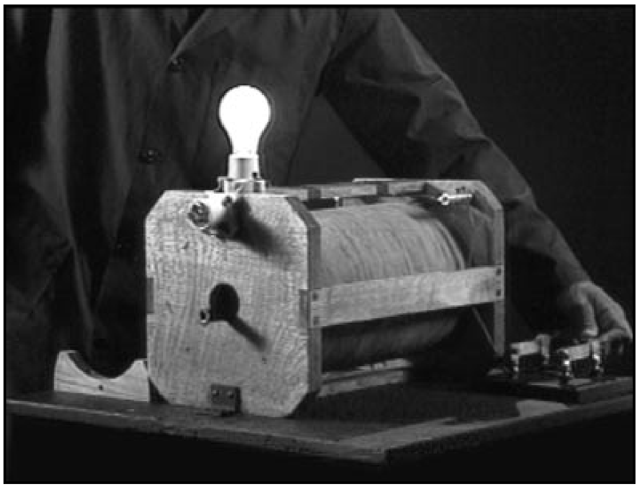

Figure 1

† Sutton, *Demonstration Experiments in Physics*, Demonstration E-80, Magnetization by Mechanical Disturbance in Earth's Field.

Magnetizing Iron / Script

If we put this iron bar inside a solenoid coil and repeatedly pulse a large current through the coil, the bar becomes magnetized.

It strongly affects a compass needle when held nearby.

Equipment

1. Soft iron bar.
2. Large solenoid.
3. Appropriate electrical leads.
4. DC power.
5. Large compass needle.

Demo 19-18 Demagnetizing Iron by Hammering

A magnet is produced by placing an iron rod in a solenoid and pulsing a large current in the solenoid coil, as in Demonstration 17. Such a magnet can then be demagnetized by tapping it on the end very violently with a hammer, as shown in the video.

If we put this iron bar inside a solenoid coil and repeatedly pulse a large current through the coil, the bar becomes magnetized.

It strongly affects a compass needle when held nearby.

If we pound on the bar with a hammer, it loses most of its magnetization.

Now the bar has little effect on the compass needle.

Equipment

1. Same as Demonstration 19-17.
2. Hammer.

Demo 19-19 Barkhausen Effect

A piece of iron becomes magnetized as its magnetic domains individually align with an external magnetic field.† The iron sample is placed in a many-turn coil, shown in *Figure 1*. As the domains flip they will create small magnetic impulses that in turn induce small electrical signals in the coil. These electrical impulses are fed into an audio amplifier so that the flipping of the domains can be "heard" as a series of small clicks. The sum of the clicks is observed as static on the loudspeaker.

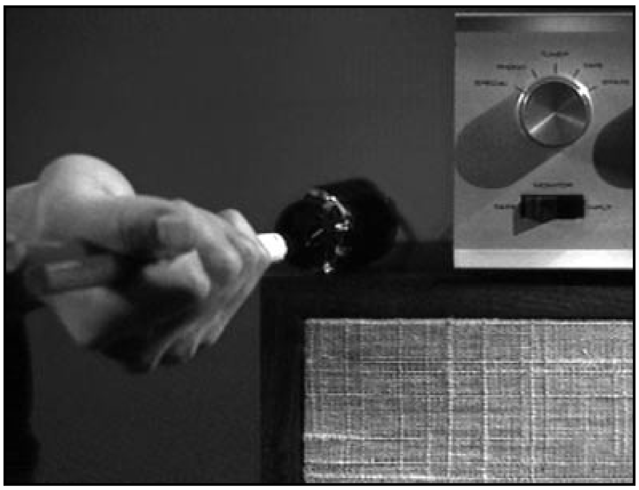

Figure 1

† Sutton, *Demonstration Experiments in Physics*, Demonstration E-94, Barkhausen Effect. Freier and Anderson, *A Demonstration Handbook for Physics*, Demonstration Es-1, Barkhausen Effect.

We'll use this coil wrapped around a soft iron core and a bar magnet to show the existence of magnetic domain.

Any changes of magnetization of the iron inside the coil will send small currents through the coil, which will be amplified and fed into a speaker. When the bar magnet is brought up to the tube, a rustling sound is heard as the domains in the iron change orientation.

This is called the Barkhausen effect.

Equipment

1. Small coil with a soft iron core.
2. Amplifier.
3. Speaker.
4. Appropriate electrical leads.
5. AC power.
6. Strong bar magnet.

Demo 19-20 Magnetic Shielding

An electromagnet is seen to readily support a collection of nails with its field. When sheets of non-magnetic materials are placed between the magnet and the nails this situation is unaffected, as seen in *Figure 1* for a copper sheet. However, when sheets of iron are inserted between the magnet and the nails, the magnetic field lines follow the iron plate, shielding the nails from the magnet so they fall off the magnet.†

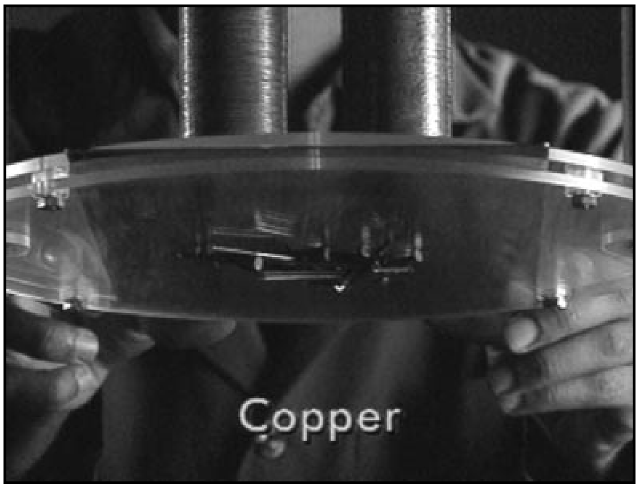

Figure 1

† Sutton, *Demonstration Experiments in Physics*, Demonstrations E-105, Magnetic Screening, and E-106.

Some materials are strongly affected by magnetic fields.

Can such materials also have a strong effect on magnetic fields? We'll use this electromagnet and sheets of various materials to find out.

When the electromagnet is turned on, these iron nails are held against an acrylic plate by the magnetic field. We'll slide sheets of various materials between the magnet and the nails to see if there is any effect.

This is a copper sheet.

This is an aluminum sheet.

This is an iron sheet.

Now we'll add a second iron sheet to the first.

Equipment

1. Large horseshoe-shaped permanent magnet.
2. Nails.
3. A suspended electromagnet and its supporting framework, including two sizable clear plastic discs that in turn are centered and mounted just below the electromagnet with a small gap between.
4. One sheet of copper, one of aluminum, and two of iron, which are slipped between the acrylic disc that separates the electromagnet from the "captured" nails.
5. DC power.

Demo 19-21 Permalloy in Earth's Field

Permalloy is a material that is very easily magnetized. If a thin rod of permalloy is aligned perpendicular to the magnetic field lines of the earth, it will remain unmagnetized. On the other hand, if the permalloy rod is aligned along the earth field lines it becomes magnetized, and is able to pick up a small iron strip, as seen in *Figure 1*.†

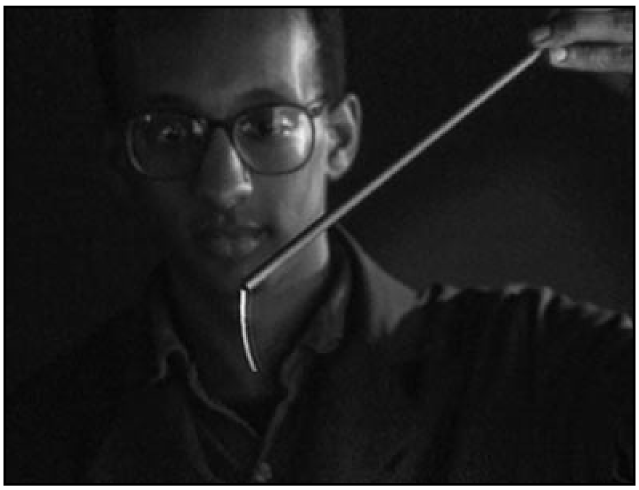

Figure 1

† Sutton, *Demonstration Experiments in Physics*, Demonstration E-80, Magnetization by Mechanical Disturbance in Earth's Field.
Freier and Anderson, *A Demonstration Handbook for Physics*, Demonstration Er-9, Permalloy Bar.

This rod of Permalloy metal is so named because of its high permeability to magnetic fields.

When the rod is aligned with the direction of the Earth's magnetic field, a small strip of iron sticks to the end.

The strip drops off when the rod is rotated 90 degrees.

This animation shows how the lines of the Earth's magnetic field are concentrated through the length of the Permalloy rod when it is aligned with the Earth's field. When the rod is rotated 90 degrees, the magnetic field lines are only slightly affected by the rod.

Equipment

1. Permalloy metal rod.
2. Small strip of iron ribbon.

Demo 19-22 Paramagnetism and Diamagnetism

Ferromagnetic materials are strongly attracted by a magnetic field, and non-magnetic materials are totally unaffected by static magnetic fields. Two other classes of materials exist: *paramagnetic* materials, which are weakly attracted by magnetic fields, and *diamagnetic* materials, which are weakly repelled by magnetic fields.† This demonstration illustrates the paramagnetism of copper sulfate crystals and the diamagnetism of a bismuth crystal by bringing a strong magnet near samples of these substances using the arrangement shown in *Figure 1*.

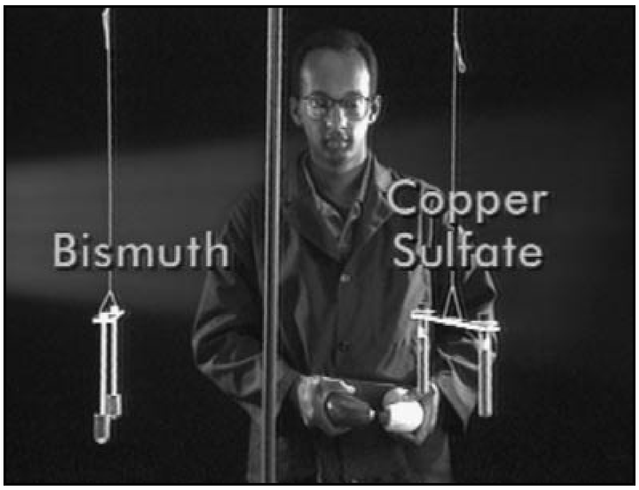

Figure 1

† Sutton, *Demonstration Experiments in Physics*, Demonstration E-102, Paramagnetism and Diamagnetism.
Freier and Anderson, *A Demonstration Handbook for Physics*, Demonstration Es-4, Paramagnetism.

We'll use these samples of bismuth and copper sulfate suspended from a light thread to show two types of magnetisms, paramagnetism and diamagnetism.

Unlike ordinary ferromagnetism, which is a strong effect, para and diamagnetism are weak effects, and exert small forces.

When the poles of a large horseshoe magnet are placed around the bismuth, the bismuth is weakly repelled by the magnetic field. This is an example of diamagnetism.

The copper sulfate is weakly attracted into the strongest part of the field, an example of paramagnetism.

Equipment

1. Tall ring stand.
2. Cross bar and a right angle clamp and two ring hooks.
3. Two samples of bismuth, drilled and tapped to fit plastic threaded rods that hang down from a plastic suspension bar, which is free to rotate at the end of a piece of string that hangs down from the cross bar above.
4. Two samples of copper sulfate in glass test tubes counter-balancing each other from a similar plastic suspension bar, which is free to rotate, as above, but on the opposite side of the support system.
5. Very strong permanent magnet where the pole faces are turned inward toward one another.

Demo 19-23 Dysprosium in Liquid Nitrogen

The Curie point of a magnetic material is the temperature above which the material becomes non-magnetic. Dysprosium is magnetic at the temperature of liquid nitrogen and non-magnetic at room temperature. A small piece of dysprosium is held by a string near a strong magnet to which it is attracted after the dysprosium is dipped into a liquid nitrogen bath, as seen in *Figure 1*. As the dysprosium sample warms up, it reaches its Curie temperature, becomes non-magnetic, and falls away from the magnet.

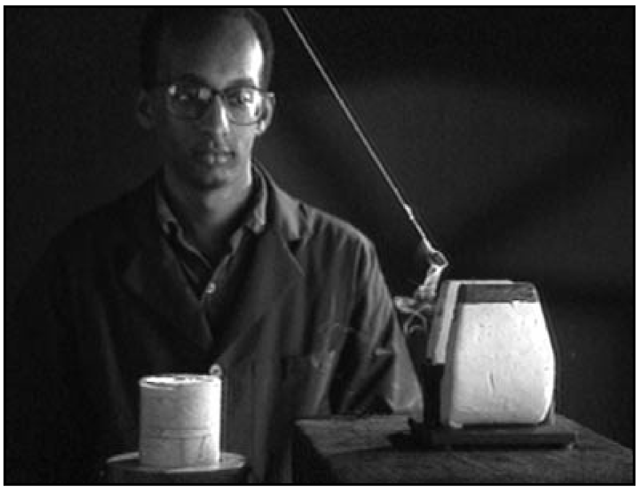

Figure 1

We'll use this piece of dysprosium metal to demonstrate the effects of changing temperatures on magnetic properties.

If we cool the dysprosium to the temperature of liquid nitrogen and bring it near a magnet, it is strongly attracted to the magnet.

When the dysprosium warms up, it loses its magnetic properties and falls away from the magnet.

If the dysprosium is again cooled in the liquid nitrogen,

it regains its magnetic properties.

Equipment

1. Piece of dysprosium metal in a cradle of thin copper wire and length of low mass string.
2. Suspension system.
3. Strong permanent magnet.
4. Dewar of liquid nitrogen.

Demo 19-24 Curie Nickel

Nickel is magnetic at room temperature but can be raised above its Curie temperature using a burner.† A Canadian five-cent piece is used as the nickel sample for this demonstration, as shown in *Figure 1*. The nickel, initially at room temperature, is held by a wire near a strong magnet, to which it is attracted, as seen in *Figure 1*. When the nickel is heated above its Curie temperature using a burner, it becomes non-magnetic and falls away from the magnet.

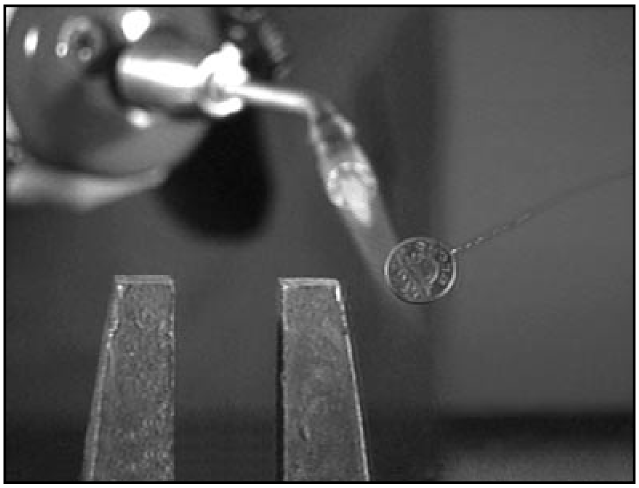

Figure 1

† Sutton, *Demonstration Experiments in Physics*, Demonstration E-103, Effect of Temperature on Magnetic Properties of Nickel.

Curie Nickel / Script

We'll use this Canadian nickel to demonstrate the effect of heating on magnetic materials.

When the nickel is at room temperature, it is strongly attracted to a magnet.

If we heat the nickel above its critical temperature, known as the Curie temperature, it loses its magnetic properties.

When the nickel cools, it again becomes magnetic.

Equipment

1. Strong permanent magnet.
2. Canadian nickel attached to a length of wire.
3. Suspension system for the nickel and wire.
4. Gas torch.
5. Source of flame.

Demo 19-25 Curie Temperature Wheel

A solid wheel, constructed from an alloy of 70% iron and 30% nickel, is free to rotate near a strong magnet mounted on the post just to the left of the wheel in *Figure 1*. When light from a bright arc lamp is focused onto the surface just above the magnet, that part of the magnetic material is raised above its Curie point and becomes non-magnetic. Thus there is a net force pulling upward on the nickel just below the magnet, and the wheel will rotate slowly clockwise as viewed in *Figure 1*.

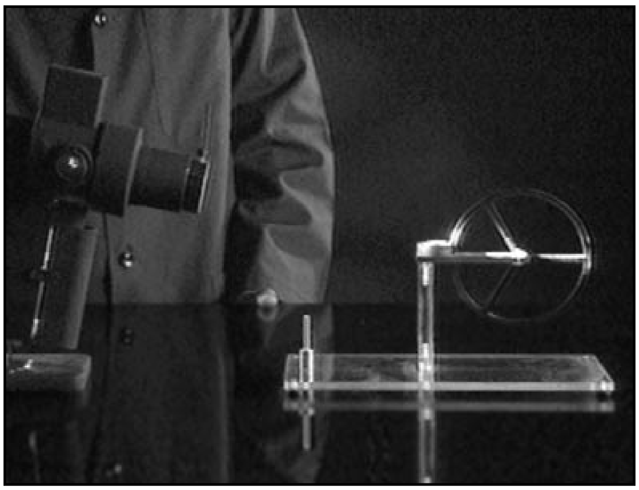

Figure 1

We'll use this wheel made of nickel to demonstrate the effect of heating on magnetic materials.

One edge of the wheel passes through the arms of a small horseshoe magnet. Since the portions of the wheel above and below the magnet are both equally attracted to the magnet, the wheel does not rotate. If we heat the portion of the wheel just above the magnet by focusing the light from an arc lamp at that point, the wheel begins to rotate.

The heated part of the wheel has lost its magnetic properties and is no longer attracted to the magnet. The cooler section below the magnet is then pulled up into the magnet and the wheel begins to rotate.

Equipment

1. Small wheel with a nickel rim is suspended and free to easily rotate between the poles of a small horseshoe magnet.
2. Arc lamp with a focusing lens.
3. Power for the arc lamp.