Magnetic Forces

Background:

Magnetism is a force observed in the attraction of iron by certain metals, including magnetized iron, nickel, and cobalt. The magnetic force can be felt but it cannot be seen. It can effect the movement of magnetic objects from a distance. The strength of the magnetic pull decreases as you move farther from the magnet.

Magnets have two poles, which are given the names North and South. By definition, the magnetic field lines leave the North pole of a magnet and return to the South pole of the magnet. If a magnet is cut in half between the poles, each piece will have a North and South magnetic pole. If two magnets are connected so that the south pole of one is at the north pole of the other, their fields will join making a single magnetic field.

Experiments:

1) Use a compass to determine the polarity of the end of each magnet in the display and label them on the chart below.
2) Construct a string of washers from a North pole on one magnet to a South pole an adjacent magnet. Make a sketch of your string.

3) Each magnet has a North and South pole. Determine the location of each pole and construct a string of washers from a North pole to the South pole of the same magnet. Make a sketch of your string.
Magnetic Interactions

Background:

Poles of magnets interact with one another. When two magnets are brought together so that the opposite poles come together, the magnets will attract each other. The magnetic field lines of one magnet flow into the opposite pole of the other magnet. Longer field lines form around the combined magnets connecting their distant ends, essentially turning the separate magnets into a single magnet.

When the magnets are brought together so that the like poles (both North poles or both South poles) come together, the magnets will repel or push away from each other. Magnetic field lines can not cross each other, so as the magnets are brought together the magnetic field lines of the adjacent ends of the magnets are compressed before looping around to the other end of the magnet. The compression can be felt as a pressure pushing between the magnets.

When magnetic materials are placed between magnets, they can provide a path for the field lines, allowing like poles to come closer without repelling each other. This is not true when non-magnetic materials are placed between the magnets.

Experiments:

1) Bring the red end of one magnet to the black end of the other magnet. Write a description what happens.

2) Bring the red ends of both magnets together. Write a description of what happens.

3) One at a time, raise one of the materials and test to see if it is magnetic, then bring the same poles of the magnets together to see the effect of the material on the interaction.

<table>
<thead>
<tr>
<th>Material</th>
<th>Magnetic (yes/no)</th>
<th>Interaction (magnets attract/repel)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td></td>
<td></td>
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<tr>
<td>Steel (square)</td>
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<td></td>
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<tr>
<td>Plastic</td>
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<tr>
<td>Aluminum</td>
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<tr>
<td>Steel (finger shape)</td>
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Magnetizing a Piece of Metal

Background:

Some metals like soft iron or steel become temporarily magnetized in the presence of a strong magnetic field. This is why you can make a chain of paper clips or other small objects hang from a permanent magnet. The reason these materials can temporarily become magnetic is that inside of them are tiny magnetic domains, like little bar magnets. The internal magnetic domains are randomly aligned so that the piece of metal does not have its own magnetic field. As the piece of metal is brought into a strong magnetic field, some of the internal magnetic domains line up with the outside field, temporarily making the piece of metal into a magnet.

Experiments:

1) Hold a nail over a small pile of paperclips and slowly lift the nail. Do the paper clips show any sign of magnetic attraction?

2) Hold the same nail over the paper clip pile while holding a magnet to the other side of the nail and slowly lift the nail. Do the paperclips show any sign of magnetic attraction?

3) Take the magnet away from the end of the nail. What happens to the paper clips?

More Background:

If you are able to line up enough magnetic domains in a piece of metal, you can give it a permanent magnetic field. You can do this by repeatedly stroking a piece of metal, in one direction, using the same end of a magnet. Another way is to use the Earth’s magnetic field and a mechanical shock to get the domains to line up. If a long piece of metal is aligned with Earth’s magnetic field, and you hit the end with a hammer several times the magnetic domains will line up with the Earth’s magnetic field. This is one way early experimenters created magnets.
Seeing Magnetic Fields

**Background:**

Magnetic fields are invisible; however, it is possible to see the location of magnetic lines of force by their effect on metal filings that line up along the magnetic field lines. The image at the right shows a device in which iron filings are suspended in clear oil, allowing them to move in the magnetic fields.

**Experiments:**

1) Rock the viewer to distribute the iron filings evenly inside the panel, and then place the panel over a cow magnet as drawn below to see the lines of force around the magnet. Make a sketch of the magnetic field lines.

2) Rock the viewer to distribute the iron filings evenly inside the panel and place the panel over two cow magnets lined up as drawn below to see how the lines of force interact. Make a sketch of the interacting magnetic field lines.
3) Rock the viewer to distribute the iron filings evenly inside the panel. Reverse the ends of one of the magnets and then place the panel over the two magnets again to see how the lines of force interact. Make a sketch of the interacting field lines.

4) In which of the experiments above (2 or 3) are the ends of the magnets attracting one another? Where are the most lines of force between the interacting magnets – in other words where the interaction is the strongest?

5) Shake the 3 dimensional magnetic field viewer to distribute the iron filings evenly through the oil in the viewer, and then place one cow magnet in the hole through the viewer to see the location of the magnetic field lines around the cow magnet in 3 dimensions.
Electromagnets

Background:

When an electric current flows through a wire it creates a magnetic field circling the wire. This effect was first investigated by Hans Christian Oersted after he saw a compass needle deflecting while he was conducting electrical experiments.

The direction of the magnetic field can be determined by applying the Right Hand Rule – placing your right palm in the direction of the wire, with your thumb pointed in the direction the current flows, your fingers will wrap around the wire in the direction of the magnetic field.

Experiments: