The green magnet and lower red magnet attract each other.

The lower red magnet and the yellow magnet repel each other.

Magnetic Forces

- How do magnetic poles interact?
- Like magnetic poles repel one another, and opposite magnetic poles attract one another.

Magnetic Forces

Magnetic force is the force a magnet exerts on another magnet, on iron or a similar metal, or on moving charges.

- Magnetic force is one aspect of electromagnetic force.
- Magnetic forces, like electric forces, act over a distance.
- Magnetic force, like electric force, varies with distance.

Magnetic Forces

All magnets have two **magnetic poles,** regions where the magnet's force is strongest.

- One end of a magnet is its north pole.
- The other end is its south pole.
- The direction of the magnetic force between two magnets depends on how the poles face.

Magnetic Fields

- **How can a magnetic field affect a magnet that enters the field?**
- **A magnetic field, which is strongest near a magnet's poles, will either attract or repel another magnet that enters the field.**

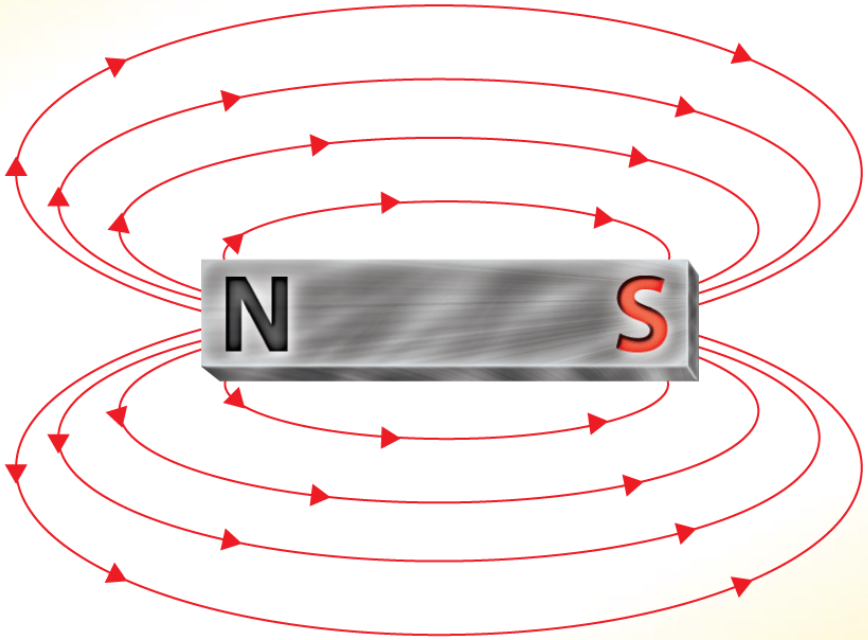
Magnetic Fields

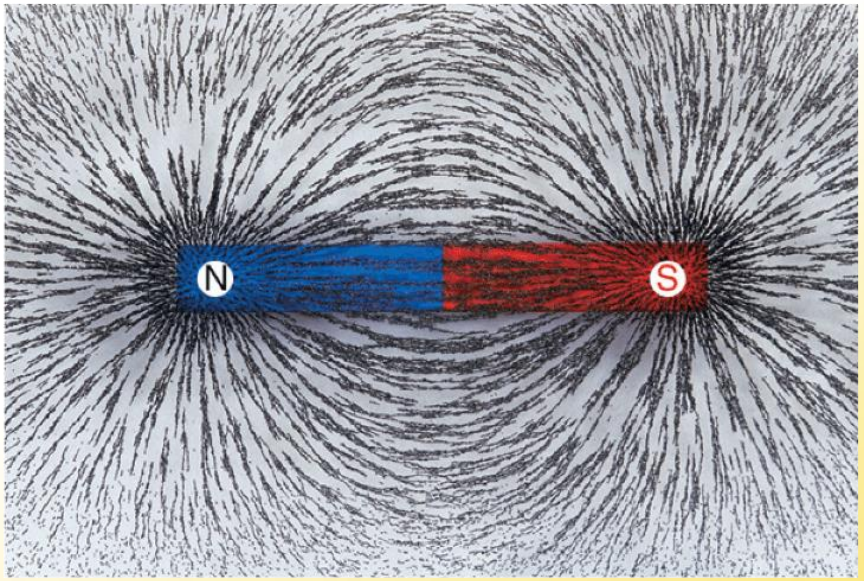
A **magnetic field** surrounds a magnet and can exert magnetic forces. Magnetic field lines begin near the north pole and extend toward the south pole.

- The arrows on the field lines indicate what direction a compass needle would point at each point in space.
- Where lines are close together, the field is strong.
- Where lines are more spread out, the field is weak.

Magnetic Fields

A magnetic field surrounds every magnet. Iron filings reveal the field lines, which start near the north pole and extend toward the south pole.





Magnetic Fields

Magnetic Fields Around Magnets

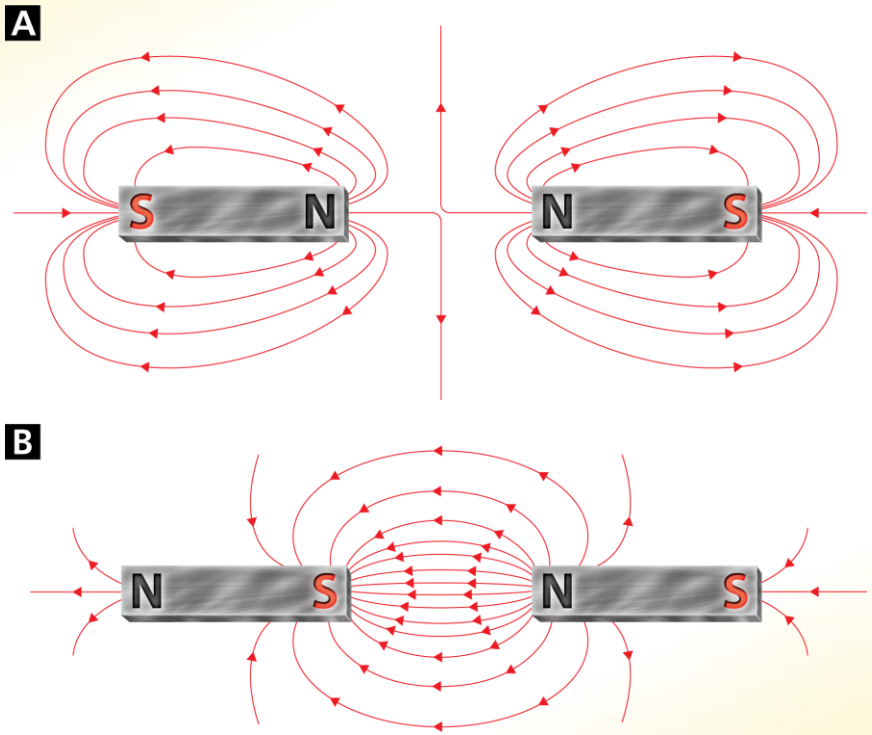
You can use iron filings to visualize how magnetic fields of two magnets interact.

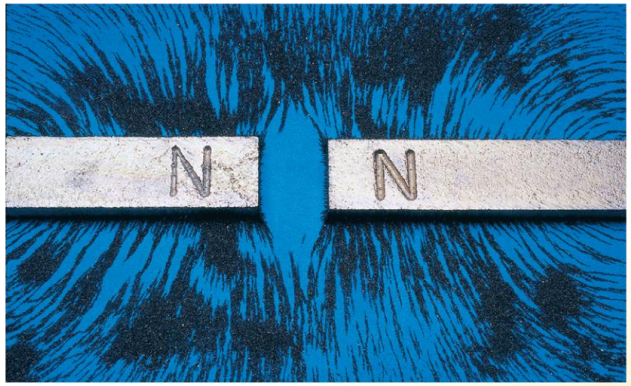
The strength of the magnetic field in a particular area is indicated by the density of iron filings.

Magnetic Fields

A. When like poles of two magnets come together, the magnets repel each other.

B. When opposite poles of magnets come together, the magnets attract each other.





Magnetic Fields

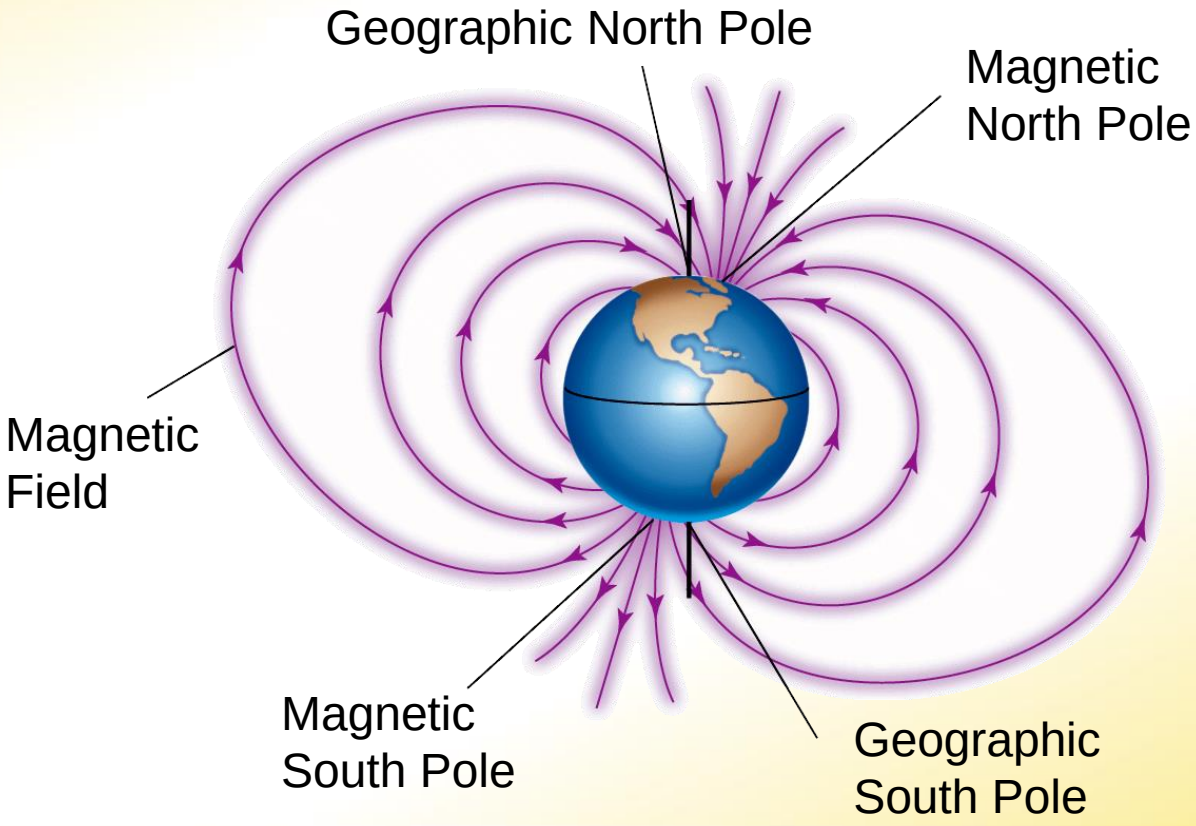
Magnetic Field Around Earth

Earth is like a giant magnet surrounded by a magnetic field. The area surrounding Earth that is influenced by this field is the **magnetosphere**.

A compass points north because it aligns with Earth's magnetic field.

Magnetic Fields

Earth is surrounded by magnetic field lines. These lines are densest at the poles.



Magnetic Materials

Why are some materials magnetic while others are not?

A **magnetic domain** is a region that has a very large number of atoms with aligned magnetic fields.

When a material is magnetized, most of its magnetic domains are aligned.

Magnetic Materials

A property of electrons called “spin” causes electrons to act like tiny magnets.

- In many materials, each electron is paired with another having an opposite spin so magnetic effects mostly cancel each other.
- Unpaired electrons in some materials produce magnetic fields that don’t combine because of the arrangement of the atoms.

Magnetic Materials

In a few materials, such as iron, nickel, and cobalt, the unpaired electrons make a strong magnetic field.

- The fields combine to form magnetic domains.
- A **ferromagnetic material, such as iron,** can be magnetized because it contains magnetic domains.

Magnetic Materials

Nonmagnetized Materials

The fact that a material is ferromagnetic does not mean it is a magnet.

If the domains of a ferromagnetic material are aligned randomly, it is not a magnet.

Magnetic Materials

Magnetized Materials

If you place a nonmagnetized ferromagnetic material in a magnetic field, it will become a magnet when the domains are aligned.

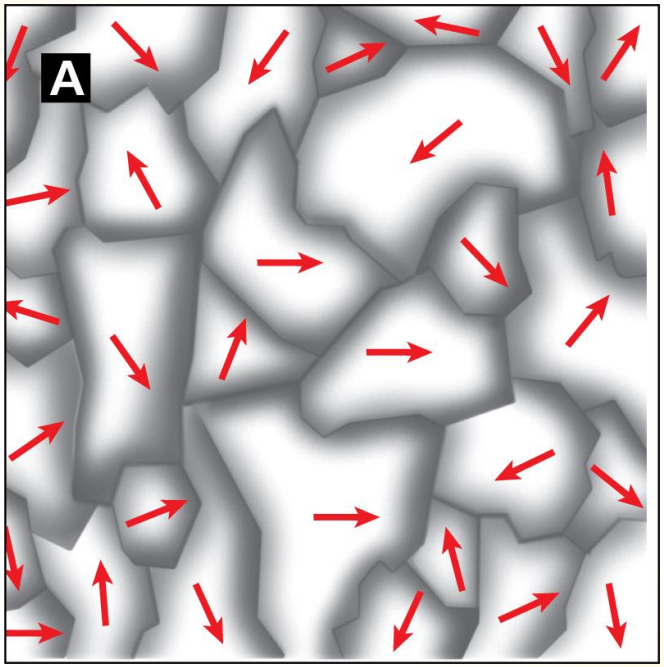
- Magnetization can be temporary. If the material is moved away from the magnet, the magnetic domains become random.
- In some ferromagnetic materials, the domains stay aligned for a long time. These materials are called permanent magnets.

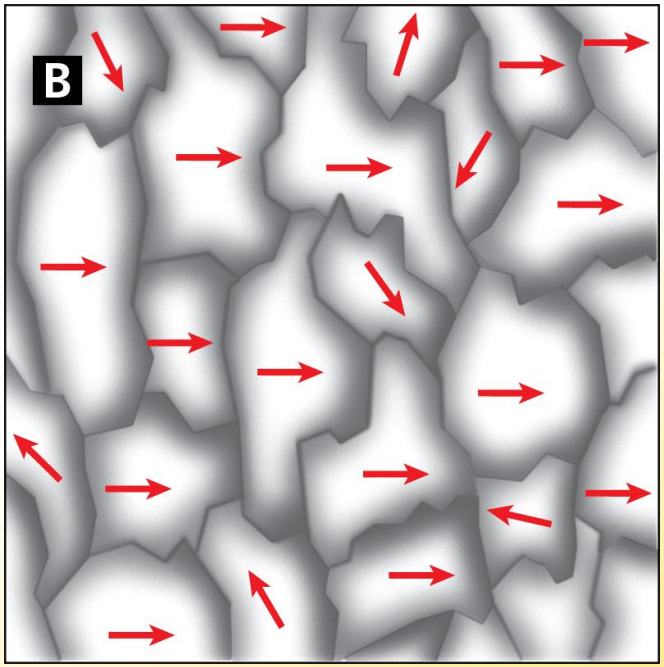
Magnetic Materials

A magnetic field can magnetize ferromagnetic materials.

A. Before magnetization, domains are random.

B. Domains aligned with the field grow during magnetization. Unaligned domains can shrink.





Magnetic Materials

If you cut a magnet in half, each half will have its own north pole and south pole because the domains will still be aligned.

A magnet can never have just a north pole or just a south pole.

Assessment Questions

1. Where does the magnetic field of a magnet have the strongest effect on another magnet?
   a. the north pole
   b. the south pole
   c. both poles equally
   d. midway between the two poles

Assessment Questions

1. Where does the magnetic field of a magnet have the strongest effect on another magnet?
   a. the north pole
   b. the south pole
   c. both poles equally
   d. midway between the two poles

   ANS: C

Assessment Questions

2. How are the magnetic field lines drawn to show the interaction of two bar magnets that are lined up with their north poles near one another?
   a. Field lines begin at the north pole of each magnet and extend to the south pole of the other magnet.
   b. Field lines begin at each magnet's north pole and extend toward its south pole.
   c. Field lines extend from the north pole of one magnet to the north pole of the other magnet.
   d. Field lines cannot be drawn because the magnetic forces cancel one another.

Assessment Questions

2. How are the magnetic field lines drawn to show the interaction of two bar magnets that are lined up with their north poles near one another?

   a. Field lines begin at the north pole of each magnet and extend to the south pole of the other magnet.

   b. Field lines begin at each magnet's north pole and extend toward its south pole.

   c. Field lines extend from the north pole of one magnet to the north pole of the other magnet.

   d. Field lines cannot be drawn because the magnetic forces cancel one another.

   ANS: B

Assessment Questions

3. Why does a compass not point exactly toward the geographic north pole?
   a. Earth's magnetic field is constantly changing due to effects of the solar wind.
   b. The magnetic pole is near but not exactly at the geographic pole.
   c. Earth's magnetic field lines are too broad for a compass point exactly toward the pole.
   d. Daily variations in the magnetic field mean that compasses are not very accurate.

Assessment Questions

3. Why does a compass not point exactly toward the geographic north pole?
   a. Earth's magnetic field is constantly changing due to effects of the solar wind.
   b. The magnetic pole is near but not exactly at the geographic pole.
   c. Earth's magnetic field lines are too broad for a compass point exactly toward the pole.
   d. Daily variations in the magnetic field mean that compasses are not very accurate.

   ANS: B

Assessment Questions

4. What happens to a permanent magnet if its magnetic domains lose their alignment?
   a. The magnetic field reverses direction.
   b. It loses its magnetic field.
   c. It has several north poles and several south poles.
   d. It is no longer a ferromagnetic material.

Assessment Questions

4. What happens to a permanent magnet if its magnetic domains lose their alignment?
   a. The magnetic field reverses direction.
   b. It loses its magnetic field.
   c. It has several north poles and several south poles.
   d. It is no longer a ferromagnetic material.

   ANS: B