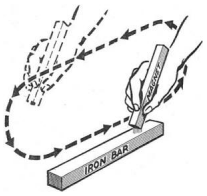
SPH3U UNIVERSITY PHYSICS

ELECTRICITY & MAGNETISM

- Magnetic Materials (P.~)

Magnetic Materials

Small pieces of iron rubbed in one direction with lodestone become magnetized. Even bringing a piece of iron near a magnet causes the iron to be magnetized. Nickel and cobalt, and any alloy containing nickel, cobalt, or iron, behave in the same way. These substances are called ***ferrogmanetic****, and you can induce them to become magnetized by rubbing them with a magnet or placing them in a magnetic field.*



Magnetic Materials

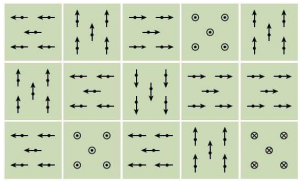
Substances that can become instantly magnetized (or unmagnetized) are called ***soft ferromagnetic materials****. Iron can be alloyed with certain materials, such as aluminum and silicon, so that the iron maintains its magnetic abilities even when the magnetizing field is removed. These alloys are used to make permanent magnets and are referred to as* ***hard ferromagnetic materials****.*

FERROMAGNETIC MATERIAL

- substance that can become magnetized
- soft ☞ quickly becomes magnetized/unmagnetized
- hard ☞ retains magnetic properties

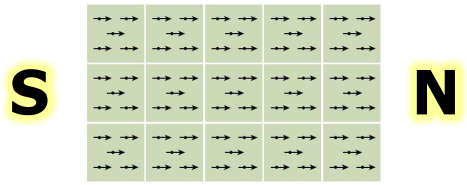
Domain Theory of Magnetism

*The atoms of ferromagnetic substances can be thought of as tiny magnets with N-poles and S-poles. These atomic magnets, or **dipoles**, interact with the nearest neighbouring dipoles and a group of them line up with their magnetic axes in the same direction to form a **magnetic domain**. An unmagnetized piece of iron contains millions of these domains, but they are pointing in random directions so that the piece of iron, as a whole, is not magnetized.*



Domain Theory of Magnetism

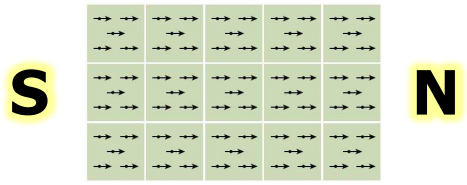
When an unmagnetized piece of iron is placed in a magnetic field (that is, near another magnet), the dipoles act like small compasses and rotate until they are aligned with the field. The piece of iron will then contain a large number of dipoles pointing north, causing one end to become a N-pole, and the other end to become a S-pole.



Domain Theory of Magnetism

NOTE!

*In most magnets many (but not all) of the dipoles are aligned in the same direction. The strength of the bar magnet can be increased only up to a certain point. This occurs when the maximum number of dipoles are aligned. The material is then said to have reached **magnetic saturation**.*



Domain Theory of Magnetism

DIPOLES

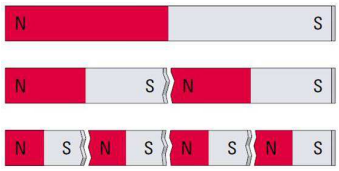
- atoms of ferromagnetic substances that act like tiny magnets

MAGNETIC DOMAIN

- formed by a group of dipoles
- magnetic axes line up in the same direction

Domain Theory of Magnetism – DYK?

Breaking a bar magnet produces two pieces of iron whose dipole alignment is identical to the original piece. Both pieces will also be magnets, with N-poles and S-poles at opposite ends. Continued breaking will produce the same results.

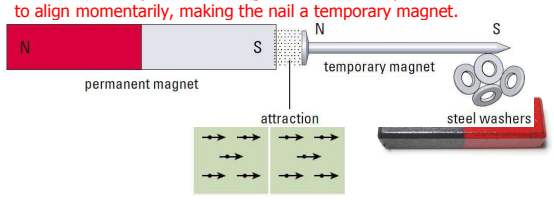


Magnetic Materials

PRACTICE

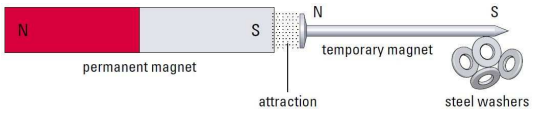
1. Why does a permanent magnet brought near an iron nail cause the nail to become a temporary magnet?

The field of the permanent magnet causes the dipoles in the iron nail to align momentarily, making the nail a temporary magnet.



Magnetic Induction

*This process of magnetizing an object from a distance is called **magnetic induction**.*



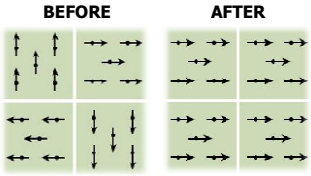
NOTE!

If magnetic induction is applied to a steel nail rather than an iron nail, the dipoles of the steel tend to retain their alignment for a longer time due to the carbon atoms in the steel. This causes the steel to act more like a permanent magnet.

Magnetic Induction

MAGNETIC INDUCTION

- process of magnetizing an object from a distance
- causes a realignment of the dipoles

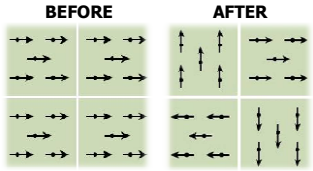


Magnetic Induction – DYK?

If a piece of iron is held in Earth's magnetic field and its atoms are agitated, either by heating or by mechanical vibration (that is, by hitting the iron with hammer), its dipoles will align. This is most easily accomplished by holding the piece of iron pointing north while tapping it with a hammer. Steel columns and beams used in building construction are usually found to be magnetized. Steel hulls of ships and railroad tracks are also magnetized by Earth's magnetic field.

Demagnetization

*When a piece of iron becomes **demagnetized**, its aligned dipoles return to random directions. Dropping or heating an induced magnet will cause this to occur. Some materials, such as pure iron, revert to random alignment as soon as they are removed from the magnetizing field. A bar magnet will become demagnetized over time because of random thermal motion of the atoms of the bar magnet.*



Demagnetization

DEMAGNETIZATION

- dipoles return to random directions
- methods include:
  - remove magnetizing field
  - drop
  - heat
  - time

Demagnetization – DYK?

Magnets can be stored with small pieces of soft iron (called "keepers") across the ends, so that demagnetization does not occur. The keepers themselves become strong induced magnets and form closed loops of magnetic dipoles that prevent the poles from demagnetizing.

Magnetic Materials

PRACTICE

2. (a) Describe how a screwdriver can be magnetized.
   (b) What might happen if the magnetized screwdriver were heated or dropped? Explain.

(a) rub/stroke the screwdriver in one direction with a magnet
(b) it would lose its magnetism – causes the dipoles to realign

Magnetic Materials

PRACTICE

3. The lodestone discovered in Magnesia was a naturally magnetized substance. Describe the process whereby the magnetism likely occurred. (Hint: volcanic eruptions are common geological events.)

lava is ejected – before the lava cools the dipoles in the molten rock (iron) align themselves with Earth's magnetic field – lava cools and naturally magnetized substance is created