

Lesson 16: Domain Theory

As mentioned in the last lesson, there are theories that magnetic poles should be able to be separated from each other, although no one has ever been able to actually do it.

- Instead, if a bar magnet is cut in half you get two *new* magnets, each with its own north and south poles.
- This means that any current theory of magnetism should be able to explain the dipolar nature of magnets.

This lesson is a bit iffy. Because the most modern theories predict the existence of monopoles, domain theory itself may eventually prove to be wrong. At present, it still serves as a good model of the behavior of magnets, especially at a high school level. In this way it is sort of like using the Bohr model of the atom in Chem; we know it isn't perfect, but it serves its purpose in our studies.

Microscopic examination reveals that a magnet is actually made up of tiny regions known as **domains**.

- Domains are at most about 1mm in length or width.
- Each domain behaves like a miniature magnet with its own north and a south pole.
 - In an unmagnetized ferromagnetic object (like a bar of iron) these domains are arranged randomly so that their magnetic effects cancel each other out. This means it is *not* a magnet.
 - In a magnet, the domains are basically lined up in one direction so that they create an overall uniform magnetic field.

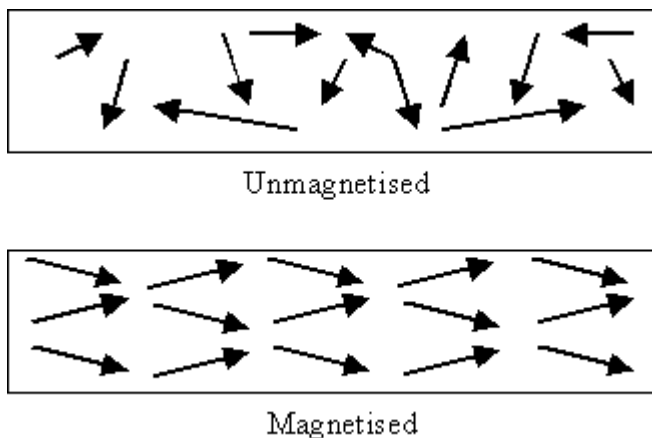


Illustration 1: Domains in a non-magnet and a magnet.

Domain theory suggests that these domains are created by the motion of electrons.

- All electrons in an atom basically orbit the nucleus. They also spin on their axis as they orbit the nucleus.
- The combined effect of this motion creates (we sometimes use the word **induces**) a tiny magnetic field.
 - Many electrons doing this at once gives rise to the domains that we measure.

A magnet can be made from an unmagnetised piece of iron by placing it in a strong magnetic field.

- This forces the domains to rotate slightly so they line up more to external magnetic field.
- It is also possible that the domains that already line up with the external magnetic field grow in size while the other domains shrink.

Warning!

All matter contains electrons, so all matter has domains. If this is true, then why can't anything be a magnetic. The reason is that only ferromagnetic materials can rearrange their domains to line up. The exact reason for this property of ferromagnetic materials is not entirely understood.

Domain theory is able to explain things like how a magnet can pick up unmagnetised pieces of iron (like some paper clips).

- The magnet's field causes a slight alignment of the domains in the unmagnetised object.
 - The object becomes a temporary magnet with its north pole facing the south pole of the other magnet.
- Once the magnet is removed, the other objects will often go back to having random domains.

This is the difference between **permanent** and a **temporary** magnet.

- This depends mostly on how the metal is forged.
- If the domains are pretty much locked in place, then a **permanent magnet** will be formed. If this is done with iron, it is called **hard iron**.
- If the domains can be moved around easily, then **temporary magnets** will be formed. This would be **soft iron**.
 - Soft iron is useful if you want to make something like an electromagnet to pick up cars. It allows the magnetic field to be "switched" off and on. We will look at electromagnets in more detail later.

The terms "**hard**" and "**soft**" iron only refer to its magnetic properties. Neither of the two irons is actually physically harder or softer than the other.

Domain theory also gives us an easy way to look at demagnetizing an existing magnet.

- If you drop a magnet on the floor or strike it with a hammer, you are basically adding energy to the atoms of magnet.
 - Some of this extra energy will cause the atoms (and the electrons) to jiggle around more randomly.
 - This will screw up the alignment of the domains.
- Heating a magnet has pretty much the same effect, since raising the temperature will also increase the random motion of the electrons and domains.
 - Above a certain temperature, known as the **Curie temperature** (1043 K for iron), a magnet cannot be made at all.

Remember that "**K**" stands for "degrees **Kelvin**." To convert it to degrees Celsius, just subtract about 273°.