A Review of Magnetism

The term 'magnet' comes from a region of Asia Minor where iron-rich rocks that were attracted to each other were discovered. Today a magnet is defined as a material that attracts **iron**, **nickel**, **cobalt** or **gadolinium**, collectively called ferromagnetic.

Some properties of magnets:

- every magnet contains a north and south pole; cutting a magnet in half will simply create two new magnets, each with a north and south pole
- magnetic effects are strongest at the poles
- when dangled from a string, the pole that points north is labelled 'north'
- two nearby magnets exert a force on each other; in terms of magnetic poles:
  - unlike poles attract
  - like poles repel
- all magnets and magnetic materials consist of **domains**

Magnetic Domains

Magnetism is produced as a result of the motion of electrons. That means:

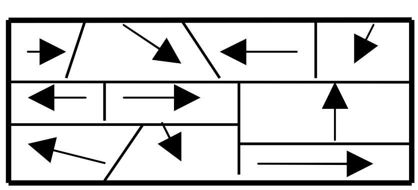
- an electron orbiting the nucleus of an atom produces a magnetic field
- an electron spinning on its own axis also produces a magnetic field

Therefore, every atom of every element produces some magnetism. However, most elements are non-magnetic. This is because, in atoms of most elements, the motions of electrons are not "in sync" with each other. This causes the atoms to have almost no magnetic field, and as such, magnetic properties are not noticed in most elements.

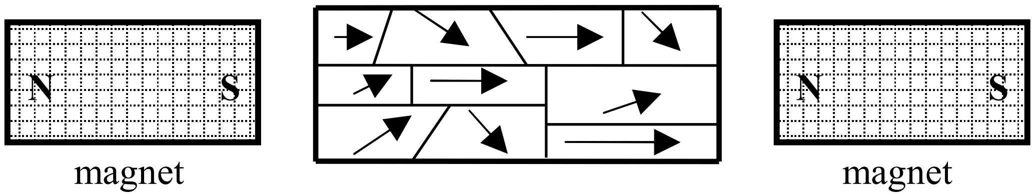
On the other hand, *ferromagnetic* materials such as iron, cobalt, nickel and gadolinium have atoms in which the motions of electrons are very similar to each other. These motions create strong magnetic fields in the atoms of these elements. Additionally, their atoms also tend to form groups of atoms in which magnetic fields are lined up in the same direction. These groups are called *domains*.

Domains of ferromagnetic materials have some interesting properties:

- they act as miniature magnets, each with a north and south pole.
- they are aimed in different directions if they are un-magnetized, and are randomly arranged.



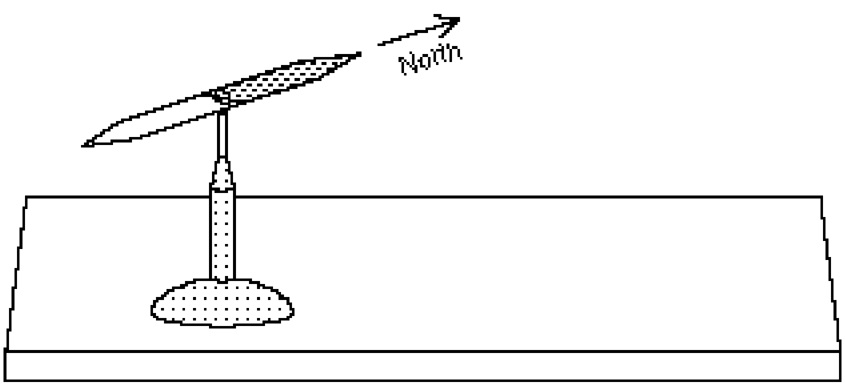
- they will generally line up in the same direction as any external magnetic field they are exposed to, making the material temporarily *magnetic*.



- this temporary magnet will have its north pole facing the south pole of the permanent magnet; hence, attraction occurs.
- e.g., a paper clip made of iron and some nickel will become a magnet if it is placed in some external magnetic field.
- once the magnetic field is removed, the temporary magnet is no longer magnetic.

Note that some materials make good *permanent magnets*, because their domains tend to stay in the same position even after an external magnetic field is removed. However, the term "permanent" is somewhat misleading, since magnetism can be lost in these devices if their domains become disordered. This can occur if the magnets are dropped or banged together, heated up, or placed the wrong way in a strong external magnetic field.

The needle of a compass is an example of a permanent magnet, placed on a pivot and free to swing, with one end attracted to the north magnetic pole of the Earth.



Note that magnetic North is not geographic North, but instead is located about 1500 km away, on Bathhurst Isl. (NWT)