Next Gen PET

UNIT M

Summary Ideas

MODEL OF MAGNETISM

Historical Perspective

Magnetism is one of the earliest known physical phenomena. The ancient Greeks studied naturally occurring magnets (called lodestones) and the basic properties of magnetic interactions were discovered before 600 BC.

By the end of the 17th century, William Gilbert had identified two different poles of a magnet. He described attraction in terms of “harmony” and repulsion in terms of “discord.” Gilbert also noticed that by cutting a magnet in half, he could produce two pieces that acted as individual magnets. His *harmony and discord* model could explain why magnets attract and repel other magnets but could not explain why magnets attract iron.

In 1644 René Descartes published an influential work that outlined his own model for magnetism in terms of an invisible substance or fluid consisting of very small spiral particles that were always in motion. According to this model, magnets contained pores or channels which were aligned so that the magnetic substance could flow easily through the magnet in one direction, but not the other. This idea helped to explain the existence of two poles, one into which the substance flows and the other out of which the fluid emerged. According to Descartes’ model, when a magnet is brought into the presence of unmagnetized iron, the streaming particles of substance push the channels in the iron into alignment, so the iron then behaves like a magnet. Thus, this model could explain why iron is attracted to a magnet.

In 1756, Franz Aepinus proposed a “magnetic fluid” which exists in all magnets. According to this model, all iron contains a magnetic fluid. A magnet was simply a piece of iron that had the magnetic fluid stuck at one end. This left it with an excess of fluid on one end and a deficit of fluid on the other. Although this model could explain the two-ended nature of the magnet, it had some difficulty explaining the “broken magnet” problem. In the late 18th century, Charles Coulomb introduced the idea of “magnetic entities” which exist within the magnet. According to this model, each *entity* contained the magnetic fluid and entities could not be broken apart. The fluid could move around within each entity but could not move between entities. This led to the modern model for magnetism.

Summary Ideas

Here are the ideas about magnetism developed by our class. These are likely very similar to those developed by scientists as they are based on much the same evidence. Make any notes you wish, such as the evidence you saw that supports each idea.

Idea M1 - Kinds of materials involved in magnetic interactions:

A magnetic interaction occurs between a magnet and another magnet, or between a magnet and an unmagnetized ferromagnetic object. Ferromagnetic objects are made from iron, nickel or cobalt, or alloys containing one or more of those materials. (For example, steel is an alloy of iron and copper and is ferromagnetic.) There is always an attraction between an unmagnetized ferromagnetic material and a magnet. (Which, if either, moves as a result of this attraction will depend on whether either, or both, are being restrained by other means.) A magnet is a ferromagnetic object that has become permanently magnetized.

Idea M2 - Magnetic Interactions between two magnets

When a magnet is allowed to rotate freely, without any other magnets nearby, the end pointing (approximately) towards the *geographical North Pole* of the earth is defined as the north pole of the magnet. The opposite end of the magnet is defined as its south pole.

A magnetic interaction occurs between a magnet and another nearby magnet. Two magnets with like poles facing each other will repel. Two magnets with unlike poles facing each other will repel. (This idea is sometimes called the *Law of Magnetic Poles*.)

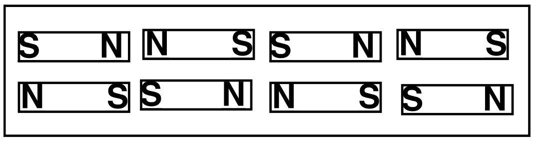
Idea M3 - Model of Magnetism:

Many magnetic effects can be explained in terms of the **Alignment of Domains Model**.

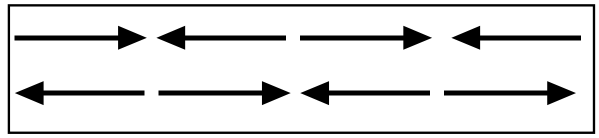
a) This model is based on the idea that inside a ferromagnetic object there are a very large number of tiny entities, sometimes called **magnetic domains**. Each magnetic domain is assumed to behave like a tiny bar magnet, with north (N) and south (S) poles. When drawing a model diagram of domains inside a ferromagnetic object, it is common to use small bar magnets to represent them. (A common alternative is to represent an individual domain using an arrow, the head of which represents the north pole of the domain.) The domains cannot move from place to place within the ferromagnetic material, but they can rotate around so that their poles point in different directions.

(When a domain is cut, it simply becomes two smaller domains aligned in the same direction as the original.)

b) In an unmagnetized ferromagnetic object the domains are randomly oriented; that is, for each domain pointing in one direction, there is another domain nearby pointing in the exact opposite direction. The magnetic effects of the north and south poles of the domains therefore cancel each other out throughout the entire object, and produce **no net magnetic effect**. Here is a simple representation where we assume the domains point either to the right or to the left. (It is also acceptable to show the domains pointing randomly in **all** directions, not only to the right or left.)

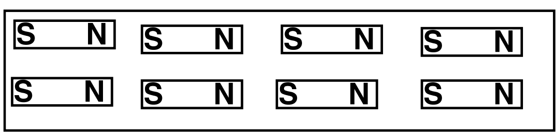


or



At the ends of the object, random orientation of the domains means they cancel each other's effects. Therefore, the entire object has neither a North Pole nor a South Pole at its ends.

c) When a ferromagnetic object is fully magnetized, all the domains become aligned, pointing in the same direction. The magnetic effects of all the domains reinforce each other and produce strong magnetic effects. The end of the object toward which all the north poles of the domains are aligned becomes the North Pole of the magnet; the end toward which all the south poles of the domains are aligned becomes the South Pole of the magnet. (In the example below, the right side would be the North Pole of the magnet and the left side would be the South Pole.)



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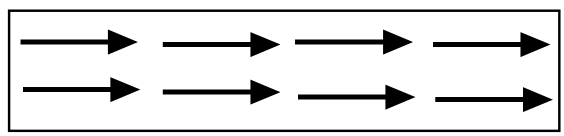

d) The domains in an unmagnetized ferromagnetic material can be aligned by using the magnetic influence of a permanent magnet in different ways.

i) When one pole of a permanent magnet is rubbed along the nail in one particular direction, the opposite poles of all the domains are attracted to it and rotate to follow it. By the time the magnet has been rubbed along the material several times, most of the domains have rotated so that they are aligned in the same direction.

ii) When one pole of a permanent magnet is held close to a ferromagnetic material, its magnetic influence causes the domains in the material to rotate by attracting their opposite poles. After being exposed to this influence for several seconds most of the domains have rotated so that they are aligned in the same direction.

e) The alignment of the domains in an magnetized ferromagnetic material can be disrupted by making them move around. Two techniques that work are:

i) 'Shocking' by vigorously hitting the material (or throwing it on the floor) and

ii) Heating the material for several seconds.

Notes: