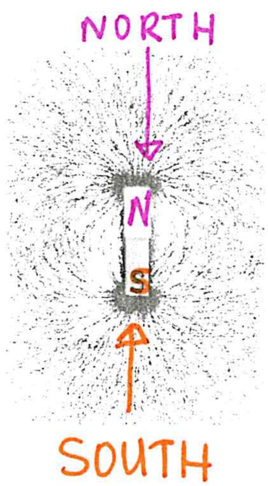
NAME: answers

U3:L5 Magnetic Fields

The effects of magnetism have been known for centuries. Even before 600 B.C., the Greeks had discovered that lodestone, a type of ore containing iron oxide, was able to exert forces of attraction on small iron objects. Also, when pivoted in a horizontal plane and allowed to rotate freely, a needle-shaped piece of lodestone would always come to rest in a north-south position, a fact that led to its widespread use in navigation. Since this type of iron ore was first found near a region in Asia Minor called Magnesia, its effects became known as magnetism.

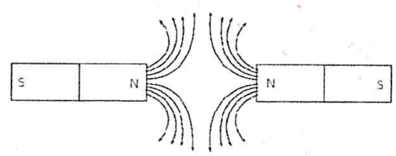


When a bar magnet is dipped in iron filings, the filings are attracted to it and accumulate most noticeably around regions at each end of the magnet, called **poles**.

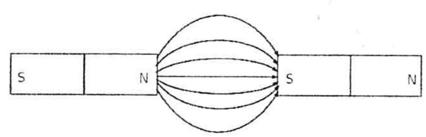
When a bar magnet is allowed to rotate freely, the pole that tends to seek the northerly direction is called the **north** magnetic pole, or simply the N-pole. The opposite end is called the **south** magnetic pole, or the S-pole.

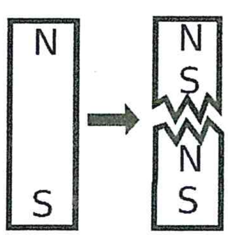
Magnets exert forces on each other.

Like forces repel.



Opposite forces attract.





It is possible to separate positive from negative charges and produce isolated charges of either kind. In contrast, no one has found a magnetic monopole (an isolated north or south pole).

mono = ONE

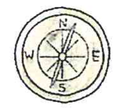
Any attempt to separate north and south poles by cutting a bar magnet in half fails, because each piece becomes a smaller magnet with its own north and south poles.

Magnetic Fields

Magnetic forces act at a distance, just like gravitational and electrical forces do. Magnetism is a non-contact force

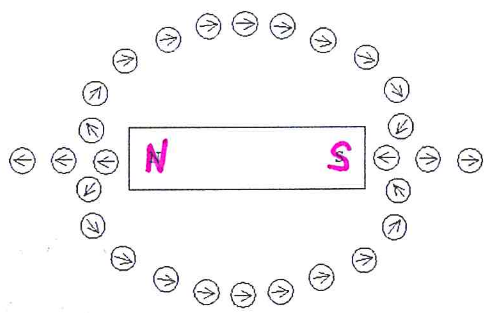
Magnets create magnetic fields just as masses create gravitational fields and electric charges create electric fields.

A magnetic field can be detected by its effect on a small compass (magnetized needle). The magnetic field is depicted visually by drawing magnetic field lines that show the direction in which the needle of the test compass points.



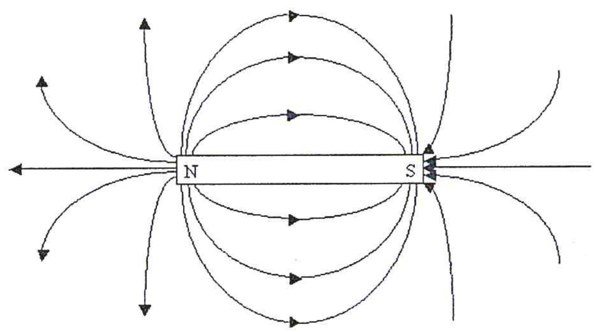
The arrow (which points to the NORTH) symbolizes the compass needle.

compass version



A simplified version of this concept is drawn like this:

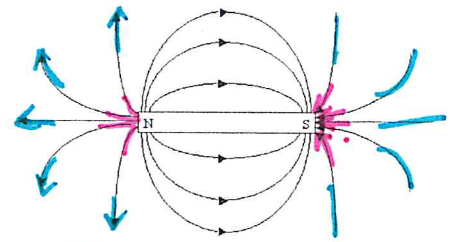
scientific version



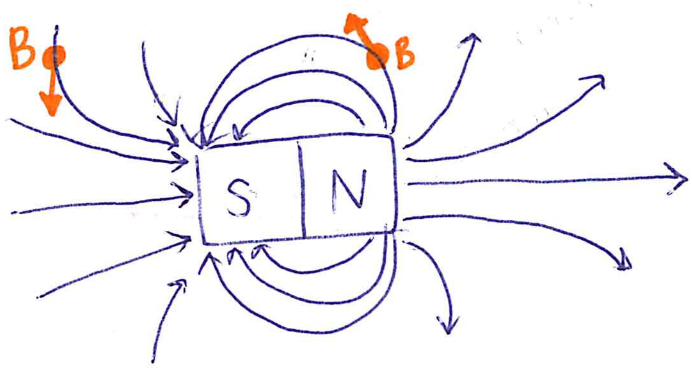
Notice that the lines appear to:

- **start** from the **north** pole
- **end** at the **south** pole
- The lines **do not start or stop in mid space.**

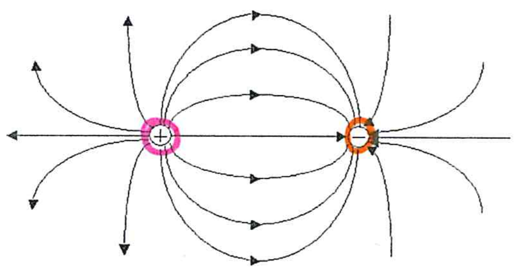
The strength of the magnetic field is proportional to the number of field lines that pass through the area. The magnetic field is **stronger** in regions where the field lines are **close together** and **weaker** where they are **far apart.**



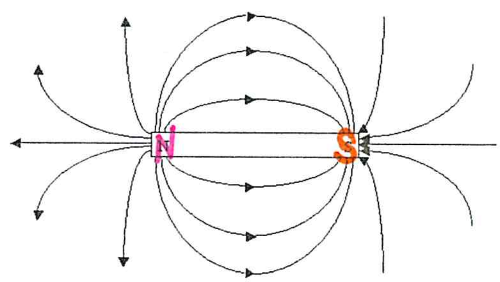
Similar to electric field lines, the direction of the magnetic field at any point is **tangent** to the magnetic field line at any point. (See tangent vector lines "B").



Notice the similarities between the electric and magnetic field lines below?



ELECTRIC



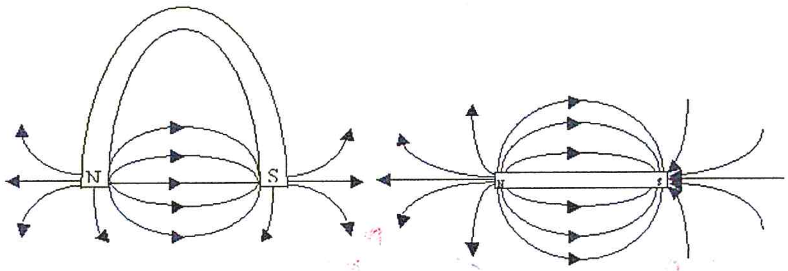
MAGNETIC

- ✓ Both follow "opposites attract" laws.
- ✓ Like electric **starting** from ⊕, magnetic starts from NORTH
- ✓ Like electric **ends** at ⊖, magnetic ends at SOUTH
- ✓ Closer lines = Stronger Field
- ✓ Further lines = Weaker Field
- ✓ Field lines continue (do not randomly stop)

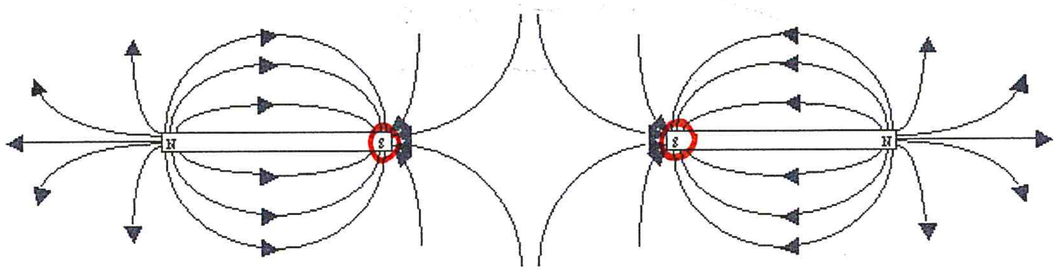
More Diagrams

In a horseshoe magnet the magnetic field lines are concentrated in the immediate region between the poles.

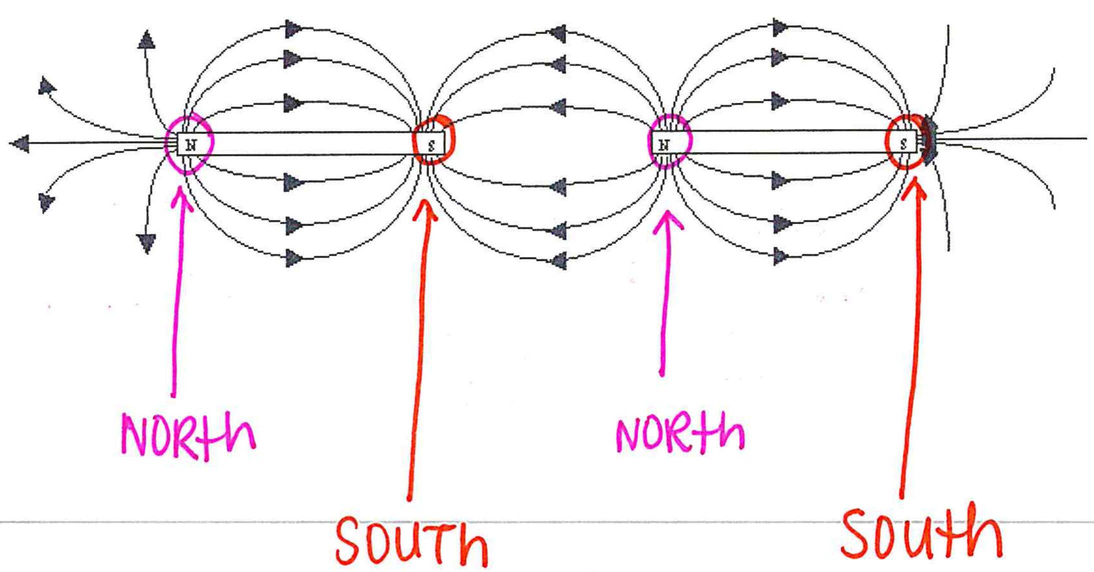
Note how the magnetic field lines for the horseshoe magnet compare to those of the bar magnet.



The diagram below shows two bar magnets with **south poles facing each other:**



The following diagram shows a possible field line pattern for **opposite poles** of bar magnets facing each other:



NAME: answers

U3:L6 Domain Theory + Earth's Magnetism

Some materials, such as iron, nickel, cobalt, and gadolinium, are not normally magnetized, but under certain circumstances, they can become magnetized. Such materials are called **ferromagnetic**. Ferromagnetic materials are strongly attracted by magnets. Ferromagnetic substances are commonly referred to as "*magnetic substances*."

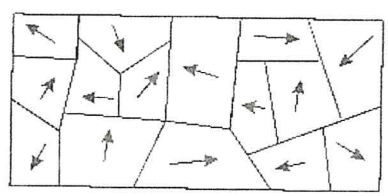
Some alloys such as alnico have extraordinary ferromagnetic properties. Alnico consists of the elements aluminum, nickel, cobalt and iron. These magnets can support a weight of over 1000 times that of the magnets themselves!

Domain Theory of Magnetism

Ferromagnetic substances are composed of a large number of tiny regions (less than 1 μm long or wide) called "**magnetic domains**."

Each domain behaves like a tiny bar magnet, with its own north and south poles.

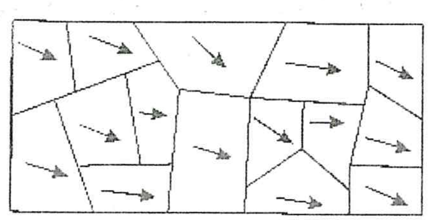
When the material is in an unmagnetized state, these millions of domains are oriented at random, so that their magnetic effects cancel out. In the diagram below, the arrows represent the domains in a small piece of unmagnetized iron.

unmagnetized  = Random

Domains aligned randomly
no magnetic effects

However, if a piece of ferromagnetic material such as iron is placed in a strong enough magnetic field, some domains actually rotate slightly to align with the external field.

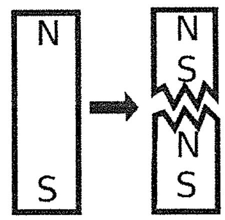
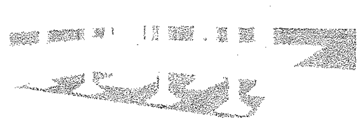
The domains are lined up together, causing the material to behave like a magnet.

magnetized 

= lined up

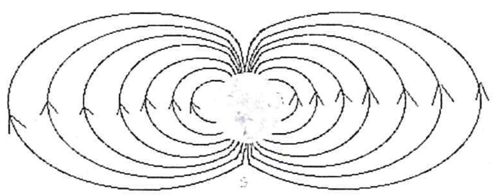
Domains aligned

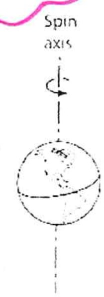
This domain theory can help explain the behavior of magnetic materials:

Compasses are cool!		Stroking it in one direction with a strong permanent magnet, aligning its domains can magnetize a needle.
Breaking a magnet makes more poles!		When a bar magnet is broken in two, rather than producing separate north and south poles, two smaller magnets are produced, each with its own north and south poles. The direction of the domains in the magnets remain as they were in the original magnet.
Some magnets are "temporary"!		Some induced magnets made of soft iron demagnetize instantaneously. These kinds of temporary magnets may be used in lifting electromagnets. Other magnets that are made of hard steel or alloys remain magnetized indefinitely. These kinds of permanent magnets have many applications such as door catches.
Magnets can become "unmagnetized"!		Heating or dropping a magnet may cause it to lose its magnetization. The domains are jostled sufficiently to allow them to move and resume their random orientation
Magnetic poles can switch!		A strong magnetic field can reverse the magnetism in bar magnets so that the pole marked S points north. This occurs when the domains reverse their direction of orientation by 180° due to the influence of a strong magnetic field in the opposite direction.
Large metal structures become magnets!		Ships' hulls, columns and beams in buildings, and many other steel structures are often found to be magnetized by the combined effects of the earth's magnetic field and the vibrations created during construction. The effect is similar to stroking a needle with a strong magnet, in that the domains within the metal are caused to line up with the earth's magnetic field.

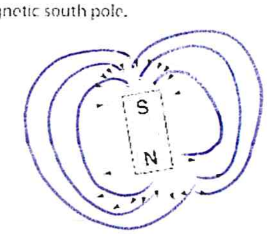
The Magnetic Field of the Earth

Ancient mariners believed that somewhere in the North was a magnetic mountain that was the source of attraction for their compasses. It was not until 1600 when Sir William Gilbert compared the earth to a large spherical lodestone. He maintained that the compass needle was drawn to the planet's magnetic pole, not to the heavens as everyone else at that time had thought. It was simply a matter of one magnet pulling on another. In simple terms, Gilbert's model was the earth's magnetic field was similar to that of a large bar magnet, inclined at a slight angle to the earth's axis and with its south pole in the northern hemisphere.



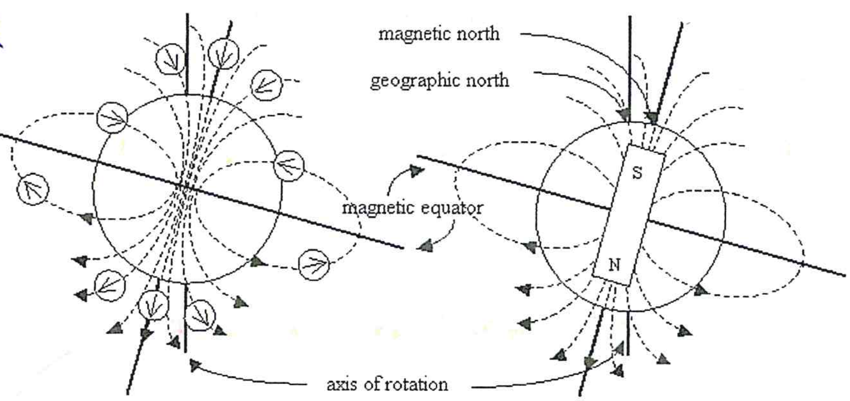


The geographic North Pole is a magnetic south pole.



In the diagram below to the left, the dashed lines show the magnetic field lines of the earth. At various places a compass has been inserted.

★Remember ↑ points North



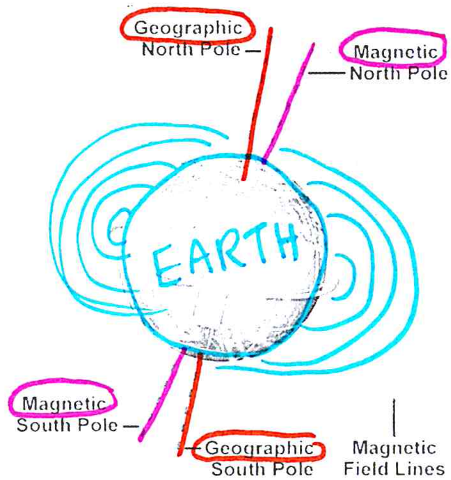
The arrows in the compass represent the direction the north end of the compass would point.

- Note that in the **northern hemisphere**, the compass needles are pointing towards the earth. This is where the **south** end of a magnet *would be.*
- In the **southern hemisphere**, the compass needles are pointing away from the earth. This is where the **north** end of a magnet *would be.*

The Geographic Poles

The **north geographic pole** is that point of the **earth's axis of rotation.**

The north <u>magnetic</u> pole is not the same as the north <u>geographic</u> pole

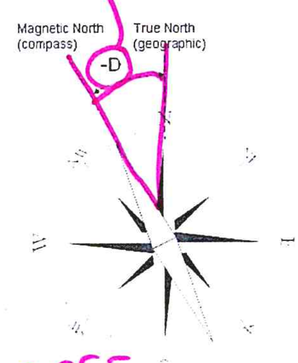


The North magnetic pole lies in Hudson Bay some 1300 km to the south.

The South magnetic pole is in Antarctica near the Ross Sea.

A compass needle points towards the **earth's magnetic north pole** rather than towards its geographic north pole.

The angle between magnetic north and geographic north varies from position to position on the earth's surface and is called **magnetic declination.**



For example, the magnetic declination for Victoria B.C. is 20° east but in St. John's Newfoundland it is 23° west. This means that a compass needle in Victoria points 23° east of geographic north and a compass needle in St. John's points 23° west of geographic north.

In order to navigate by compass, the angle of declination for a particular location must be known to permit calculation of true north.

- Navigating in the wilderness
- Coast Guard
- Wilderness Fire Fighters
- Sailors

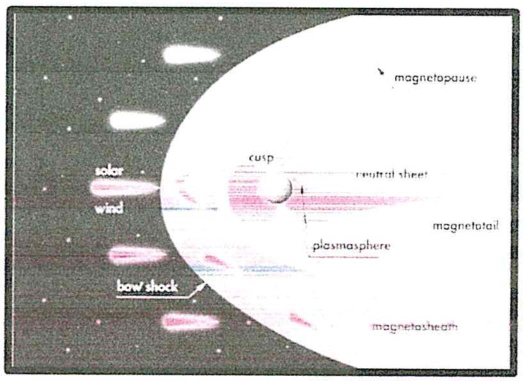
etc...

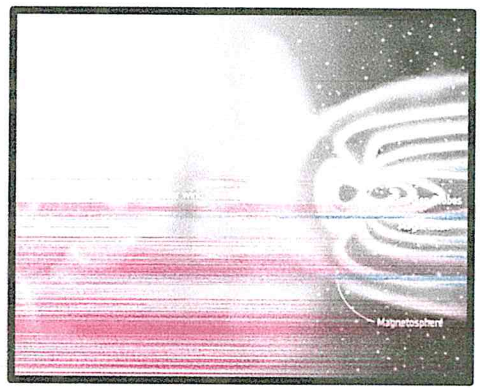
The Aurora - aka: The Northern Lights

The magnetosphere is a region of the upper atmosphere beyond approximately 200 km in which the motion of charged particles from space is governed by the magnetic field of the earth.

The magnetosphere on the side facing the sun extends beyond the earth's surface approximately 57 000 km or about 10 earth radii. On the side away from the sun, the magnetosphere probably extends outward for hundreds of earth radii.

The elongated shape results from the influence of the onrushing solar wind. The solar wind consists mainly of protons and electrons emitted by the sun, and this compresses the magnetosphere on the side nearest the sun.



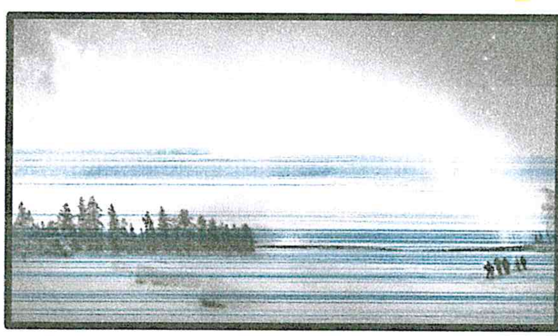


Auroras (commonly called the northern or southern lights) are caused by high energy particles from the solar wind that are trapped in the belts of the earth's magnetic field.

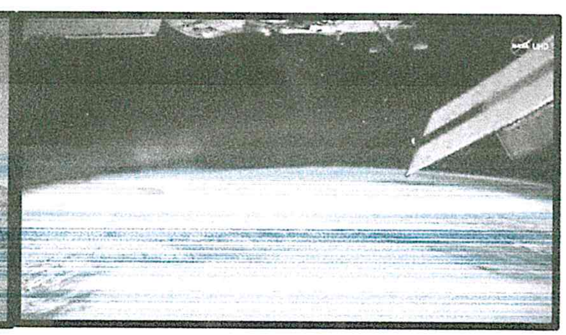
As these particles waver along the magnetic field lines, they enter the atmosphere near the north and south magnetic poles.

Energetic electrons collide with the oxygen and nitrogen molecules in the atmosphere. These collisions excite the molecules.

When they escape from their excited states, they emit the light we see in the auroras.



AURORA FROM EARTH



AURORA FROM SPACE!

Green light is emitted by oxygen, and pink light by nitrogen, but often the light is so dim that only white light can be seen.

so many cool photos online! Google "AURORA from space" :)