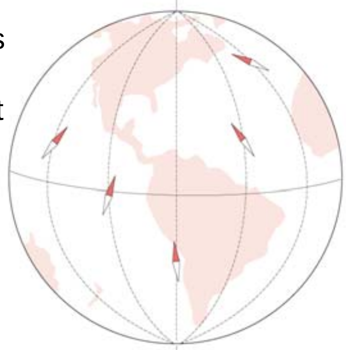
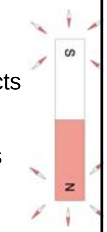
The Earth is a big magnet



Observations about magnetic fields



Poles of a magnet are the ends where objects are most strongly attracted
- Two poles, called *north* and *south*

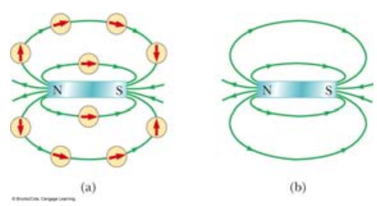
Like poles repel each other and unlike poles attract each other
- Similar to electric charges

Magnetic poles cannot be isolated
- If a permanent magnetic is cut in half repeatedly, you will still have a north and a south pole
- This differs from electric charges
- There is some theoretical basis for monopoles, but none have been detected

Slightly more quantitative

- A vector quantity
- Symbolized by $\vec{B}$
- Direction is given by the direction a *north pole* of a compass needle points in that location
- *Magnetic field lines* can be used to show how the field lines, as traced out by a compass, would look

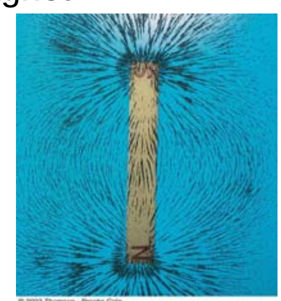
Magnetic Field Lines, sketch



- A compass can be used to show the direction of the magnetic field lines (a)
- A sketch of the magnetic field lines (b). Direction and strength just like E-field

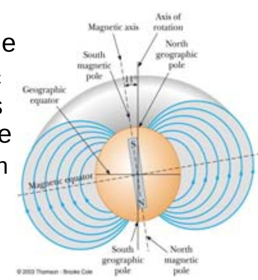
Magnetic Field Lines, Bar Magnet

- Iron filings are used to show the pattern of the magnetic field lines
- The direction of the field is the direction a north pole would point



Earth's Magnetic Field

- The Earth's geographic north pole corresponds to a magnetic south pole
- The Earth's geographic south pole corresponds to a magnetic north pole
  - Strictly speaking, a north pole should be a "north-seeking" pole and a south pole a "south-seeking" pole

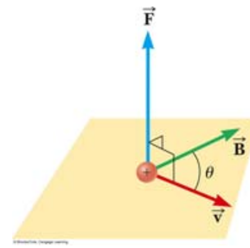


Magnetic Fields

- When a charged particle is moving through a magnetic field, a magnetic force acts on it
  - This force has a maximum value when the charge moves perpendicularly to the magnetic field lines
  - This force is zero when the charge moves along the field lines

Finding the Direction of Magnetic Force

- Experiments show that the direction of the magnetic force is always perpendicular to both $\vec{\mathbf{v}}$ and $\vec{\mathbf{B}}$
- F_{max} occurs when $\vec{\mathbf{v}}$ is perpendicular to $\vec{\mathbf{B}}$
- F = 0 when $\vec{\mathbf{v}}$ is parallel to $\vec{\mathbf{B}}$
- Proportional to the magnitude of the $\vec{\mathbf{v}}$, $\vec{\mathbf{B}}$, and charge q.



Magnetic Fields, cont

- One can define a magnetic field in terms of the magnetic force exerted on a test charge moving in the field with velocity $\vec{\mathbf{v}}$
  - Similar to the way electric fields are defined
- $$B \equiv \frac{F}{qv\sin\theta}$$

Units of Magnetic Field

- The SI unit of magnetic field is the *Tesla* (T)

$$T = \frac{Wb}{m^2} = \frac{N}{C\cdot(m/s)} = \frac{N}{A\cdot m}$$

  - Wb is a Weber
- The cgs unit is a *Gauss* (G)
  - 1 T = 10^4 G

A Few Typical B Values

- Conventional laboratory magnets
  25000 G or 2.5 T
- Superconducting magnets
  200000 G or 20 T
- Magnet lab (Tallahassee)
  about 1000000 G or 100 T
- Earth's magnetic field
  0.5 G or 5 x 10^{-5} T