Magnetism

- Magnet has two poles (North and South)
- Magnetic field composed of line of force
- Become more concentrated in ferrous materials such as iron or steel
- Unaffected by non-magnetic materials such as wood, air, etc.
Magnetic Poles
Lines of Force
Earth’s Magnetic Field
Magnetic Flux

- Refers to the lines of magnetic force
  - $\phi$
  - **Maxwell (Mx)** – number of lines of force
  - **Weber (Wb)** – $1 \times 10^8$ maxwells
  - $1 \mu\text{Wb} = 100$ lines or Mx
Flux Density (B)

- Number of magnetic lines of force per unit area
  - \( B = \frac{\phi}{A} \)
  - \( B \) - flux density
  - \( \phi \) - flux
  - \( A \) - area
Flux Density

**Figure 13–5** Total flux \( \Phi \) is six lines or 6 Mx. Flux density \( B \) at point \( P \) is two lines per square centimeter or 2 G.
Gauss

- One line of force per square centimeter
- 1 Mx/cm²
Based on webers per square centimeter

1 Tesla = 1 weber/cm²
Induction

- Electrical or magnetic effect of one body or other without contact
- Also known as *magnetizing*
Induction

Figure 13–7  Magnetizing an iron bar by induction.
Permeability

- Ability to concentrate magnetic flux
- Symbol is $\mu$
- For air it is 1.0
- For iron and steel 100 - 9000
Air Gap

- Space between the poles of a magnet
- Bar vs a horseshoe magnet
Electromagnet

- Current in wire generates a magnetic field
- Magnetic field can be concentrated by coiling the wire around a ferrous core
Permanent Magnets

- Magnetized by induction during manufacturing
- Alnico
  - Alloy of aluminum, nickel, & cobalt
- Rare earth magnets
  - Produce a very high magnetic flux
Permanent Magnets

- Magnetic field is reduced
  - Shock, high temperatures, or a demagnetizing field

- Curie Temperature
  - Temperature where material loses its magnetic field
    - Iron - 800° C
Material Classification

- **Ferromagnetic** – become strongly magnetized in the same direction as the magnetic field with high value of permeability
  - Iron, steel, Alnico, Permalloy
Material Classification

- **Paramagnetic** – become weakly magnetized in the same direction as the magnetic field
  - Permeability is slightly over 1.0
  - Aluminum, chromium, manganese
Material Classification

- **Diamagnetic** – become weakly magnetized in the direction opposite from the magnetizing field
  - Permeability is less than 1.0
  - Bismuth, copper, zinc, gold
Ferrites

- Nonmetallic material
- Ferromagnetic properties of iron
- Nonconductive ceramic material
- Permeability is 50 to 3000