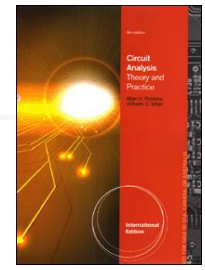
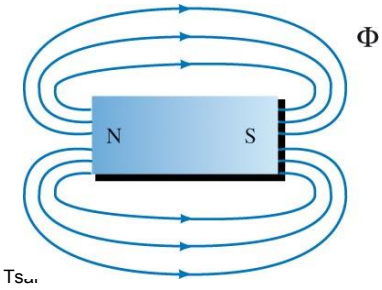


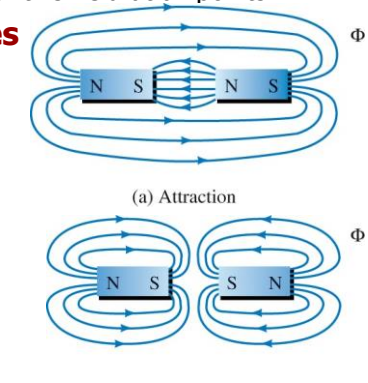
Chapter 12

Magnetism and Magnetic Circuits

The Nature of a Magnetic Field

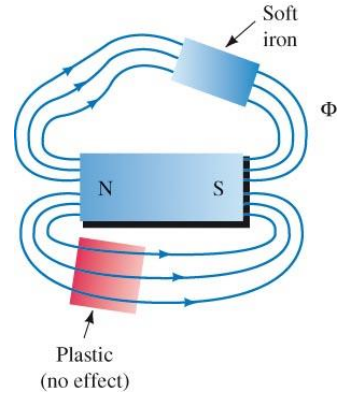
- Magnetism
  - Force of attraction or repulsion that acts between magnets and other magnetic materials
- Flux lines
  - Show direction and intensity of this field at all points
- **Field is strongest at poles**
  - **Direction is from N to S**



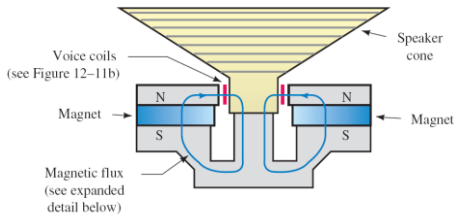


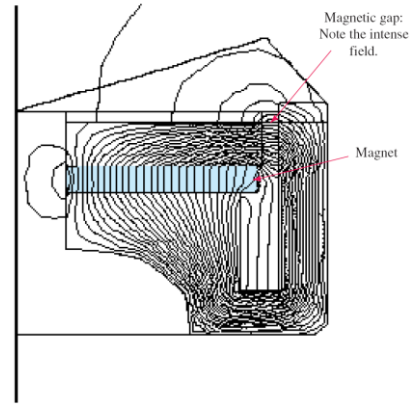
Ferromagnetic Materials

- Attracted by magnets
  - Provide an easy path for magnetic flux
  - **Iron, nickel, cobalt, and their alloys**
- Nonmagnetic materials such as **plastic, wood, and glass**
  - Have no effect on the field



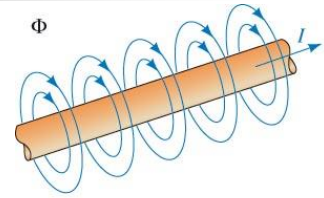
Application: Loudspeaker



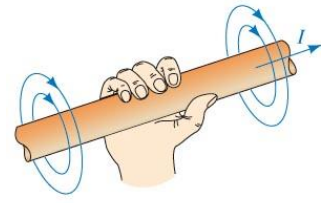


Electromagnetism

- Many applications of magnetism involve magnetic effects due to electric currents
- Direction of magnetic field may be determined by the **Right Hand Rule**
- Place your right hand around conductor with **your thumb** in the direction of the **current**
- **Your fingers** will point in the direction of the **magnetic field**



(a) Magnetic field produced by current. Field is proportional to *I*.

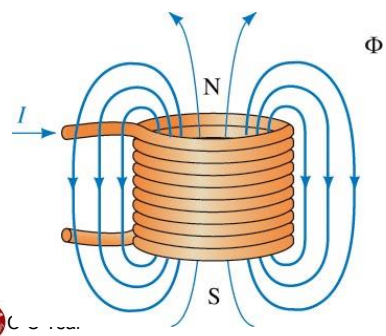


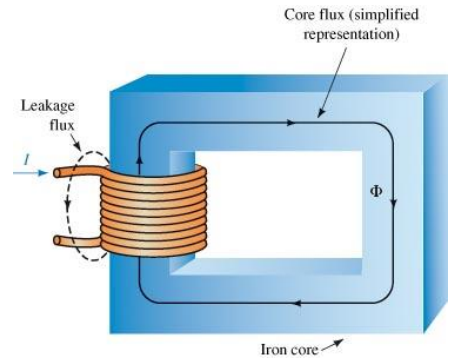
(b) Right-hand rule

Electromagnetism

Rules for coils

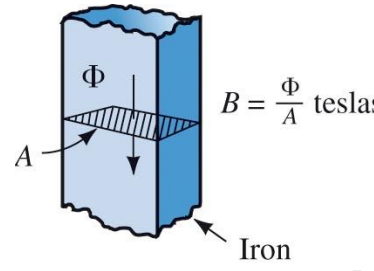
- **Curl fingers** of right hand around coil in direction of the **current**
- **Thumb** will point in direction of the **field**





Magnetic Flux and Flux Density

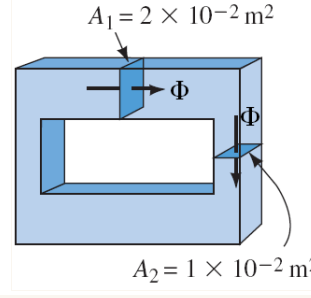
- Flux, Φ : Total number of lines
- **Flux density, $B = \Phi/A$**, : Number of lines per unit area
- Units for magnetic flux are webers (Wb)
- Area is measured in square meters
- Units for flux density
  - Wb/m^2 or teslas (T)
  - 1 tesla = 10 000 gauss
- B may also be measured in gauss
- We will work only with teslas



Example: Magnetic Flux and Flux Density

- Given the flux density at cross section 1 is B_1 = 0.4T, determine B_2

$\Phi = B_1 \times A_1 = B_2 \times A_2$

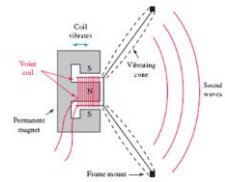


Solution $\Phi = B_1 \times A_1 = (0.4\,\text{T})(2 \times 10^{-2}\,\text{m}^2) = 0.8 \times 10^{-2}\,\text{Wb}$. Since all flux is confined to the core, the flux at cross section 2 is the same as at cross section 1. Therefore,

$$B_2 = \Phi/A_2 = (0.8 \times 10^{-2}\,\text{Wb})/(1 \times 10^{-2}\,\text{m}^2) = 0.8\,\text{T}$$

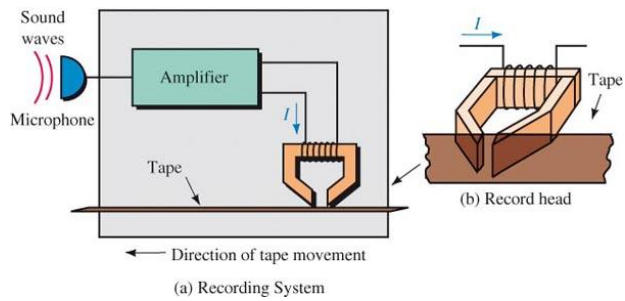
Magnetic Circuits

- Found in **motors**, **generators**, **speakers**, **transformers**
- Magnetic fields can be created by electric currents and permanent magnets
- Magnetic stripe containing information
  - Used in bank ATM cards, library cards, etc.
  - Magnetic patterns encode information
  - Reader sees varying magnetic field
    - Induces a voltage in the pickup winding
    - Voltage is amplified and sent to decoding circuitry
- MRI machine uses superconductor coils
  - Create intense magnetic field

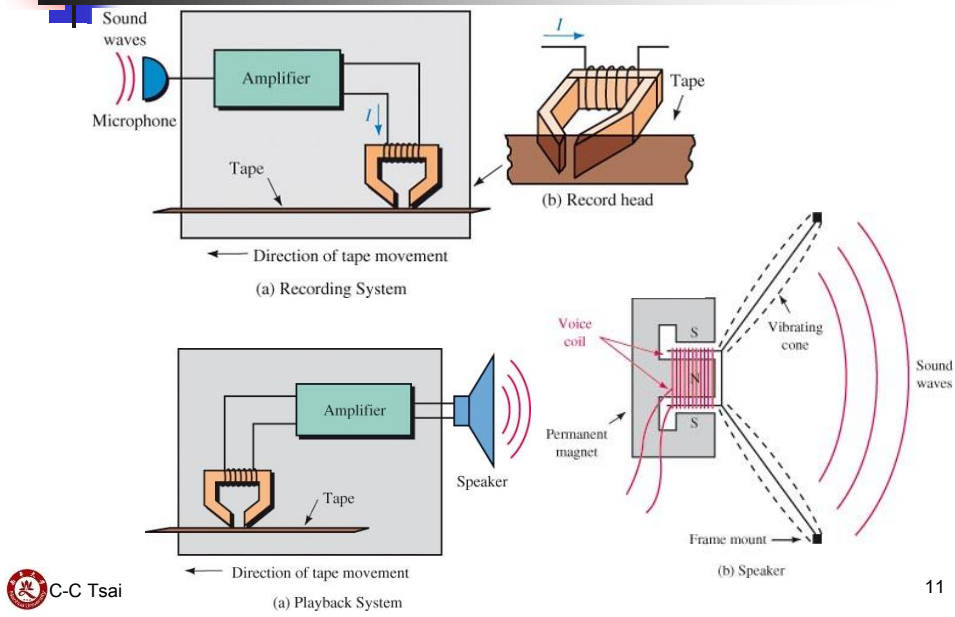


Applications of Magnetic Circuits

- Practical applications
  - Use structures to guide and shape magnetic flux
  - Called magnetic circuits
- Magnetic circuit guides flux to an air gap
  - This provides field for the voice coil
- Playback heads on **tape recorders**
  - VCRs and disk drives pick up the varying magnetic field and convert it to voltage

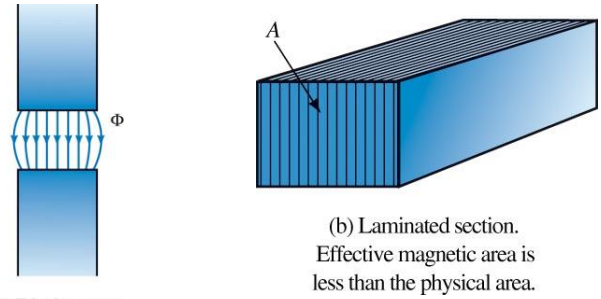


Applications of Magnetic Circuits



Air Gaps, Fringing, and Laminated Cores

- Magnetic Circuits have air gaps essential to their operation
- Increase each cross-sectional dimension of gap by the size of the gap
- Laminated cores are created with thin sheets of stacked irons or steels
- Stacking factor is used to determine core's effective area



(a) Fringing at gap

(b) Laminated section. Effective magnetic area is less than the physical area.