LECTURE NO 24

Magnetostatics

Topics

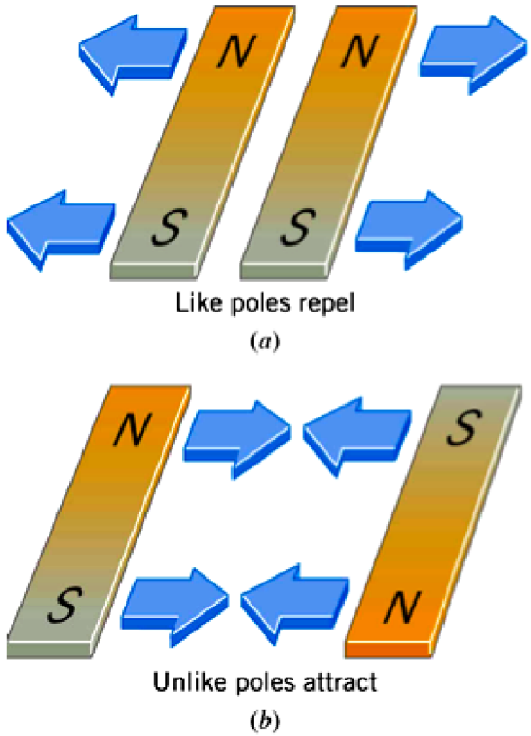
- Magnetostatics:
- Introduction
- Magneto-static fields,
- Biot-Savart's Law,
- Ampere's circuit law

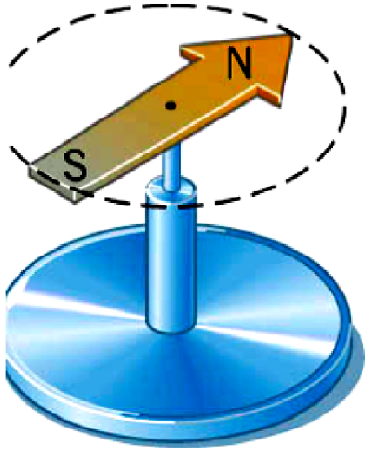
1) Magnets and Magnetic Fields

a) Natural permanent magnets

- Like poles repel, unlike attract
- come in pairs (no monopoles)
- Interact with earth;

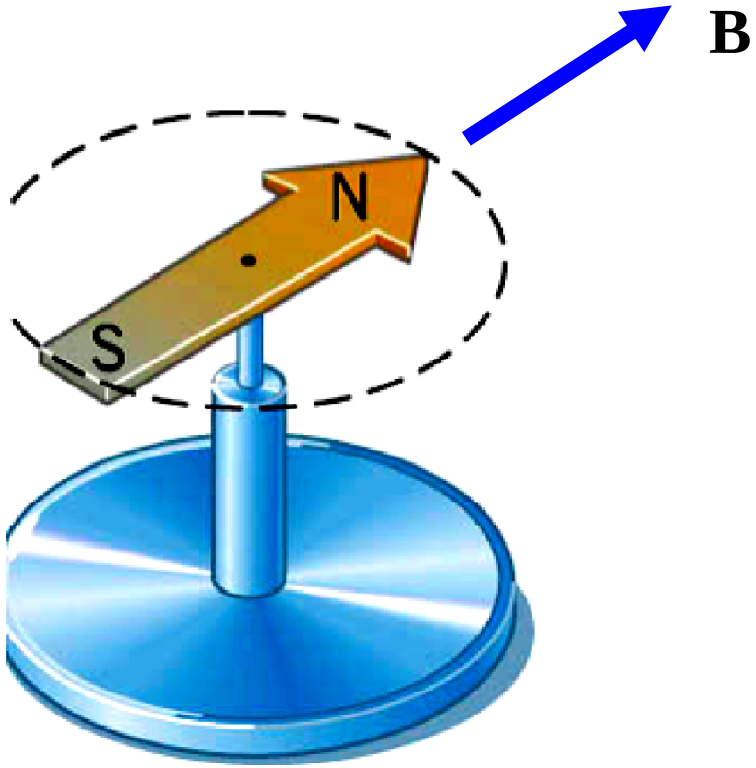
  define N (or north-seeking) pole as pole attracted to North pole of earth



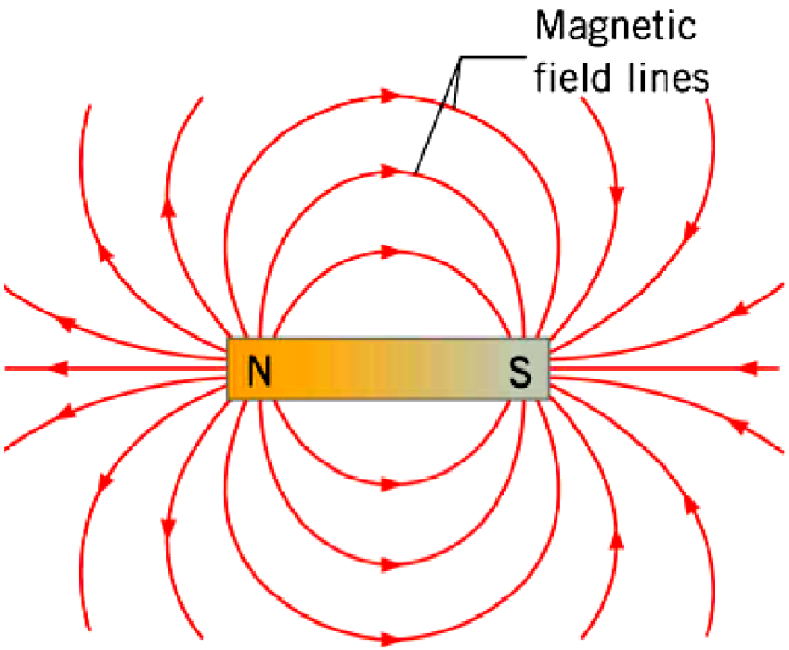


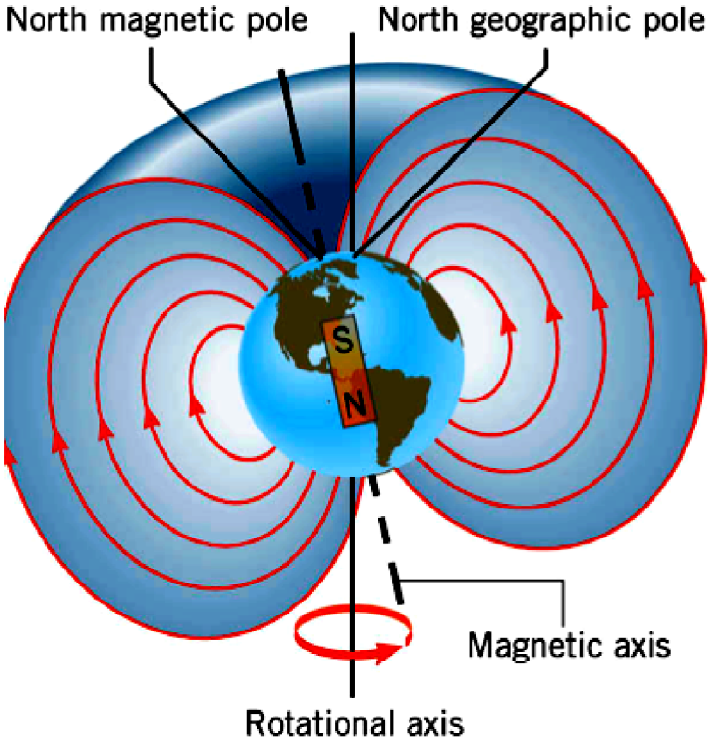
b) Magnetic field direction:

- direction of force on N pole



c) Field of dipole





d) Magnetostatics for poles

(identical to electrostatics for charges)

- 2 types: N, S vs +,-
- Unlike attract, like repel
- Inverse square law
- Force along joining line
- Magnetic Field:

$$\vec{B} = \frac{\vec{F}}{q_M}$$

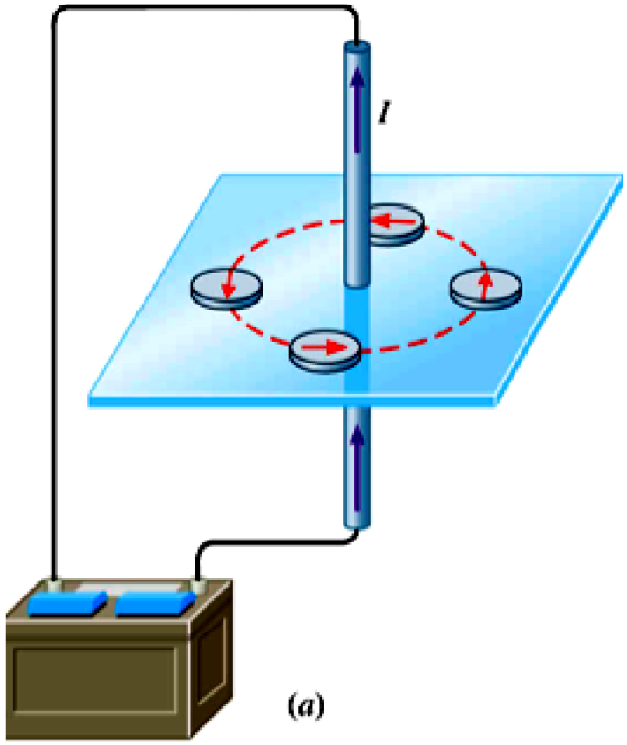
e) Why study magnetism?

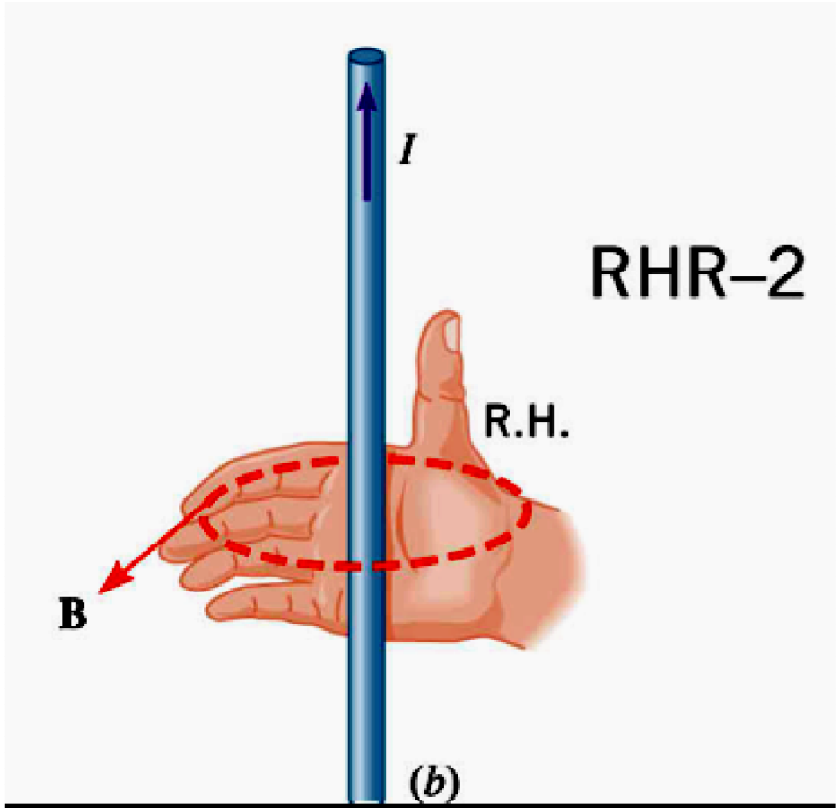
- No monopoles (yet)
- Poles (dipoles) produced by moving charges (no direct control of pole distribution)
- Charges affected by magnetic field

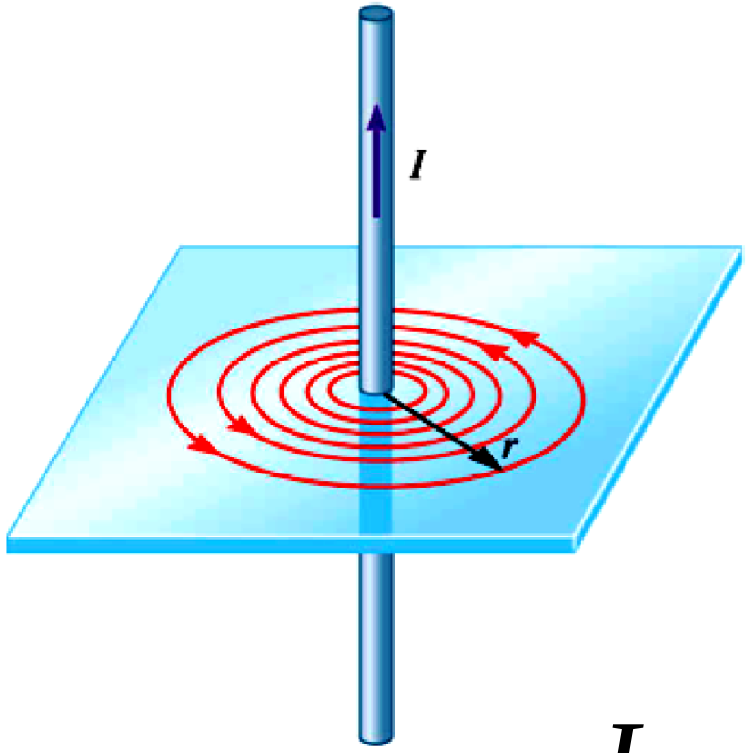
i.e. fundamental unit is still *charge*; want magnetic field due to charge, and force on charge due to magnetic field

2) Magnetic field due to current *(direction)*

- Oersted (1820)



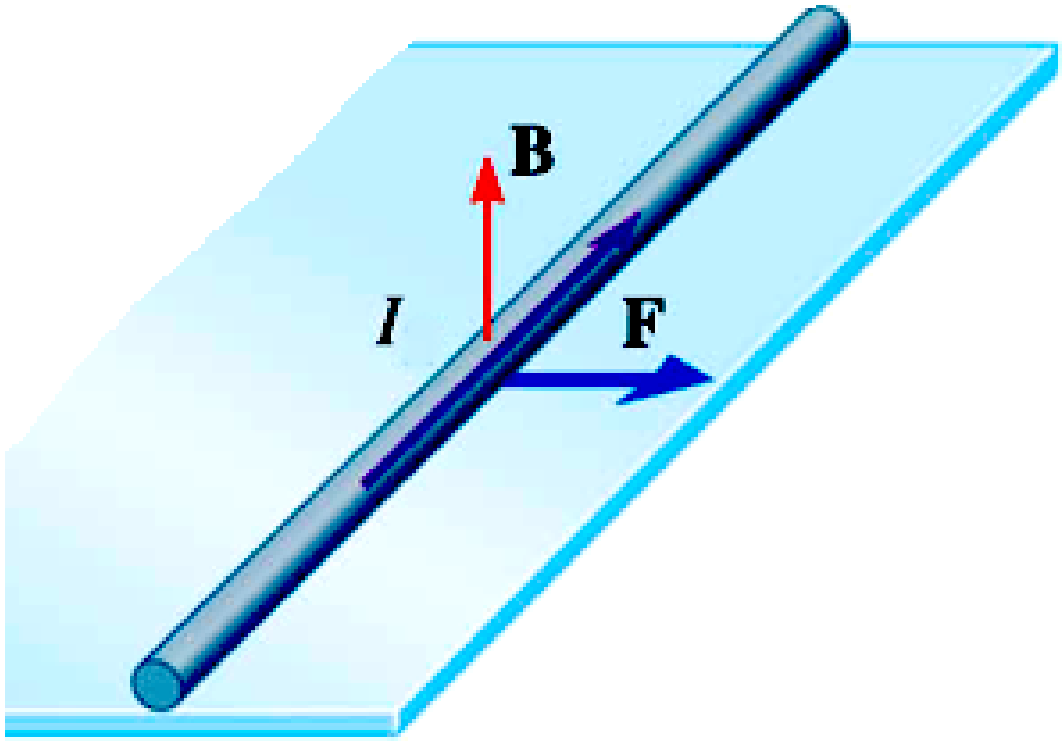




$$B \propto \frac{I}{r}$$

3) Magnetic force on current

a) Orthogonal case



Force per unit length

$$\frac{F}{\ell} = IB$$

defines B

Direction from RHR1: B fingers, I thumb, F palm

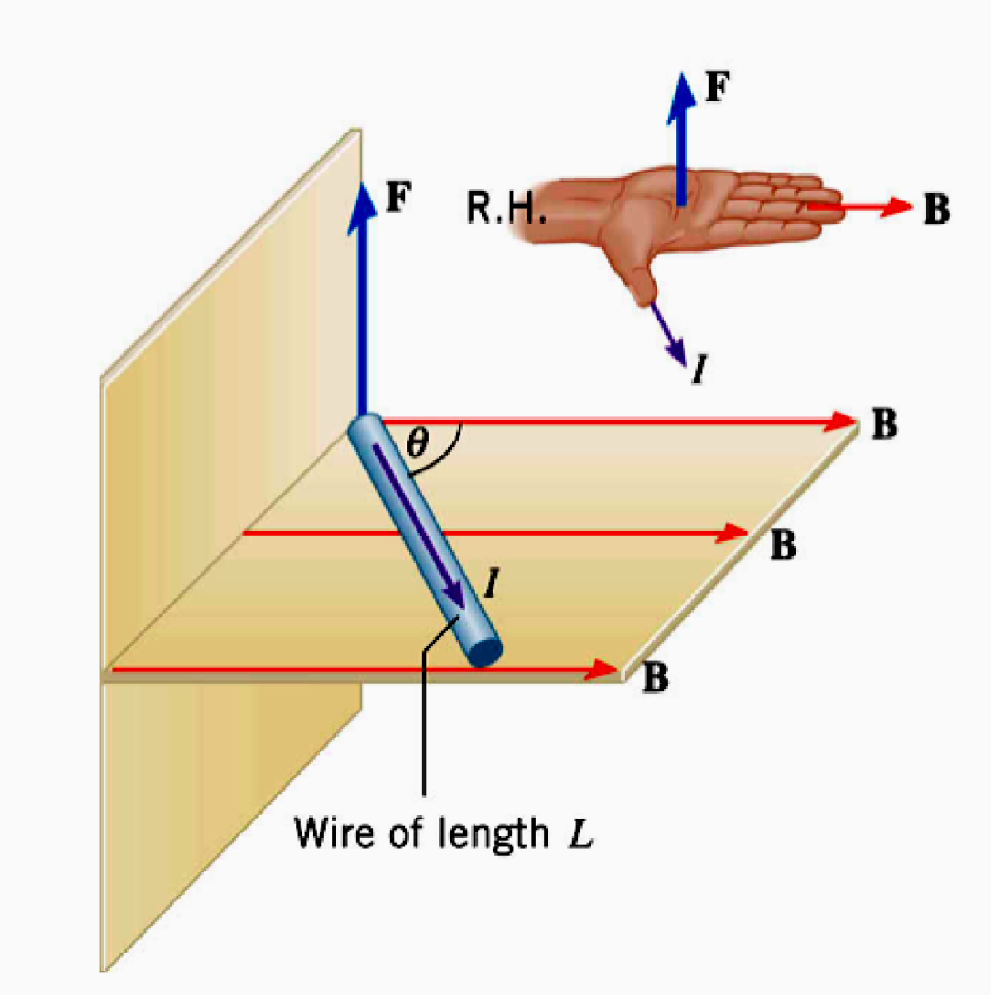
Units: $$B = \frac{F}{I\ell} \rightarrow \quad \frac{\text{N}}{\text{Am}} = \text{tesla (T)}$$

$$B_{earth} \cong .5 \text{ gauss } = 5 \times 10^{-5} \text{T}$$

$$B_{\text{fridge magnet}} \approx .01\text{T}$$

$$B_{\text{super conducing}} \approx 1 - 10 \text{ T}$$

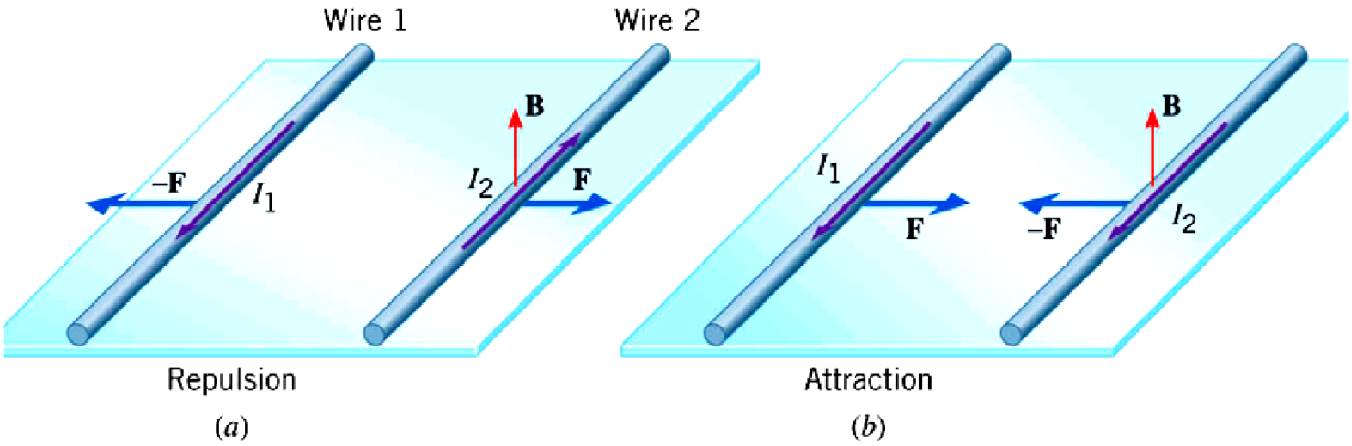
b) General case



Force per unit length

$$\frac{F}{L} = IB\sin\theta$$

4) Force between parallel wires



$$B \propto \frac{I_1}{d}; \qquad \frac{F}{\ell} = I_2 B$$

$$\frac{F}{\ell} = k' \frac{I_1 I_2}{d}$$