Maxwell's Equations (MKS unit)

$$\begin{cases} \nabla \times \vec{E} = -\frac{\partial}{\partial t}\vec{B} & \text{Faraday's Law} \\ \nabla \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t} & \text{Ampere's Law} \\ \nabla \cdot \vec{D} = \rho & \text{Gauss Law} \\ \nabla \cdot \vec{B} = 0 & \end{cases}$$

MKS unit:

Field
- E: V/m Electric field
- H: A/m Magnetic field
- D: C/m^2 Electric displacement flux density
- B: $V\text{-}s/m^2$ = webers/m^2 Magnetic flux density

Source
- ρ: C/m^3 charge density
- J: A/m^2 current density

Continuity Equation:

$$\nabla \cdot \vec{J} + \frac{\partial \rho}{\partial t} = 0$$

net current flow out a small box

net charge increase rate

$$\left.\begin{aligned}\vec{D} &= \epsilon \vec{E} \\ \vec{B} &= \mu \vec{H}\end{aligned}\right\}$$ Constitutive Relations

$\epsilon = \epsilon_0 \epsilon_r$ permitivity

ϵ_0 : 8.854×10^{-12} F/m : free-space permitivity

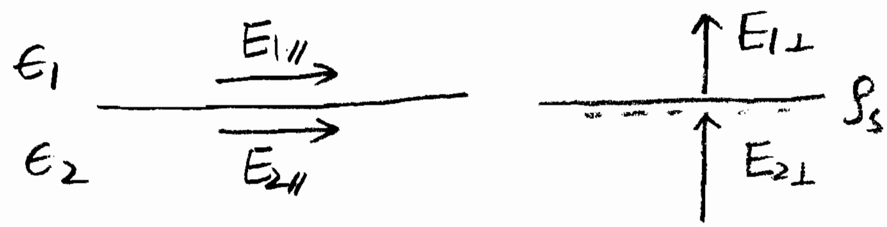
$\mu = \mu_0 \mu_r$ permeability

μ_0 : $4\pi \times 10^{-7}$ H/m : free-space permeability

Material response

Boundary Conditions:

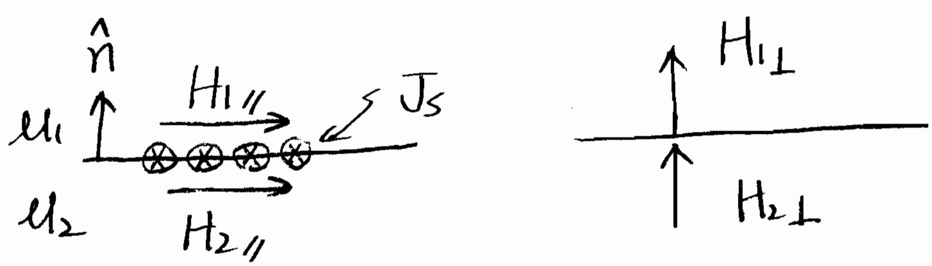
Electric fields



$$E_{1//} = E_{2//} \qquad \epsilon_1 E_{1\perp} - \epsilon_2 E_{2\perp} = \rho_s$$

ρ_s: surface charge density (C/m^2)

Magnetic fields



$$H_{1//} - H_{2//} = J_s \qquad \mu_1 H_{1\perp} = \mu_2 H_{2\perp}$$

$$\hat{n} \times (\vec{H}_1 - \vec{H}_2) = \vec{J}_s$$

$\vec{J}_s$: surface current density (A/m)