Strong minds discuss ideas
Average minds discuss events
Weak minds discuss people

SOCRATES

$\nabla \cdot \vec{B} = 0 \quad \Rightarrow \quad \vec{B} = \nabla \times \vec{A}$

$\nabla \times \vec{B} = \mu_0 \vec{J} \quad =$

$\oint \vec{B} \cdot d\vec{a} = 0$

$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{enc}$

MAGNETIZATION $\quad \vec{M}$

$\vec{J}_b = \nabla \times \vec{M}$

$\vec{K}_b = \vec{M} \times \hat{n}$

$$\nabla \times \vec{B} = \mu_0 \vec{J} = \mu_0 (\vec{J}_f + \vec{J}_b) = \mu_0 (\vec{J}_f + \nabla \times \vec{M})$$

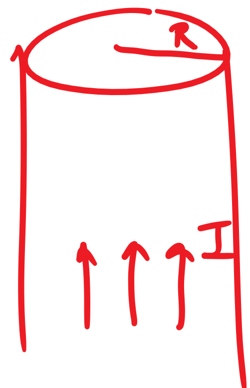
$$\nabla \times \left(\frac{\vec{B}}{\mu_0} - \vec{M} \right) = \vec{J}_f$$

$$\vec{H} = \frac{\vec{B}}{\mu_0} - \vec{M}$$

$$\boxed{\nabla \times \vec{H} = \vec{J}_f}$$

$$\boxed{\oint \vec{H}\cdot d\vec{l} = I_{f\,enc}}$$

Example



$$\vec{H} = \frac{I r}{2\pi R^2}\hat{\varphi} \qquad r<R$$

$$= \frac{I}{2\pi r}\hat{\varphi} \qquad r>R$$

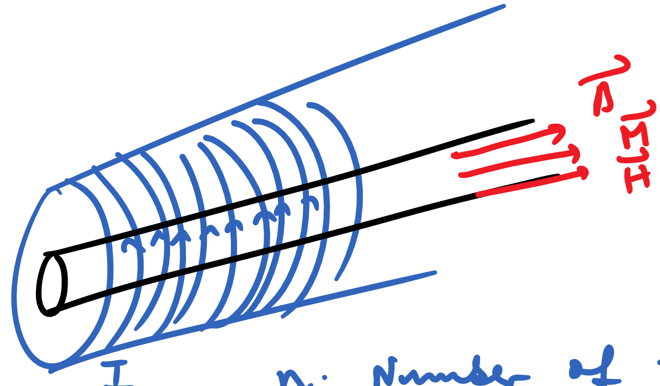
$$\vec{B} = \mu \vec{H} \qquad r<R$$

$$= \frac{\mu I r}{2\pi R^2}\hat{\varphi} \qquad r<R$$

$$= \mu_0 \vec{H} \qquad r>R$$

$$= \frac{\mu_0 I}{2\pi r}\hat{\varphi} \qquad r>R$$

Example



n: Number of turns per unit length

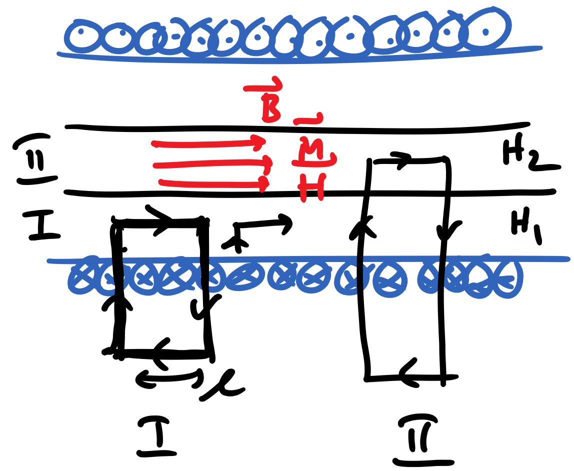
$$\oint \vec{H}\cdot d\vec{l} = I_{f\,enc}$$

$$\oint \vec{H}\cdot d\vec{l} = I_{fenc}$$

$$H_1 l = n I l$$

$$\boxed{\vec{H}_1 = nI\hat{z}} \quad \mathrm{I}$$

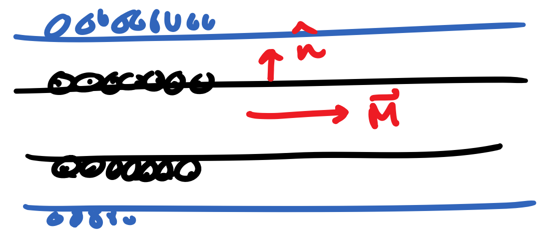
$$\boxed{\vec{H}_2 = nI\hat{z}} \quad \vec{H}_2 = \vec{H}_1$$



In Region I $\qquad \vec{B} = \mu_0 \vec{H} = \mu_0 n I \hat{z}$

In Region II $\qquad \vec{B} = \mu \vec{H} = \mu n I \hat{z}$

$$\vec{M} = \chi_m \vec{H} = \chi_m n I \hat{z} \qquad \neq \text{ Region II}$$



$$\vec{J}_b = \nabla\times\vec{M} = 0$$

$$\vec{K}_b = \vec{M}\times\hat{n} = \chi_m n I \,\hat{z}\times\hat{r}$$

$$= \chi_m n I \,\hat{\phi}$$

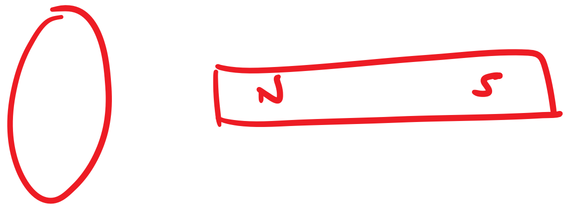
Diamagnetic : $\chi_m < 0$

Paramagnetic : $\chi_m > 0$

Ferromagnetic : $\chi_m \ggg 0$

Electromagnetic Induction

Michael Faraday



EMF $\quad \mathcal{E} = -\dfrac{\partial \Phi_m}{\partial t}$

$$\Phi_m = \int \vec{B} \cdot d\vec{a}$$

$$\mathcal{E} = \oint \vec{E} \cdot d\vec{l}$$

$$\boxed{\oint \vec{E} \cdot d\vec{l} = -\frac{\partial}{\partial t} \int \vec{B} \cdot d\vec{a}}$$

$$\int (\nabla \times \vec{E}) \cdot d\vec{a} = -\int \frac{\partial \vec{B}}{\partial t} \cdot d\vec{a}$$

$$\boxed{\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}}$$

$$\vec{B} = \nabla \times \vec{A}$$

$$\nabla \times \vec{E} = -\frac{\partial}{\partial t}(\nabla \times \vec{A}) = -\nabla \times \frac{\partial \vec{A}}{\partial t}$$

$$\Rightarrow \boxed{\vec{E} = -\frac{\partial \vec{A}}{\partial t}}$$

No charges

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \qquad \nabla \times \vec{B} = \mu_0 \vec{J}$$

$$\nabla \cdot \vec{E} = 0 \qquad \nabla \cdot \vec{B} = 0$$