$\vec{M} = \frac{\vec{m}}{V}$

Magnetization

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

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

Magnetostatics

Eqn of Continuity.

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

$$\nabla \cdot B = 0$$

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

$$\nabla \times B = \mu_0 J$$

Electrostatics

$\nabla \cdot E = \rho / \epsilon_0$

$\nabla \times E = 0$

$$\boxed{\vec{T} = \vec{p} \times \vec{E}}$$

Matter

$$\vec{D} = \epsilon \vec{E} + \vec{P}$$

$$\vec{\nabla} \cdot \vec{D} = \rho_{free}$$

$$\sigma_b = \vec{P} \cdot \hat{n}$$

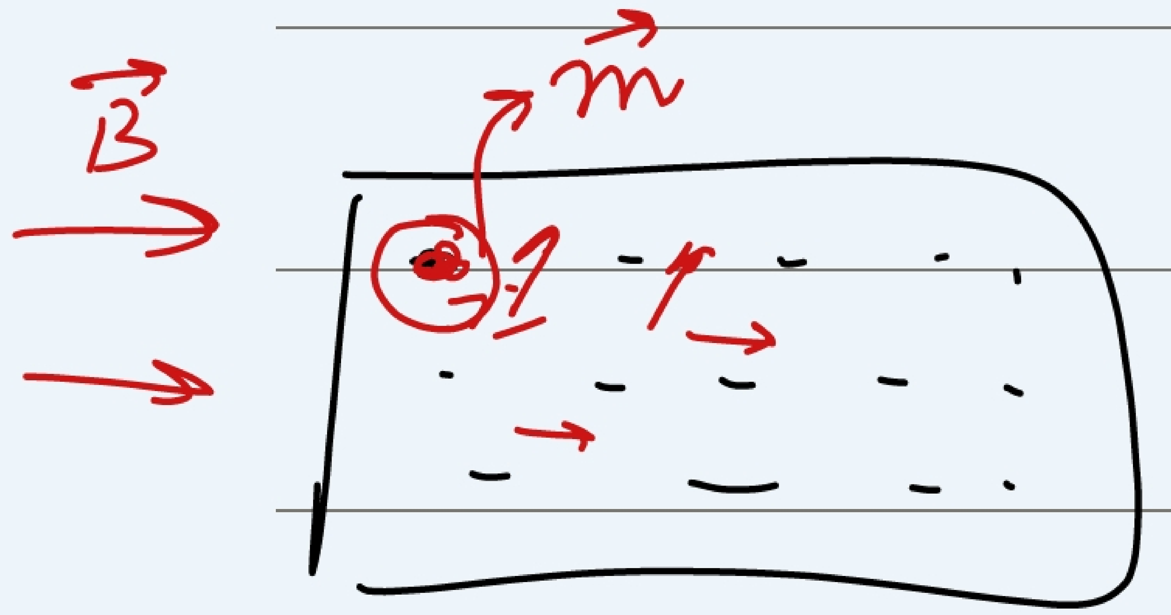
$$\boxed{\rho_b = -\nabla \cdot \vec{P}}$$

$$\vec{P} = \frac{\vec{p}}{V}$$

Magnetostatics in Matter

- Para — $\chi_m > 1$
- Dia — $\chi_m < 1$
- Ferro

$$\tau = \vec{m} \times \vec{B}$$



$$\vec{m} = I A$$

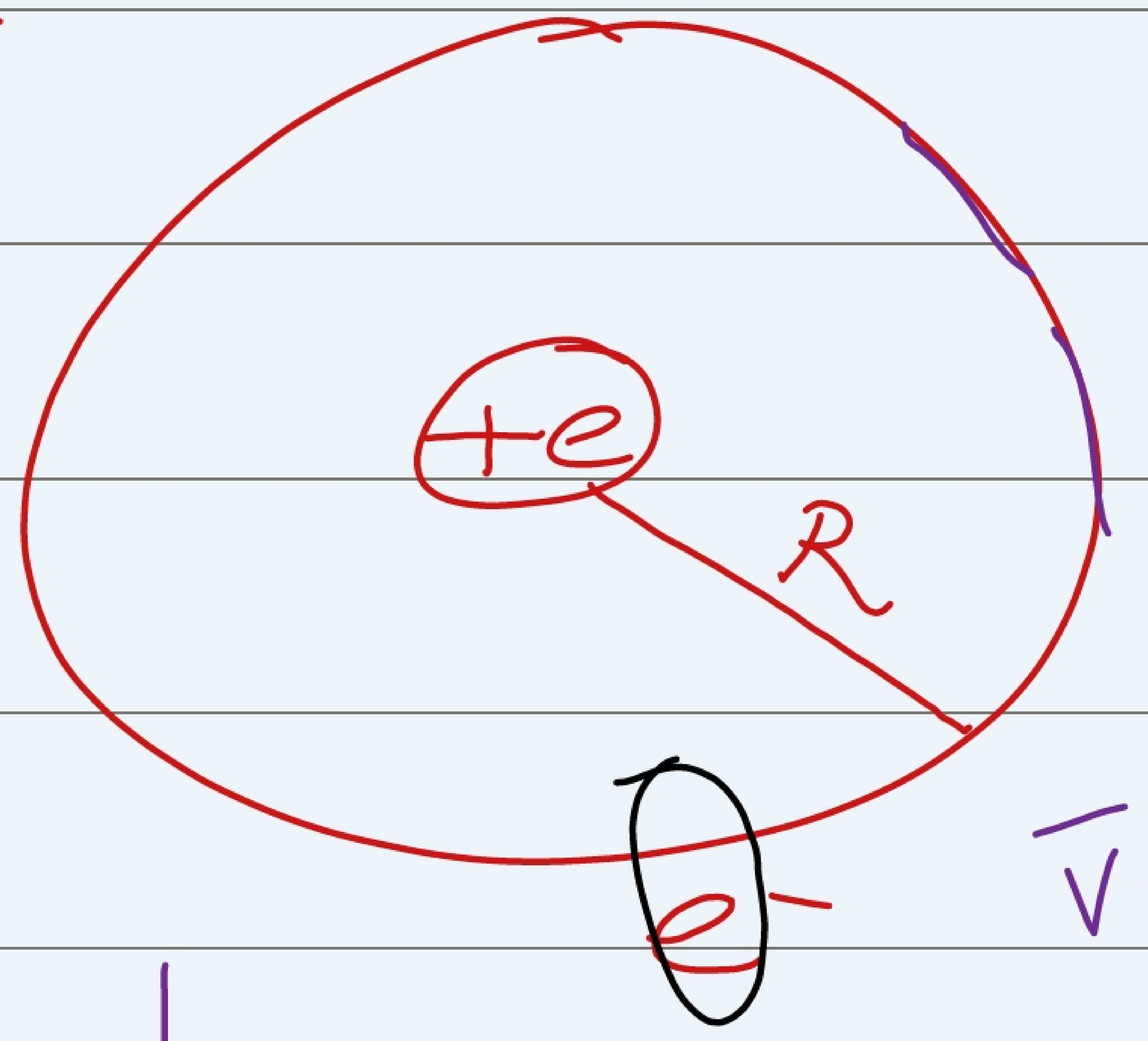
Effect of Magnetic field on Atomic Orbits:→

R = circular

Interaction with atoms

$$T = \frac{2\pi R}{v} \Rightarrow v = \frac{2\pi R}{T}$$

$\longrightarrow \vec{B}$



$\vec{V}$

$\bar{V}+v \simeq 2\bar{V}$

$\bar{V}-v \neq 0,$

$$\vec{m} = IA$$

$$= (-)\frac{ev}{2\pi R}\pi R^2 \quad , \quad I = -\frac{e}{T} = -\frac{ev}{2\pi R}$$

$$\boxed{\vec{m} = -\frac{1}{2} e v R \,\hat{z}} \rightarrow \boxed{\Delta m = -\frac{1}{2} e (\Delta V) R} \propto -B$$

$$q\bar{v}B = \frac{m}{R}(\bar{V}^2 - v^2)$$

$$= \frac{m}{R}(\bar{V}-v)(\bar{V}+v)$$

$\vec{B} = 0,$

$$\frac{1}{4\pi\epsilon_0}\frac{e^2}{R^2} = \frac{m_e v^2}{R}$$

$\vec{B} \neq 0$

$$\frac{1}{4\pi\epsilon_0}\frac{e^2}{R^2} + q\bar{v}B = \frac{m\bar{v}^2}{R}$$

$$q\cancel{\bar{v}}B = \frac{m}{R}(\Delta V)2\cancel{\bar{v}}$$

$$\boxed{\Delta V = \frac{qRB}{2m}}$$

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

$$J = J_f + J_b$$
$$= J_f + \vec{\nabla} \times \vec{M},$$

J_f = free current density

$$\frac{1}{\mu_0}\left[\nabla \times \vec{B}\right] = \vec{J}_f + \nabla \times \vec{M}$$

$$\nabla \times \underbrace{\left[\frac{\vec{B}}{\mu_0} - \vec{M}\right]}_{\vec{H}} = \vec{J}_f.$$

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

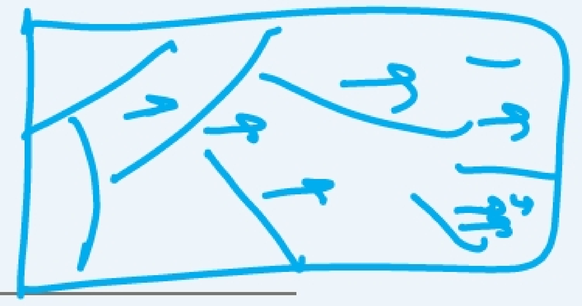
$$\boxed{\vec{\nabla} \times \vec{H} = \vec{J}_f}$$

$$\boxed{\oint \vec{H} \cdot d\vec{l} = I_f}$$

$$\boxed{\vec{\nabla} \cdot \vec{H} = -\vec{\nabla} \cdot \vec{M}}$$

χ_m

μ_0, μ



Linear Media $\Rightarrow$ $\vec{P} = \epsilon_0 \chi_e \vec{E}$

$$\vec{M} = \chi_m \vec{H}$$

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

$$\vec{B} = \mu_0 \left[\vec{H} + \vec{M} \right]$$

$$\vec{B} = \mu_0 \left[1 + \chi_m \right] \vec{H}$$

$$\boxed{\vec{B} = \mu \vec{H}}$$

$$\mu = \mu_0 \left[1 + \chi_m \right]$$

Electrodynamics :-

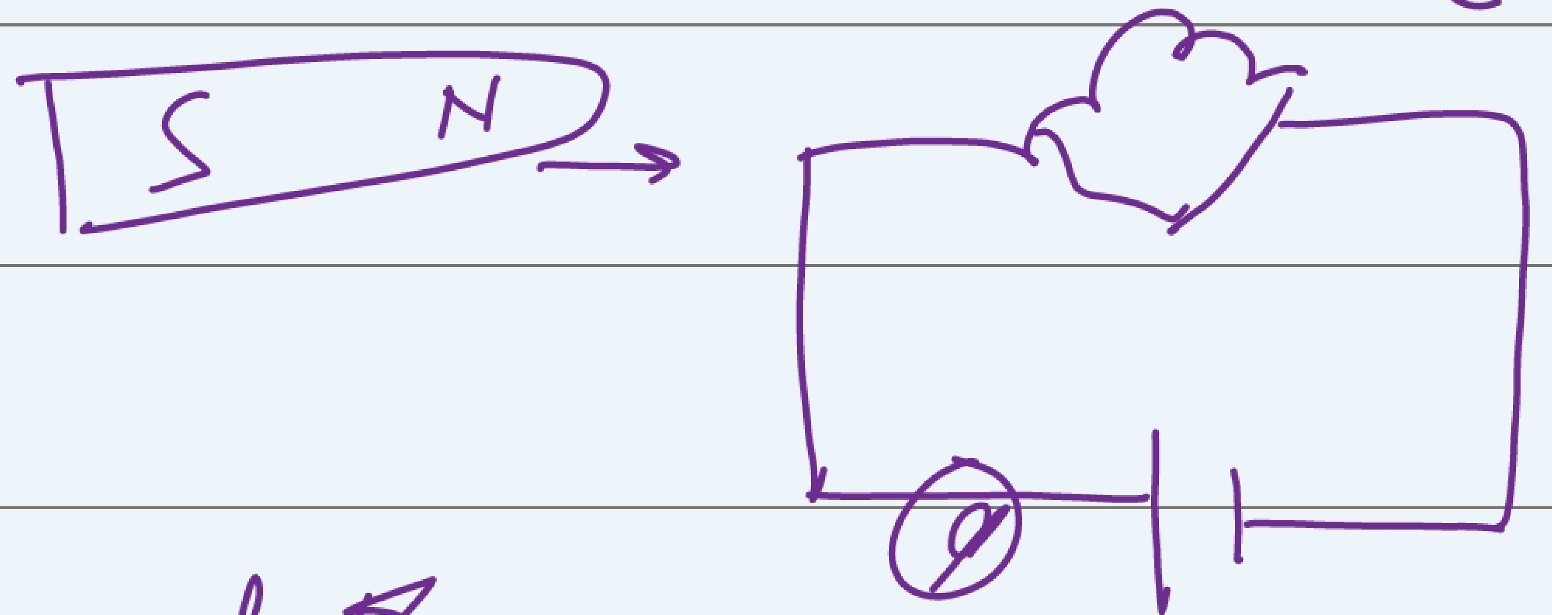
Faraday Law :-

change flux $\propto$ induced emf

(opposition of the cause).

$$\left\{ \; EMF = -N\frac{d\phi}{dt} \right.$$

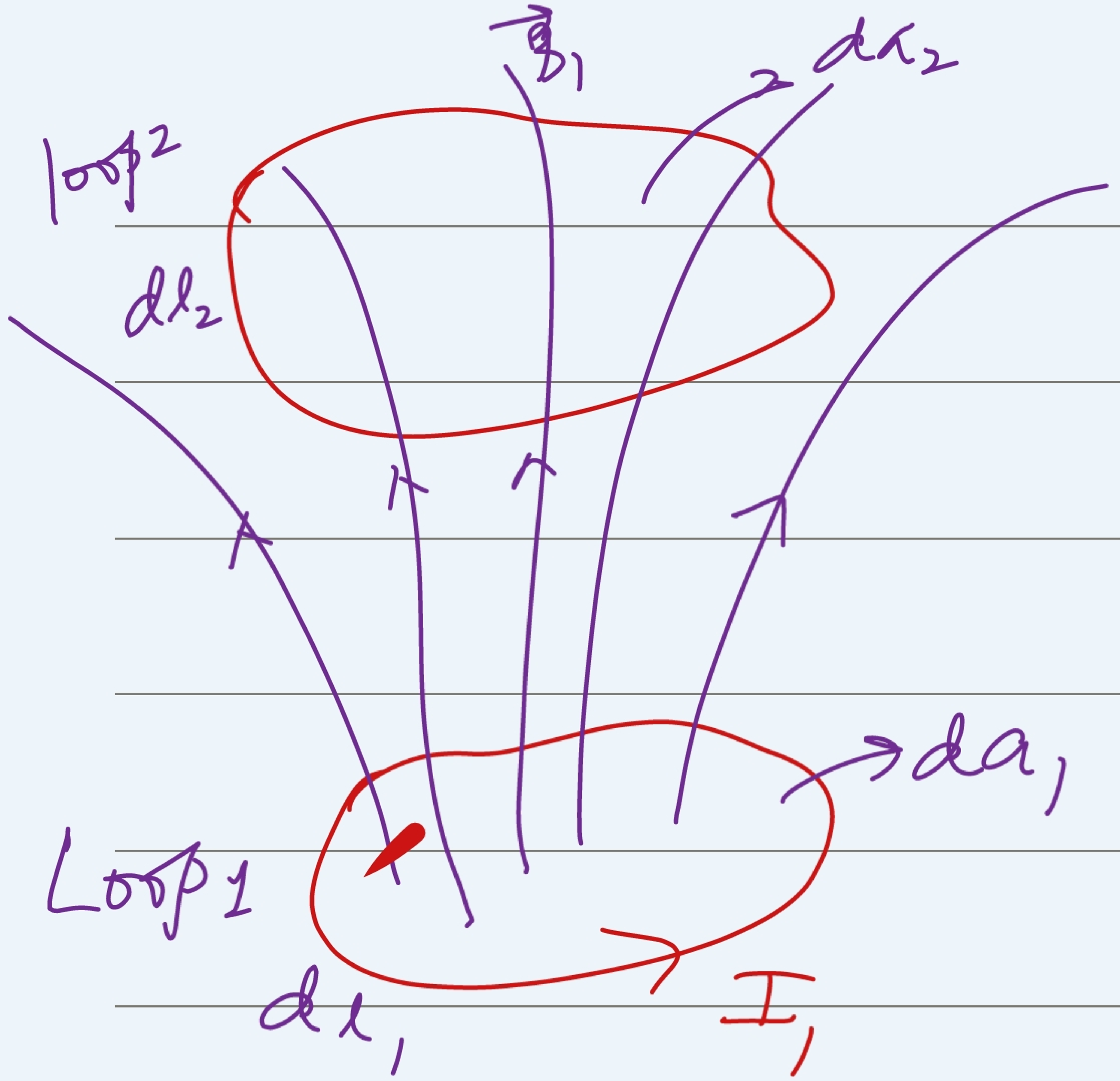
$$\phi_B = \vec{B}\cdot\vec{A}$$



$$\mathcal{E} = \oint \vec{E}\cdot d\vec{l} = -\frac{d\phi_B}{dt} = -\frac{d}{dt}\int \vec{B}\cdot d\vec{A} \Rightarrow \boxed{\nabla\times\vec{E} = -\frac{\partial\vec{B}}{\partial t}}$$

$$\iint (\nabla\times\vec{E})\cdot d\vec{a}$$

Changing $\vec{B}$ will generate $\vec{E}$.



$$\phi_2 = \int \vec{B}_1 \cdot \vec{da}_2 = M_{21} I_1$$

Mutual Inductance

$$= \int (\nabla \times \vec{A}_1) \cdot \vec{da}_2$$

$$A_1 = \frac{\mu_0 I}{4\pi} \oint \frac{dl}{r}$$

$$\Rightarrow \oint \vec{A}_1 \cdot \vec{dl}_2 = M_{21} I_1$$

$$\phi = L I$$

$$\frac{\mu_0 I_1}{4\pi} \oint \left[\oint \frac{dl_1}{r} \right] \cdot \vec{dl}_2 = M_{21} I_1$$

M_{21}

size
area
distance

$$\mathcal{E} = -L \frac{dI}{dt}$$

self ind

Maxwell's Eqn.

$\vec{D}$

$\frac{\partial \vec{E}}{\partial t}$.