ED FORMULAE

*] Electrostats

$\longrightarrow \vec{F} = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2}\hat{r}$

$\longrightarrow \vec{F} = q\vec{E}$

$\longrightarrow \Phi_{stuff} = \oint \vec{stuff} \cdot \vec{dA}$

o] Gauss Law:

$\Phi_E = \oint E \cdot dA = \frac{q_{en}}{\varepsilon_0}$ ~~Reduces~~

$\Rightarrow \boxed{\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\varepsilon_0}}$ ∵ (Divergence)

$\longrightarrow V = -\int E \cdot dl$

$\longrightarrow \oint E \cdot dl = 0$

$\Rightarrow \boxed{\vec{\nabla} \times \vec{E} = 0}$ ∵ (Stokes)

$\longrightarrow \vec{E} = -\vec{\nabla} \cdot V$

$\Rightarrow \boxed{\nabla^2 V = -\frac{\rho}{\varepsilon_0}}$ → Poisson's Eqn.

↳ Reduces to Laplace for $\rho = 0$

$\longrightarrow WD = q\Delta V$

$= \frac{1}{2}\int \rho \, d\tau \, V$ ∵ (from $q_i q_j$)

$\Rightarrow \boxed{WD = \frac{\varepsilon_0}{2}\int E^2 d\tau}$

$\longrightarrow C = Q/V \Rightarrow WD = \frac{1}{2}CV^2$ ∵ $(dW = \frac{q}{c}dq)$

o] Dipole:

$\rightarrow \boxed{V(\vec{r}) = \frac{\vec{p} \cdot \hat{r}}{4\pi\varepsilon_0 r^2}}$

$\rightarrow \boxed{\vec{E}(r,\theta) = \frac{p}{4\pi\varepsilon_0 r^3}(2\cos\theta\,\hat{r} + \sin\theta\,\hat{\theta})}$

o] Polarized: (Dielec)

$\rightarrow \vec{P} = \vec{p}/V$

$\rightarrow \boxed{V(\vec{r}) = \int \frac{\sigma_b \, da'}{R} + \int \frac{\rho_b \, d\tau'}{R}}$

$\sigma_b = \vec{P} \cdot \hat{n}$ $\qquad$ $\rho_b = -\vec{\nabla} \cdot \vec{P}$

$\rightarrow \boxed{\vec{E} = \frac{-\vec{P}}{3\varepsilon_0}}$

$\rightarrow \boxed{\vec{\nabla} \cdot \vec{D} = \rho_f}$ → Electric Displacement

*] Magnetostats:

$\rightarrow \vec{F} = q(\vec{v} \times \vec{B})$,

$\rightarrow$ Fmag does no work

$\rightarrow \vec{F}_{wire} = \int i\,\vec{dl} \times \vec{B}$

$\longrightarrow \vec{J} = \vec{i}/a_\perp$

o] Continuity:

$\rightarrow \boxed{\vec{\nabla} \cdot \vec{J} = -\frac{\partial \rho}{\partial t}}$ → local charge conserv. $= 0$ for steady current

o] Biot-Savart:

$\rightarrow \boxed{\vec{B} = \frac{\mu_0}{4\pi}\int \frac{i\,\vec{dl} \times \hat{r}}{r^2}}$

o] Ampere's Law:

$\rightarrow \oint B \cdot dl = \mu_0 i_{net}$

$\rightarrow \boxed{\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}_{net}}$ ∵ (Stokes)

$\rightarrow \boxed{\vec{\nabla} \cdot \vec{B} = 0}$ ⇒ no monopole exist as each closed loop nothing acts as source

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

$\rightarrow \mu_0 \vec{J} = -\nabla^2 \vec{A}$ ∵ ($\vec{\nabla} \times \vec{B}$ & invariance under Gauge)

→ $A_{monopole} = 0$ ∵ (expected)

→ $A_{dipole} = \frac{\mu_0 (\vec{ia}) \times \hat{r}}{4\pi r^2}$

→ Dipole:

$$\boxed{\vec{m} = i \cdot \vec{a} = i \oint \vec{da}}$$

→ $\vec{B}_{dipole} = \vec{\nabla} \times \vec{A} = \frac{\mu_0 \vec{m}}{4\pi r^3} (2\cos\theta \hat{r} + \sin\theta \hat{\theta})$

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

✪ Torque is in such a dirn as to line up dipole parallel to $\vec{B}$

⇒ **PARAMAGNETISM** "only non paired"

→ $\Delta v_e = \frac{eRB}{2m_e}$ → after introducing B (~~subtract~~ eqns)

& $\Delta m = -\frac{1}{2} e \Delta v R \hat{z}$

∴ $\Delta v \uparrow$ $\Delta m \downarrow$ ⇒ antiparallel alignment wrt field

⇒ **DIAMAGNETISM**