ELECTROSTATICS

Maxwell: $\nabla E = \nabla\cdot E + i\nabla\times E = \rho/\varepsilon_0$ $\quad E = -\nabla V \quad \nabla^2 V = -\rho/\varepsilon_0$

$$V = \frac{1}{4\pi\varepsilon_0}\left(\frac{1}{r} * \rho\right) = \frac{1}{4\pi\varepsilon_0}\int\frac{\rho(r')}{|r-r'|}d\tau' \qquad E = \frac{1}{4\pi\varepsilon_0}\left(\frac{\hat{r}}{r^2} * \rho\right) = \frac{1}{4\pi\varepsilon_0}\int\frac{\hat{r}}{r^2}\rho(r')d\tau'$$

Gauss's law: $\oint E\cdot da = Q_{enc}/\varepsilon_0$

Conductors: $E = 0$ inside, E perpendicular to the surface outside

Boundary conditions: $\hat{n}E]_2^1 = \hat{n}\cdot E]_2^1 + i\hat{n}\times E]_2^1 = \sigma/\varepsilon_0$

Electric dipole:

$$N = p\times E \qquad F = \nabla(p\cdot E) \qquad U = -p\cdot E \qquad V = \frac{p\cdot\hat{r}}{4\pi\varepsilon_0 r^2}$$

Dielectrics:

$$V_d(r) = \frac{1}{4\pi\varepsilon_0}\int\frac{P(r')\cdot\hat{r}}{r^2}d\tau' = \frac{1}{4\pi\varepsilon_0}\int\frac{\rho_b}{r}d\tau' + \frac{1}{4\pi\varepsilon_0}\oint\frac{\sigma_b}{r}da'$$

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

$$D = \varepsilon_0 E + P \qquad \nabla\cdot D = \rho_{free} \qquad \nabla\times E = 0 \qquad \oint D\cdot da = Q_{free}$$

MAGNETOSTATICS

Maxwell: $\nabla B = \nabla\cdot B + i\nabla\times B = i\mu_0 J$

$$B = \nabla\times A \qquad \nabla^2 A = -\mu_0 J \qquad A(r) = \frac{\mu_0}{4\pi}\left(\frac{1}{r} * J\right) \qquad B(r) = \frac{\mu_0}{4\pi}\int\frac{J(r')\times\hat{r}}{r^2}d\tau'$$

Ampere's law: $\oint B\cdot dl = \mu_0 I_{enc}$

Superconductors: $B = 0$ inside

Boundary conditions: $\hat{n}B]_2^1 = \hat{n}\cdot B]_2^1 + i\hat{n}\times B]_2^1 = i\mu_0 K$

Magnetic dipole:

$$N = m\times B \qquad F = \nabla(m\cdot B) \qquad U = -m\cdot B \qquad A = \frac{\mu_0 m\times\hat{r}}{4\pi r^2}$$

Magnetic materials:

$$A_d(r) = \frac{\mu_0}{4\pi}\int\frac{M(r')\times\hat{r}}{r^2}d\tau' = \frac{\mu_0}{4\pi}\int\frac{J_b}{r}d\tau' + \frac{\mu_0}{4\pi}\oint\frac{K_b}{r}da'$$

$$J_b = \nabla\times M \qquad K_b = M\times\hat{n}$$

$$B = \mu_0(H + M) \qquad \nabla\times H = J_f \qquad \nabla\cdot B = 0 \qquad \oint H\cdot dl = I_{free}$$