Force $\vec{F}_{elec} = Q\vec{E}$

Electrostatics

ρ

$V = \frac{1}{4\pi\epsilon_0}\int \frac{\rho}{\mathscr{r}}\, d\tau$

$\nabla^2 V = -\rho/\epsilon_0$

$\vec{E} = \frac{1}{4\pi\epsilon_0}\int \frac{\rho\, d\tau}{\mathscr{r}^2}\hat{\mathscr{r}}$

$\vec{\nabla}\cdot\vec{E} = \rho/\epsilon_0$ Gauss's law $\oint \vec{E}\cdot d\vec{a} = \frac{Q_{encl}}{\epsilon_0}$

$\vec{\nabla}\times\vec{E} = 0$

V $\quad$ E

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

$V = -\int \vec{E}\cdot d\vec{l}$

Boundary Conditions (p.88 & 89)

$$\left.\begin{array}{l} E^{\perp}_{above} - E^{\perp}_{below} = \frac{\sigma}{\epsilon_0} \\ \vec{E}^{\parallel}_{above} = \vec{E}^{\parallel}_{below}\end{array}\right\}\ \vec{E}_{above} - \vec{E}_{below} = \frac{\sigma}{\epsilon_0}\hat{n}$$

$$V_{above} = V_{below}$$

$$\frac{\partial V_{above}}{\partial n} - \frac{\partial V_{below}}{\partial n} = -\frac{\sigma}{\epsilon_0}$$

(p. 185) $D^{\perp}_{above} - D^{\perp}_{below} = \sigma_f$

$\vec{D}^{\parallel}_{above} - \vec{D}^{\parallel}_{below} = \vec{P}^{\parallel}_{above} - \vec{P}^{\parallel}_{below}$

Multipole Expansion (p. 153 ff)

$$V(\vec{r}) = \frac{1}{4\pi\epsilon_0}\sum_{n=0}^{\infty}\frac{1}{r^{(n+1)}}\int (r')^n P_n(\cos\alpha)\rho(\vec{r}\,')\,d\tau'$$

$V_{mon}(\vec{r}) = \frac{1}{4\pi\epsilon_0}\frac{Q}{r}$ $\quad$ $V_{dip}(\vec{r}) = \frac{1}{4\pi\epsilon_0}\frac{1}{r^2}\hat{r}\cdot\underbrace{\int \vec{r}\,'\rho(\vec{r}\,')\,d\tau'}$

$\vec{p}$ = electric dipole

$\vec{E}_{dip} = \frac{1}{4\pi\epsilon_0}\frac{1}{r^3}\left[3(\vec{p}\cdot\hat{r})\hat{r} - \vec{p}\right]$

$\uparrow^{z}_{\vec{p}}$: $\vec{E}_{dip} = \frac{p}{4\pi\epsilon_0 r^3}(2\cos\theta\,\hat{r} + \sin\theta\,\hat{\theta})$

for point charges $\vec{p} = \sum_{i=1}^{n} q_i \vec{r}_i\,'$

$\vec{N} = \vec{p}\times\vec{E}$

$\vec{F}_{dip} = (\vec{p}\cdot\vec{\nabla})\vec{E}$

Magnetostatics

$\vec{J}$

$K\,da$, $I\,d\vec{l}$

only if current finite $\rightarrow$ $\boxed{\vec{A} = \frac{\mu_0}{4\pi}\int \frac{\vec{J}\,d\tau}{\mathscr{r}}}$

$\boxed{\nabla^2\vec{A} = -\mu_0\vec{J}}$

$\vec{B} = \frac{\mu_0}{4\pi}\int \frac{\vec{J}\times\hat{\mathscr{r}}}{\mathscr{r}^2}\,d\tau$

Ampere's Law $\boxed{\vec{\nabla}\times\vec{B} = \mu_0\vec{J}}$

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

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

A $\quad$ B

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

Forces $\vec{F}_{mag} = Q\vec{v}\times\vec{B}$

$\vec{F}_{mag} = \int I\, d\vec{l}\times\vec{B}$

OR

$\int \vec{K}\times\vec{B}\,da = \vec{F}_{mag}$

OR

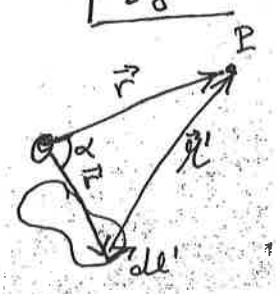
$\int \vec{J}\times\vec{B}\,d\tau = \vec{F}_{mag}$

Boundary Conditions (p. 250)

$$\left.\begin{array}{l} B^{\perp}_{above} = B^{\perp}_{below} \\ B^{\parallel}_{above} - B^{\parallel}_{below} = \mu_0 K\end{array}\right\}\ \vec{B}_{above} - \vec{B}_{below} = \mu_0(\vec{K}\times\hat{n})$$

$$\vec{A}_{above} = \vec{A}_{below}$$

$$\frac{\partial\vec{A}_{above}}{\partial n} - \frac{\partial\vec{A}_{below}}{\partial n} = -\mu_0\vec{K}$$



Multipole Expansion (p. 252 ff)

$$\vec{A}(\vec{r}) = \frac{\mu_0 I}{4\pi}\sum_{n=0}^{\infty}\frac{1}{r^{(n+1)}}\oint (r')^n P_n(\cos\alpha)\,d\vec{l}\,'$$

$\uparrow I$: $\vec{B}_{dip}(\vec{r}) = \frac{\mu_0 m}{4\pi r^3}(2\cos\theta\,\hat{r} + \sin\theta\,\hat{\theta})$

$\vec{B}_{dip}(\vec{r}) = \frac{\mu_0}{4\pi r^3}\left[3(\vec{m}\cdot\hat{r})\hat{r} - \vec{m}\right]$ $\quad$ $\vec{A}_{dip}(\vec{r}) = \frac{\mu_0}{4\pi}\frac{\vec{m}\times\hat{r}}{r^2}$

$\vec{m} = I\int d\vec{a}$ magnetic moment