Force ($\mathbf{F}$, $\mathbf{f}$)
$\mathbf{F} = \frac{1}{4\pi\epsilon_0}\frac{qQ}{\mathscr{r}^2}\hat{\boldsymbol{\mathscr{r}}}$ *point charge*
$\mathbf{F} = Q\mathbf{E}$ *e-field*
$\mathbf{f} = \sigma\mathbf{E}$ *per unit A*
$\mathbf{f} = \frac{1}{2}\sigma(\mathbf{E}_{abv} + \mathbf{E}_{blw})$ *general*
Electric Field (E)
$\mathbf{E}(\mathbf{r}) = \frac{1}{4\pi\epsilon_0}\sum_{i=1}^{n}\frac{q_i}{\mathscr{r}_i^2}\hat{\boldsymbol{\mathscr{r}}}_i$ *point charges*
$\mathbf{E}(\mathbf{r}) = \frac{1}{4\pi\epsilon_0}\int\frac{1}{\mathscr{r}^2}\hat{\boldsymbol{\mathscr{r}}}dq$ *continuous q-dist*
$\mathbf{E}(\mathbf{r}) = \frac{1}{4\pi\epsilon_0}\int\frac{\lambda(\mathbf{r}')}{\mathscr{r}^2}\hat{\boldsymbol{\mathscr{r}}}dl'$ *linear q-dist*
$\mathbf{E}(\mathbf{r}) = \frac{1}{4\pi\epsilon_0}\int\frac{\sigma(\mathbf{r}')}{\mathscr{r}^2}\hat{\boldsymbol{\mathscr{r}}}da'$ *surface q-dist*
$\mathbf{E}(\mathbf{r}) = \frac{1}{4\pi\epsilon_0}\int\frac{\rho(\mathbf{r}')}{\mathscr{r}^2}\hat{\boldsymbol{\mathscr{r}}}d\tau'$ *volume q-dist*
$\oint\mathbf{E}\cdot d\mathbf{a} = \frac{1}{\epsilon_0}Q_{enc}$ *G-symm q-dist*
$\mathbf{E} = -\nabla V$ *e-potential*
$\mathbf{E} = \mathbf{0}$ *inside conductor*
$\mathbf{E} \neq \mathbf{0}$ *cavity in conductor*
$\mathbf{E} = \frac{\sigma}{\epsilon_0}\hat{n}$ *just outside conductor*

Electric Potential (V)
$V(\mathbf{r}) \equiv \int_{\mathcal{O}=\infty}^{\mathbf{r}}\mathbf{E}\cdot d\mathbf{l}$ *def*
$V = \sum_i V_i$ *linsup*
$V = \frac{1}{4\pi\epsilon_0}\sum_i\frac{q_i}{\mathscr{r}_i}$ *point charges*
$V(\mathbf{r}) = \frac{1}{4\pi\epsilon_0}\int\frac{1}{\mathscr{r}}dq$ *continuous q-dist*
$V(\mathbf{r}) = \frac{1}{4\pi\epsilon_0}\int\frac{\rho(\mathbf{r}')}{\mathscr{r}}d\tau'$ *volume q-dist*
$V = \frac{1}{4\pi\epsilon_0}\int\frac{\lambda(\mathbf{r}')}{\mathscr{r}}dl'$ *linear q-dist*
$V = \frac{1}{4\pi\epsilon_0}\int\frac{\sigma(\mathbf{r}')}{\mathscr{r}}da'$ *surface q-dist*
$V(\mathbf{r}) = W/Q$ *work*
$\nabla^2 V = -\frac{\rho}{\epsilon_0}$ *Poisson w/ bc's*
$\nabla^2 V = 0$ *no enclosed ρ, uniqueness thms*
$\pm\mathbf{q}$ q_i *above conducting plane(s)*
$V(\mathbf{r}) = \frac{1}{4\pi\epsilon_0}\sum_{n=0}^{\infty}\frac{1}{r^{n+1}}$
$\int(r')^n P_n(\cos\alpha)\rho(\mathbf{r}')d\tau'$ *far from q-dist (mp exp)*
$V(\mathbf{r}) = \frac{1}{4\pi\epsilon_0}(\frac{1}{r}\int\rho(\mathbf{r}')d\tau'$
$+ \frac{1}{r^2}\int r'\cos\alpha\rho(\mathbf{r}')d\tau'$
$+ \frac{1}{r^3}\int(r')^2(\frac{3}{2}\cos\alpha^2))$ *far from q-dist (mp exp)*
$V_{dip}(\mathbf{r}) = \frac{1}{4\pi\epsilon_0}\frac{\mathbf{p}\cdot\hat{\mathbf{r}}}{r^2}$ *no net charge*
Work (W)
$W = \int_a^b\mathbf{F}\cdot d\mathbf{l}$ *def*
$W = QV(\mathbf{r})$ *e-potential*
$W = \frac{1}{2}\sum_{i=1}^{n}q_iV(\mathbf{r}_i)$ *p-q's, V_i of others*
$W = \frac{1}{2}\int\sigma V da$ *surf-q density*
$W = \frac{1}{2}\int\rho V d\tau$ *vol-q density*
$W = \frac{\epsilon_0}{2}\int E^2 d\tau$ *e-field, all space*
Energy (W)
$W = \frac{1}{2}\sum_{i=1}^{n}q_iV(\mathbf{r}_i)$ *assembly*
$W = \frac{\epsilon_0}{2}\int E^2 d\tau$ *total, e-field*
$W = \frac{1}{2}\int\rho V d\tau$ *total, q-dist*
$W = \frac{1}{2}CV^2$ *capacitor*

Dipole Moment ($\mathbf{p}$)
$\mathbf{p} \equiv \int\mathbf{r}'\rho(\mathbf{r}')d\tau'$ *gen*
$\mathbf{p} = \sum_i^n q_i\mathbf{r}'_i$ *p-q's*
$\mathbf{p} = q\mathbf{d}$ *equal/opp q's*

Physical Dipole ($\mathbf{d}$)

Curl of E
$\nabla\times\mathbf{E} = \mathbf{0}$ *static q-dist*
Charge Density (ρ)
$\nabla\cdot\mathbf{E} = \frac{1}{\epsilon_0}\rho$ *e-field*
$\nabla^2 V = -\frac{\rho}{\epsilon_0}$ *e-potential*
$\rho = 0$ *inside conductor*

Capacitance (C)
$C \equiv \frac{Q^+}{V^+}$ *def*

Surface Charge (σ)
$\sigma = -\epsilon_0\frac{\partial V}{\partial n}$ *conductor*

e-Pressure
$P = \frac{\epsilon_0}{2}E^2$ *conductor in e-field*

Charge Enclosed (Q_{enc})
$\oint\mathbf{E}\cdot d\mathbf{a} = \frac{1}{\epsilon_0}Q_{enc}$ *G-symm q-dist*
$Q_{enc} = \int\lambda dl = \int\sigma da = \int\rho d\tau$ *general*
$Q_{enc} = Q_{surf}$ *conductor*
$Q_{enc} = -q_{induced}$ *induction*
$Q_{enc} = \sum q_i$ *conductor w/ cavity q's*

Laplace ($\nabla^2 V = 0$)
$V(x,y) = \sum_{n,m,\ldots}(Ae^{kx} + Be^{-kx})(C\sin ky + D\cos ky)$ *planes, "box"*
$V(r,\theta) = \sum_{l=0}^{\infty}\left(A_l r^l + \frac{B_l}{r^{l+1}}\right)P_l(\cos\theta)$ *spherical*

Cartesian Coefficients (A, B, C, D)
$C = 0$ *term diverges*
$C = \mathcal{F}$ *orthogonal series*
$C = \mathcal{B}$ *boundary conditions*

Spherical Coefficients (A_l, B_l)
$C = 0$ *term diverges*
$C = \mathcal{F}$ *orthogonal series*
$C = \mathcal{B}$ *boundary conditions*

Method of Images ($\pm\mathbf{q}$)

Fourier Method ($\mathcal{F}$)

Legendre Polynomials (P_l, P_n)
$P_l = P_n \equiv \frac{1}{2^l l!}(\frac{d}{dx})^l(x^2-1)^l$ *Rodrigues*

Boundary Conditions ($\mathcal{B}$)
$\mathcal{B} = \mathcal{B}(V_{in/out})$ *(sphr) e-pot cont. across bndry*
$\mathcal{B} = \mathcal{B}(V_0)$ *surf pot specified*
$\mathcal{B} = \mathcal{B}(\sigma_0)$ *surf charge specified*

Separation vector
$\boldsymbol{\mathscr{r}} = \mathbf{r} - \mathbf{r}'$ *general*
Charge differential
$dq = \lambda dl'$ *linear dist*
$dq = \sigma da'$ *surface dist*
$dq = \rho d\tau'$ *volume dist*
Line differential
$d\mathbf{l} = dr\hat{\mathbf{r}} + rd\theta\hat{\theta} + r\sin\theta d\phi\hat{\phi}$
Volume differential
$d\tau = s'ds'd\phi dz$ *cylin*
$d\tau = r^2 \sin\theta dr d\theta d\phi$ *sphr*
Boundary Conditions
$E^{\perp}_{above} - E^{\perp}_{below} = \frac{\sigma}{\epsilon_0}$ *any boundry*
$\frac{\partial V_{above}}{\partial n} - \frac{\partial V_{below}}{\partial n} = -\frac{\sigma}{\epsilon_0}$ *any boundry*
$V_{in}(R) = V_{out}(R)$ *V cont across boundry*
$V(\theta_1) = V(\theta_2)$ *conductor* $\rightarrow$ *equipotential*
Normal Derivative
$\frac{\partial V}{\partial n} = \nabla V \cdot \hat{n}$ *general*