cylindrical $\nabla\times\mathbf{A} = \left[\frac{1}{s}\frac{\partial A_z}{\partial\phi} - \frac{\partial A_\phi}{\partial z}\right]\hat{\mathbf{s}} + \left[\frac{\partial A_s}{\partial z} - \frac{\partial A_z}{\partial s}\right]\hat{\phi} + \frac{1}{s}\left[\frac{\partial (sA_\phi)}{\partial s} - \frac{\partial A_s}{\partial \phi}\right]\hat{\mathbf{z}}$ $\vec{\nabla} f = \hat{\mathbf{s}}\frac{\partial f}{\partial s} + \hat{\phi}\frac{1}{s}\frac{\partial f}{\partial \phi} + \hat{\mathbf{z}}\frac{\partial f}{\partial z}$

$\nabla\cdot\mathbf{A} = \frac{1}{s}\frac{\partial (sA_s)}{\partial s} + \frac{1}{s}\frac{\partial A_\varphi}{\partial \varphi} + \frac{\partial A_z}{\partial z}$ $d\tau = s\, ds\, d\phi\, dz$ $da = s\, d\phi\, dz$ $d\mathbf{l} = ds\,\hat{\mathbf{s}} + s\, d\phi\,\hat{\boldsymbol{\phi}} + dz\,\hat{\mathbf{z}}$

spherical $\vec{\nabla} = \hat{r}\frac{\partial f}{\partial r} + \hat{\theta}\frac{1}{r}\frac{\partial f}{\partial \theta} + \hat{\phi}\frac{1}{r\sin\theta}\frac{\partial f}{\partial \phi}$ $d\mathbf{l} = dr\,\hat{\mathbf{r}} + r\, d\theta\,\hat{\boldsymbol{\theta}} + r\sin\theta\, d\phi\,\hat{\boldsymbol{\phi}}$

Polar (2d) $da = r\, dr\, d\theta$

$\nabla\times\mathbf{A} = \frac{1}{r\sin\theta}\left[\frac{\partial}{\partial\theta}\sin\theta A_\phi - \frac{\partial A_\theta}{\partial \phi}\right]\hat{\mathbf{r}} + \frac{1}{r}\left[\frac{1}{\sin\theta}\frac{\partial A_r}{\partial\phi} - \frac{\partial}{\partial r}(rA_\phi)\right]\hat{\theta} + \frac{1}{r}\left[\frac{\partial (rA_\theta)}{\partial r} - \frac{\partial A_r}{\partial \theta}\right]\hat{\phi}$

$da = r^2\, d\theta\, \sin\theta\, d\phi$ $d\tau = dr\, da = r^2\, dr\, d\theta\, \sin\theta\, d\phi$

cartesian $d\mathbf{l} = dx\,\hat{\mathbf{x}} + dy\,\hat{\mathbf{y}} + dz\,\hat{\mathbf{z}}$ $d\tau = dx\, dx\, dz$ $\vec{\nabla} f = \hat{\mathbf{x}}\frac{\partial f}{\partial x} + \hat{\mathbf{y}}\frac{\partial f}{\partial y} + \hat{\mathbf{z}}\frac{\partial f}{\partial z}$ $\nabla\times\mathbf{A} = \begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ A_x & A_y & A_z \end{vmatrix}$

Gauss's Law: $\nabla\cdot\mathbf{E} = \frac{\rho}{\varepsilon_0}$ $\mathbf{E} = \frac{q}{4\pi\varepsilon_0}\frac{\hat{\mathbf{r}}}{r^2}$ $V(r_b) - V(r_a) = -\int_{r_a}^{r_b}\mathbf{E}\cdot d\mathbf{l}$ $\nabla^2 V = 0 \Rightarrow \frac{1}{X}\frac{d^2X}{dx^2} + \frac{1}{Y}\frac{d^2Y}{dy^2} + \frac{1}{Z}\frac{d^2Z}{dz^2} = 0$

$V(\mathbf{r}) = \frac{1}{4\pi\varepsilon_0}\int_{surface}\frac{\sigma(\mathbf{r}')}{|\mathbf{r}-\mathbf{r}'|}da'$ $V(\mathbf{r}) = \frac{1}{4\pi\varepsilon_0}\int_{volume}\frac{\rho(\mathbf{r}')}{|\mathbf{r}-\mathbf{r}'|}d\tau'$ $V(r,\theta) = \sum_{l=0}^{\infty}\left(A_l r^l + \frac{B_l}{r^{l+1}}\right)P_l(\cos\theta)$

$\nabla^2 V = -\frac{\rho}{\varepsilon_0}$ $\mathbf{E} = -\nabla V$ $\mathbf{E} = \frac{1}{4\pi\varepsilon_0}\int\frac{\hat{\varsigma}}{\varsigma^2}\rho(r')d\tau'$ where $\vec{\varsigma} = \mathbf{r} - \mathbf{r}'$

$\mathbf{E}_{dip} = \frac{p}{4\pi\varepsilon_0 r^3}\left(2\cos\theta\,\hat{\mathbf{r}} + \sin\theta\,\hat{\theta}\right)$

$V(\mathbf{r}) = \frac{1}{4\pi\varepsilon_0}\sum_{n=0}^{\infty}\frac{1}{r^{n+1}}\int_{volume} d\tau'(r')^n P_n(\cos(\theta'))\rho(\mathbf{r}')$ $V_{dipole}(\mathbf{r}) = \frac{1}{4\pi\varepsilon_0}\frac{\mathbf{p}\cdot\hat{\mathbf{r}}}{r^2}$

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

$\mathbf{D} = \varepsilon_0\mathbf{E} + \mathbf{P}$ $\nabla\cdot\mathbf{D} = \rho_{free}$ $\mathbf{P} = \varepsilon_0\chi_e\mathbf{E}$ (*linear dielectrics*) $\mathbf{D} = \varepsilon_0(1+\chi_e)\mathbf{E}$

$\mathbf{N} = \mathbf{p}\times\mathbf{E}$ or $\mathbf{N} = \mathbf{m}\times\mathbf{B}$, $\mathbf{F} = \nabla(\mathbf{p}\cdot\mathbf{E})$ or $\nabla(\mathbf{m}\cdot\mathbf{B})$ $\mathbf{p} = \int_{volume}\mathbf{r}'\rho(\mathbf{r}')d\tau' = \sum_i \mathbf{r}_i q_i$ $dq = \rho\, d\tau = \sigma\, da = \lambda\, dx$

$E_\perp^{above} - E_\perp^{below} = \frac{\sigma}{\varepsilon_0}$ $W = \frac{\varepsilon_0}{2}\int_{all\ space}E^2 d\tau$

$\mathbf{B}(\mathbf{r}) = \frac{\mu_0}{4\pi}\int\frac{I d\boldsymbol{\ell}\times\hat{\varsigma}}{\varsigma^2} = \frac{\mu_0}{4\pi}\int\frac{\mathbf{J}\times\hat{\varsigma}}{\varsigma^2}d\tau$ where $\vec{\varsigma} = \mathbf{r} - \mathbf{r}'$

$\mathbf{B} = \nabla\times\mathbf{A}$ $\mathbf{H} = \frac{\mathbf{B}}{\mu_0} - \mathbf{M}$ $\nabla\times\mathbf{H} = \mathbf{J}_{free}$

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

$\nabla\times\mathbf{B} = \mu_0\mathbf{J} \rightarrow \oint\mathbf{B}\cdot d\ell = \mu_0 I_{enc}$ $I = \lambda v$ $K = \sigma v$ $J = \rho v$ $K_b = M\times n$ $J_b = \mathrm{curl}(\mathbf{M})$

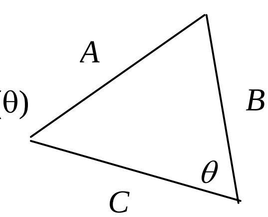
$\nabla\cdot\mathbf{B} = 0$ $I_{enc} = \int\mathbf{J}\cdot d\mathbf{a}$ $\mathbf{F} = Q\mathbf{v}\times\mathbf{B}$ $d\mathbf{F} = I\, d\ell\times\mathbf{B} = da\,\mathbf{K}\times\mathbf{B} = d\tau\,\mathbf{J}\times\mathbf{B}$

$\int_{volume}\nabla\cdot\mathbf{A}\, d\tau = \oint_{surface}\mathbf{A}\cdot d\mathbf{a}$ ← Divergence Theorem Stokes Theorem → $\int(\nabla\times\mathbf{A})\cdot d\mathbf{a} = \oint\mathbf{A}\cdot d\mathbf{l}$

$\varepsilon_0 = 8.85\times 10^{-12}\ C^2/Nm^2$ $\mu_0 = 4\pi\times 10^{-7}\ N/A^2$

$$\int_0^\pi d(\cos\theta)P_m(\cos\theta)P_l(\cos\theta) = \begin{cases} 0 & if\ m\neq l \\ \frac{2}{2m+1} & if\ m = l\end{cases}$$

$A^2 = B^2 + C^2 - 2\,B\,C\cos(\theta)$



$P_0(x) = 1,\quad P_1(x) = x,\quad P_2(x) = \frac{1}{2}(3x^2 - 1),\quad \ldots$

$\int\frac{dx}{(x^2+a^2)^{3/2}} = \frac{x}{a^2\sqrt{x^2+a^2}}$ $\int_0^a\sin\left(\frac{n\pi x}{a}\right)\sin\left(\frac{m\pi x}{a}\right)dx = \begin{matrix} 0 & if\ n\neq m \\ a/2 & if\ n = m\end{matrix}$

$\int\sin(kx)dx = \frac{-1}{k}\cos(kx)$ $\int\frac{\sin(\theta)d\theta}{\sqrt{1-\cos(\theta)}} = 2\sqrt{1-\cos(\theta)}$ $\int\cos(kx)dx = \frac{1}{k}\sin(kx)$