Electric and Magnetic field equations

$$\overline{E}(\overline{r}) = \int_{c'} \frac{\rho_l(\overline{r}')dl'}{4\pi\varepsilon R^2}\hat{a}_R \qquad \overline{E}(\overline{r}) = \int_{s'} \frac{\rho_s(\overline{r}')ds'}{4\pi\varepsilon R^2}\hat{a}_R \qquad \overline{E}(\overline{r}) = \int_{v'} \frac{\rho_v(\overline{r}')dv'}{4\pi\varepsilon R^2}\hat{a}_R$$

$$V(\overline{r}) = \int_{c'} \frac{\rho_l(\overline{r}')dl'}{4\pi\varepsilon R} \qquad V(\overline{r}) = \int_{s'} \frac{\rho_s(\overline{r}')ds'}{4\pi\varepsilon R} \qquad V(\overline{r}) = \int_{v'} \frac{\rho_v(\overline{r}')dv'}{4\pi\varepsilon R}$$

$$\oint_s \overline{E}.\overline{ds} = \frac{1}{\varepsilon_0}\int_v \rho_v\, dv \qquad \nabla.\overline{E} = {}^{\rho}/_{\varepsilon_0} \qquad \nabla\times\overline{E} = 0 \qquad \nabla^2 V = -{}^{\rho_v}/_{\varepsilon_0} \qquad \nabla.\overline{D} = \rho_v \qquad \overline{D} = \varepsilon\overline{E}$$

$$\oint_s \overline{D}.\overline{ds} = Q \qquad V = \int_L \overline{E}.\overline{dl} \qquad C = \frac{Q}{V} \qquad \rho_{ps} = \overline{P}.\hat{a}_n \qquad \rho_{pv} = -\nabla.\overline{P} \qquad \overline{D} = \varepsilon_0\overline{E} + \overline{P} \qquad \overline{P} = \varepsilon_0\chi_e\overline{E}$$

$$\overline{B}(\overline{r}) = \int_{c'} \frac{\mu_0 I\overline{dl'}\times\vec{R}}{4\pi R^3} \qquad \overline{B}(\overline{r}) = \int_{s'} \frac{\mu_0\vec{J}_s(\overline{r}')\times\vec{R}ds'}{4\pi R^3} \qquad \overline{B}(\overline{r}) = \int_{v'} \frac{\mu_0\vec{J}_v(\overline{r}')\times\vec{R}dv'}{4\pi R^3}$$

$$\overline{A}(\overline{r}) = \int_{c'} \frac{\mu_0 I\overline{dl'}}{4\pi R} \qquad \overline{A}(\overline{r}) = \int_{s'} \frac{\mu_0\vec{J}_s(\overline{r}')ds'}{4\pi R} \qquad A(\overline{r}) = \int_{v'} \frac{\mu_0\vec{J}_v(\overline{r}')dv'}{4\pi R}$$

$$\oint_s \overline{B}.\overline{ds} = 0 \qquad \nabla.\overline{B} = 0 \qquad \nabla\times\overline{B} = \mu_0\vec{J}_v \qquad \nabla^2\overline{A} = -\mu_0\vec{J}_v \qquad \nabla\times\overline{H} = \vec{J}_v \qquad \overline{B} = \mu_0\overline{H}$$

$$\oint_L \overline{H}.\overline{dL} = I \qquad L = \frac{\Psi}{I} \qquad \vec{J}_{ms} = \overline{M}\times\hat{a}_n \qquad \vec{J}_{mv} = \nabla\times\overline{M} \qquad \overline{H} = \frac{1}{\mu_0}\overline{B} - \overline{M} \qquad \overline{M} = \frac{\chi_m}{\mu_0}\overline{B}$$

Boundary conditions

$$\hat{a}_{n21}\times(\overline{E}_1 - \overline{E}_2) = 0 \qquad \hat{a}_{n21}.(\overline{D}_1 - \overline{D}_2) = \rho_s$$

$$\hat{a}_{n21}\times(\overline{H}_1 - \overline{H}_2) = \vec{J}_s \qquad \hat{a}_{n21}.(\overline{B}_1 - \overline{B}_2) = 0$$

Some useful integrals

$$\int \frac{dx}{(x^2 + a^2)^{3/2}} = \frac{x}{a^2(x^2 + a^2)^{1/2}} \qquad \int \frac{xdx}{(x^2 + a^2)^{3/2}} = \frac{-1}{(x^2 + a^2)^{1/2}}$$

Cylindrical to Cartesian coordinate transforms

Inner product (.)	$\hat{a}_x$	$\hat{a}_y$	$\hat{a}_z$
$\hat{a}_r$	cosφ	sinφ	0
$\hat{a}_\varphi$	-sinφ	cosφ	0
$\hat{a}_z$	0	0	1

Spherical to Cartesian coordinate transforms

Inner product (.)	$\hat{a}_x$	$\hat{a}_y$	$\hat{a}_z$
$\hat{a}_r$	sinθ cosφ	sin θ sinφ	cosθ
$\hat{a}_\theta$	cosθ cosφ	cosθ sinφ	- sinθ
$\hat{a}_\varphi$	- sinφ	cosφ	0

$$\nabla.\overline{A} = \frac{1}{h_1h_2h_3}\left[\frac{\partial}{\partial u_1}(h_2h_3A_1) + \frac{\partial}{\partial u_2}(h_1h_3A_2) + \frac{\partial}{\partial u_3}(h_1h_2A_3)\right]$$

$$\nabla\times\overline{A} = \frac{1}{h_1h_2h_3}\begin{vmatrix} h_1\hat{a}_{u_1} & h_2\hat{a}_{u_2} & h_3\hat{a}_{u_3} \\ \frac{\partial}{\partial u_1} & \frac{\partial}{\partial u_2} & \frac{\partial}{\partial u_3} \\ h_1A_1 & h_2A_2 & h_3A_3 \end{vmatrix}$$

$$\nabla f = \frac{1}{h_1}\frac{\partial f}{\partial u_1}\hat{a}_{u_1} + \frac{1}{h_2}\frac{\partial f}{\partial u_2}\hat{a}_{u_2} + \frac{1}{h_3}\frac{\partial f}{\partial u_3}\hat{a}_{u_3}$$

$$\nabla^2 f = \frac{1}{h_1h_2h_3}\left[\frac{\partial}{\partial u_1}\left(\frac{h_2h_3}{h_1}\frac{\partial f}{\partial u_1}\right) + \frac{\partial}{\partial u_{21}}\left(\frac{h_1h_3}{h_2}\frac{\partial f}{\partial u_2}\right) + \frac{\partial}{\partial u_3}\left(\frac{h_1h_2}{h_3}\frac{\partial f}{\partial u_3}\right)\right]$$

Cartesian coordinate

$\overline{dl}_x = dx\hat{a}_x$, $\overline{dl}_y = dy\hat{a}_y$, $\overline{dl}_z = dz\hat{a}_z$

$\overline{dl} = dx\hat{a}_x + dy\hat{a}_y + dz\hat{a}_z$

$\overline{ds}_x = dydz\hat{a}_x$, $\overline{ds}_y = dxdz\hat{a}_y$, $\overline{ds}_z = dxdy\hat{a}_z$

$dv = dxdydz$

$\overline{r} = x\hat{a}_x + y\hat{a}_y + z\hat{a}_z$

Cylindrical coordinate

$\overline{dl}_r = dr\hat{a}_r$, $\overline{dl}_\varphi = rd\varphi\hat{a}_\varphi$, $\overline{dl}_z = dz\hat{a}_z$

$\overline{dl} = dr\hat{a}_r + rd\varphi\hat{a}_\varphi + dz\hat{a}_z$

$\overline{ds}_r = rd\varphi dz\hat{a}_r$, $\overline{ds}_\varphi = drdz\hat{a}_\varphi$, $\overline{ds}_z = rdrd\varphi\hat{a}_z$

$dv = rdrd\varphi dz$

$\overline{r} = r\hat{a}_r + z\hat{a}_z$

Spherical coordinate

$\overline{dl}_r = dr\hat{a}_r$, $\overline{dl}_\theta = rd\theta\hat{a}_\theta$, $\overline{dl}_\varphi = r\sin\theta d\varphi\hat{a}_\varphi$

$\overline{dl} = dr\hat{a}_r + rd\theta\hat{a}_\theta + r\sin\theta d\varphi\hat{a}_\varphi$

$\overline{ds}_r = r^2\sin\theta d\theta d\varphi\hat{a}_r$, $\overline{ds}_\theta = r\sin\theta drd\varphi\hat{a}_\theta$, $\overline{ds}_\varphi = rdrd\theta\hat{a}_\varphi$

$dv = r^2\sin\theta drd\theta d\varphi$

$\overline{r} = r\hat{a}_r$

Trigonometric Identities

$sin^2 x = \frac{1-\cos(2x)}{2}$, $cos^2 x = \frac{1+\cos(2x)}{2}$

$sin^3 x = \frac{1}{4}(-\sin(3x) + 3sinx)$

$cos^3 x = \frac{1}{4}(\cos(3x) + 3scosx)$