Constants:

$$
\begin{aligned}
k_e &\equiv 1/4\pi\epsilon_o = 8.98755\times 10^{9}\ \mathrm{N\cdot m^2\cdot C^{-2}}\\
\epsilon_o &= 8.85\times 10^{-12}\ \mathrm{C^2/N\cdot m^2}\\
\mu_o &\equiv 4\pi\times 10^{-7}\ \mathrm{T\cdot m/A}\\
c^2 &= 1/\mu_o\epsilon_o \approx \left(3\times 10^{8}\ \mathrm{m/s}\right)^2\\
e &= 1.60218\times 10^{-19}\ \mathrm{C}
\end{aligned}
$$

Maxwell's equations, Lorentz, & continuity
(without polarization or magnetization)

$$\vec F_B = q\vec v\times\vec B$$

$$\vec\nabla\cdot\vec E = \frac{\rho}{\epsilon_0}$$

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

$$\vec\nabla\times\vec E = -\frac{\partial\vec B}{\partial t}$$

$$\vec\nabla\times\vec B = \mu_o\vec j + \epsilon_o\mu_o\frac{\partial\vec E}{\partial t}$$

$$\partial\rho/\partial t + \nabla\cdot\vec j = 0$$

$$\oint_S \vec E\cdot d\vec A = \frac{q}{\epsilon_0\epsilon_r} = \frac{1}{\epsilon_0}\int_V \rho\, dV$$

$$\oint_S \vec B\cdot d\vec A = 0$$

$$\oint_C \vec E\cdot d\vec l = -\frac{\partial}{\partial t}\int_S \vec B\cdot d\vec A$$

$$\oint_C \vec B\cdot d\vec l = \mu_o\int_S \vec j\cdot d\vec A + \epsilon_o\mu_o\frac{\partial}{\partial t}\int_S \vec E\cdot d\vec A$$

$$\int_S \vec j\cdot d\vec A = -\frac{d}{dt}\int_V \rho\, dV$$

$$\text{Note } c^2 = \frac{1}{\mu_0\epsilon_0}$$

Electric Force & Field (static case):

$$\vec F_{12} = k_e\frac{q_1q_2}{r_{12}^2}\,\hat{\mathbf r}_{12} = q_2\vec E_1 \qquad \vec r_{12} = \vec r_1 - \vec r_2$$

$$\vec E_1 = \vec F_{12}/q_2 = k_e\frac{q_1}{r_{12}^2}\,\hat{\mathbf r}_{12}$$

$$\vec E = k_e\sum_i \frac{q_i}{r_i^2}\,\hat{\mathbf r}_i \to k_e\int\frac{dq}{r^2}\,\hat{\mathbf r} = k_e\int_V\frac{\rho\hat{\mathbf r}}{r^2}\,d\tau$$

$$\rho\, d\tau \to \sigma\, da \to \lambda\, dl$$

$$\vec\nabla\cdot\vec E = \rho/\epsilon_o \qquad \vec E = -\vec\nabla V$$

Electric Potential (static case):

$$\Delta V = V_B - V_A = \frac{\Delta U}{q} = -\int_A^B \vec E\cdot d\vec l$$

$$V_{\text{point}} = k_e\frac{q}{r} \to V_{\text{continuous}} = k_e\int\frac{dq}{r} = k_e\int\frac{\rho}{r}\,d\tau$$

$$U_{\text{pair of point charges}} = k_e\frac{q_1q_2}{r_{12}} = V_1q_2 = V_2q_1$$

$$U_{\text{field}} = \frac{\epsilon_o}{2}\int E^2\,d\tau = \frac{1}{2}\int\rho V\,d\tau$$

Field transformations
(primed frame moves with v relative to unprimed along x)

$$E'_x = E_x \qquad E'_y = \gamma\left(E_y - vB_z\right) \qquad E'_z = \gamma\left(E_z + vB_y\right)$$

$$B'_x = B_x \qquad B'_y = \gamma\left(B_y + \frac{v}{c^2}E_z\right) \qquad B'_z = \gamma\left(B_z - \frac{v}{c^2}E_y\right)$$

Current & Resistance:

$$I = \int_S \vec j\cdot d\vec A \xrightarrow{\text{uniform } j} I = \frac{dQ}{dt} = nqAv_d$$

$$j = \sum_k n_kq_kv_k \xrightarrow{\text{uniform } j} j = \frac{I}{A} = nqv_d$$

$$R = \Delta V/I \quad \text{or} \quad \vec j = \sigma\vec E \quad \text{Ohm, isotropic}$$

$$j_i = \sum_{j=1}^{3}\sigma_{ij}E_j \quad \text{Ohm, anisotropic/general}$$

Vector Calculus:

$$d\vec l = \hat{\mathbf x}\,dx + \hat{\mathbf y}\,dy + \hat{\mathbf z}\,dz = \hat{\mathbf r}\,dr + \hat{\boldsymbol\theta}\,r\,d\theta + \hat{\boldsymbol\varphi}\,r\sin\theta\,d\varphi \quad \text{cartesian, spherical}$$

$$d\tau = dx\,dy\,dz \quad = r^2\sin\theta\,dr\,d\theta\,d\varphi \quad \text{cartesian, spherical}$$

$$\vec\nabla = \hat{\mathbf x}\frac{\partial}{\partial x} + \hat{\mathbf y}\frac{\partial}{\partial y} + \hat{\mathbf z}\frac{\partial}{\partial z} \quad \text{cartesian}$$

$$\vec\nabla = \hat{\mathbf r}\frac{\partial}{\partial r} + \hat{\boldsymbol\theta}\frac{1}{r}\frac{\partial}{\partial\theta} + \hat{\boldsymbol\varphi}\frac{1}{r\sin\theta}\frac{\partial}{\partial\varphi} \quad \text{spherical}$$

$$\vec\nabla\cdot\vec F = \frac{\partial}{\partial x} + \frac{\partial}{\partial y} + \frac{\partial}{\partial z} \quad \text{cartesian}$$

$$\vec\nabla\cdot\vec F = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2F_r\right) + \frac{1}{r\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\,F_\theta\right) + \frac{1}{r\sin\theta}\frac{\partial F_\varphi}{\partial\varphi} \quad \text{spherical}$$

$$\vec\nabla\times\vec v = \frac{1}{r\sin\theta}\left[\frac{\partial}{\partial\theta}\left(\sin\theta\,v_\varphi\right) - \frac{\partial v_\theta}{\partial\varphi}\right]\hat{\mathbf r} + \frac{1}{r}\left[\frac{1}{\sin\theta}\frac{\partial v_r}{\partial\varphi} - \frac{\partial}{\partial r}\left(rv_\varphi\right)\right]\hat{\boldsymbol\theta}$$
$$+\frac{1}{r}\left[\frac{\partial}{\partial r}\left(rv_\theta\right) - \frac{\partial v_r}{\partial\theta}\right]\hat{\boldsymbol\varphi} \quad \text{spherical}$$

	cartesian (x, y, z)
spherical	$r = \sqrt{x^2+y^2+z^2}$ $\varphi = \tan^{-1}\left(\frac{y}{x}\right)$ $\theta = \tan^{-1}\left(\sqrt{x^2+y^2}/z\right)$
	spherical $(r, \varphi\vert_0^{2\pi}, \theta\vert_0^{\pi})$
cartesian	$x = r\sin\theta\cos\varphi$ $y = r\sin\theta\sin\varphi$ $z = r\cos\theta$

	cartesian $(x, y, z,)$
spherical	$\hat{\mathbf r} = \frac{1}{r}\left(x\,\hat{\mathbf x} + y\,\hat{\mathbf y} + z\,\hat{\mathbf z}\right)$ $\hat{\mathbf r} = \sin\theta\cos\varphi\,\hat{\mathbf x} + \sin\theta\sin\varphi\,\hat{\mathbf y} + \cos\theta\,\hat{\mathbf z}$ $\hat{\boldsymbol\theta} = \cos\theta\cos\varphi\,\hat{\mathbf x} + \cos\theta\sin\varphi\,\hat{\mathbf y} - \sin\theta\,\hat{\mathbf z}$ $\hat{\boldsymbol\varphi} = -\sin\varphi\,\hat{\mathbf x} + \cos\varphi\,\hat{\mathbf y}$
	spherical $(r, \varphi\vert_0^{2\pi}, \theta\vert_0^{\pi})$
cartesian	$\hat{\mathbf x} = \sin\theta\cos\varphi\,\hat{\mathbf r} + \cos\theta\cos\varphi\,\hat{\boldsymbol\theta} - \sin\varphi\,\hat{\boldsymbol\varphi}$ $\hat{\mathbf y} = \sin\theta\sin\varphi\,\hat{\mathbf r} + \cos\theta\sin\varphi\,\hat{\boldsymbol\theta} + \cos\varphi\,\hat{\boldsymbol\varphi}$ $\hat{\mathbf z} = \cos\theta\,\hat{\mathbf r} - \sin\theta\,\hat{\boldsymbol\theta}$

Relativity

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$\Delta t'_{\text{moving}} = \gamma\Delta t_{\text{stationary}} = \gamma\Delta t_p$$

$$L'_{\text{moving}} = \frac{L_{\text{stationary}}}{\gamma} = \frac{L_p}{\gamma}$$

$$x' = \gamma\left(x - vt\right)$$

$$\Delta t' = t'_1 - t'_2 = \gamma\left(\Delta t - \frac{v\Delta x}{c^2}\right)$$

$$p = \gamma mv$$

$$v_{\text{obj}} = \frac{v + v'_{\text{obj}}}{1 + \frac{vv'_{\text{obj}}}{c^2}} \qquad v'_{\text{obj}} = \frac{v_{\text{obj}} - v}{1 - \frac{vv_{\text{obj}}}{c^2}}$$