$\nabla \cdot \mathbf{D} = \rho, \quad \nabla \cdot \mathbf{B} = 0, \quad \nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}, \quad \nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$ Maxwell's Equations (6.6)

$\mathbf{E}(\mathbf{x}) = \frac{1}{4\pi\epsilon_0}\int \rho(\mathbf{x}')\frac{\mathbf{x}-\mathbf{x}'}{|\mathbf{x}-\mathbf{x}'|^3}d^3x'$ Coulomb's Law (1.5)

$\delta(f(x)) = \sum_i \frac{1}{\left|\frac{\mathrm{d}f}{\mathrm{d}x}(x_i)\right|}\delta(x-x_i)$ Delta function Rule 5

$\mathbf{E} = -\nabla\Phi$ Electric field in terms of scalar potential (1.16)

$\Phi(\mathbf{x}) = \frac{1}{4\pi\epsilon_0}\int \frac{\rho(\mathbf{x}')}{|\mathbf{x}-\mathbf{x}'|}d^3x'$ Scalar potential in terms of charge density (1.17)

$\nabla^2\Phi = -\rho/\epsilon_0$ Poisson Equation (1.28)

$q = \int \rho(\mathbf{x}')\ d^3x'$ Monopole (4.4)

$\mathbf{p} = \int \mathbf{x}'\rho(\mathbf{x}')\ d^3x'$ Dipole (4.8)

$Q_{ij} = \int(3x_i'x_j' - r'\delta_{ij})\rho(\mathbf{x}')d^3x' = 3M_{ij} - \mathrm{Tr}(\mathbf{M}\delta_{ij})$ Quadrupole (4.9)

$M_{ij} = \int x_i'x_j'\rho(x')\ d^3x$ Dana definition

$\Phi(\mathbf{x}) = \frac{1}{4\pi\epsilon_0}\left[\frac{q}{r} + \frac{\mathbf{p}\cdot\mathbf{x}}{r^3} + \frac{1}{2}\sum_{i,j}Q_{ij}\frac{x_ix_j}{r^5} + \ldots\right]$ Multipole Expansion (4.10)

$\mathbf{D} = \epsilon_0\mathbf{E} + \mathbf{P}$ Electric displacement(4.34)

$\mathbf{P} = \epsilon_0\chi_e\mathbf{E}$ Induced polarization (4.36)

$\mathbf{P} = (\epsilon - \epsilon_0)\mathbf{E}$ Better expression for polarization

$\mathbf{D} = \epsilon\mathbf{E}$ Electric displacement (4.37)

$\epsilon = \epsilon_0(1+\chi_e)$ Electric permittivity (4.38)

$\sigma_b = \mathbf{P}\cdot\hat{\mathbf{n}}, \quad \rho_b = -\nabla\cdot\mathbf{P}$ Electric bound charge density (G. 4.11)

$\begin{cases}(\mathbf{D}_2 - \mathbf{D}_1)\cdot\mathbf{n}_{21} = \sigma \\ (\mathbf{E}_2 - \mathbf{E}_1)\times\mathbf{n}_{21} = 0\end{cases}$ Boundary conditions (4.40)

$\begin{cases}\Phi_{\text{in}} = -\left(\frac{3}{\epsilon/\epsilon_0+2}\right)E_0 r\cos\theta \\ \Phi_{\text{out}} = -E_0 r\cos\theta + \left(\frac{\epsilon/\epsilon_0-1}{\epsilon/\epsilon_0+2}\right)E_0\frac{a^3}{r^2}\cos\theta\end{cases}$ Dielectric sphere in $\mathbf{E} = E_0\hat{\mathbf{z}}$ (4.54)

$W = \int\rho(\mathbf{x})\Phi(\mathbf{x})\ d^3x = \frac{1}{2}\int\mathbf{E}\cdot\mathbf{D}\ d^3x$ Energy to bring charges from ∞ (4.83,89)

$\Delta W = -\frac{1}{2}\int_{V_1}\mathbf{P}\cdot\mathbf{E}_0\ d^3x$ Dielectric placed in $\mathbf{E}_0$ (4.93)

$W = q\Phi(0) - \mathbf{p}\cdot\mathbf{E}(0) - \frac{1}{6}\sum_i\sum_j Q_{ij}\frac{\partial E_j}{\partial x_i}(0) + \ldots$ Work multipole expsn. (4.24)

$\boldsymbol{\tau} = \mathbf{p}\times\mathbf{E}$ Torque on electric dipole (G. 4.4)

$\mathbf{F} = (\mathbf{P}\cdot\nabla)\mathbf{E}$ Force on electric dipole (G. 4.5)

$\Phi = -E_0\left(r - \frac{a^3}{r^2}\right)$ Electric potential of conducting sphere in $\mathbf{E} = E_0\hat{\mathbf{z}}$ (2.14)

$E_r = \frac{2p\cos\theta}{4\pi\epsilon_0 r^3}, \quad E_\theta = \frac{p\sin\theta}{4\pi\epsilon_0 r^3}$ Electric dipole at origin in $\hat{\mathbf{z}}$ (4.12)

$\mathbf{E}(\mathbf{x}) = \frac{3\mathbf{n}(\mathbf{p}\cdot\mathbf{n}) - \mathbf{p}}{4\pi\epsilon_0|\mathbf{x}-\mathbf{x}_0|^3}$ **E**-field due to dipole **p** (4.13)

$\boldsymbol{\tau} = \mathbf{m}\times\mathbf{B}$ Torque on magnetic dipole moment (5.1)

$\nabla\cdot\mathbf{J} = 0$ Condition of magnetostatics (5.3)

$d\mathbf{B} = kI\frac{d\mathbf{l}\times\mathbf{x}}{|\mathbf{x}|^3}$ Biot-Savart Law (5.4)

$\oint_C \mathbf{B}\cdot d\mathbf{l} = \mu_0 I$ Ampère's law (5.25)

$\mathbf{B}(\mathbf{x}) = \nabla\times\mathbf{A}(\mathbf{x})$ Magnetic vector potential (5.27)

$\mathbf{A}(\mathbf{x}) = \frac{\mu_0}{4\pi}\int\frac{\mathbf{J}(\mathbf{x}')}{|\mathbf{x}-\mathbf{x}'|}d^3x'$ Magnetic vector potential of current distribution (5.32)

$\mathbf{m} = \frac{1}{2}\int\mathbf{x}'\times\mathbf{J}(\mathbf{x}')\ d^3x$ Magnetic moment definition (5.54)

$\mathbf{m} = \frac{I}{2}\oint\mathbf{x}\times d\mathbf{l}$ Magnetic moment of closed circuit (J. pg. 186)

$|\mathbf{m}| = I\times(\text{Area})$ Magnetic moment of plane loop (5.57)

$\mathbf{A}(\mathbf{x}) = \frac{\mu_0}{4\pi}\frac{\mathbf{m}\times\mathbf{x}}{|\mathbf{x}|^3}$ Dipole vector potential (5.55)

$\mathbf{B}(\mathbf{x}) = \frac{\mu_0}{4\pi}\left[\frac{3\mathbf{n}(\mathbf{n}\cdot\mathbf{m}) - \mathbf{m}}{|\mathbf{x}|^3}\right]$ Dipole induction (5.56)

$\mathbf{F} = \nabla(\mathbf{m}\cdot\mathbf{B})$ Force on dipole (5.69)

$\mathbf{H} = \frac{1}{\mu_0}\mathbf{B} - \mathbf{M}$ Magnetic field (5.81)

$\mathbf{M} = (\mu/\mu_0 - 1)\mathbf{H}$ Magnetization in linear media (G. 6.29)

$\mathbf{B} = \mu\mathbf{H}$ Linear condition (5.84)

$\begin{cases}(\mathbf{B}_2 - \mathbf{B}_1)\cdot\mathbf{n} = 0 \\ \mathbf{n}\times(\mathbf{H}_2 - \mathbf{H}_1) = \mathbf{K}_f\end{cases}$ Interface BC (5.86)

$\mathbf{H} = -\nabla\Phi_M$ Magnetic scalar potential (5.93)

$\mathbf{J}_M = \nabla\times\mathbf{M}, \quad \mathbf{K}_b = \mathbf{M}\times\mathbf{n}$ Bound current density (G. 6.13,14)

$\rho_M = -\nabla\cdot\mathbf{M}, \quad \sigma_M = \mathbf{n}\cdot\mathbf{M}$ Effective magnetic charge density (5.96,99)

$\Phi_M(\mathbf{x}) = \frac{\mathbf{m}\cdot\mathbf{x}}{4\pi r^3}$ Magnetic scalar potential of dipole (J. pg. 196)

$\mathbf{m} = \int\mathbf{M}\ d^3x$ Total magnetic moment (J. pg. 197)

$\nabla^2\mathbf{A} = -\mu_0\mathbf{J}_M$ Poisson equation in terms of magnetic vector potential (5.101)

$\Phi_M(r,\theta) = \frac{1}{3}M_0a^2\frac{r_<}{r_>^2}\cos\theta$ Sphere with $\mathbf{M} = M_0\hat{\mathbf{z}}$ $[(r_<, r_>),\ (r,a)]$ (5.104)

$\mathbf{M} = \frac{3}{\mu_0}\left(\frac{\mu-\mu_0}{\mu+2\mu_0}\right)\mathbf{B}_0$ Permeable sphere in uniform magnetic field $\mathbf{B}_0$ (5.115)

$F = \int_S\mathbf{B}\cdot\mathbf{n}\ da = \oint\mathbf{A}\cdot d\boldsymbol{\ell}$ Magnetic flux (5.133)

$\mathscr{E} = \oint_C\mathbf{E}'\cdot d\mathbf{l}$ Electromotive force (5.134)

$\mathscr{E} = -k\frac{\mathrm{d}F}{\mathrm{d}t}$ Faraday's Law (5.135)

$W = \frac{1}{2}\int\mathbf{J}\cdot\mathbf{A}\ d^3x$ Energy to ramp current from zero (4.83)::(5.149)

$W = \frac{1}{2}\int\mathbf{H}\cdot\mathbf{B}\ d^3x$ Magnetic energy in fields (4.89)::(5.148)

$\frac{\mathrm{d}W}{\mathrm{d}t} = \int\mathbf{H}\cdot\frac{\mathrm{d}\mathbf{B}}{\mathrm{d}t}\ d^3x$ Power in magetic field (5.147)

$\Delta W = \frac{1}{2}\int_{V_1}\mathbf{M}\cdot\mathbf{B}_0\ d^3x$ Energy to place permeable object in $\mathbf{B}_0$ (4.93)::(5.150)

$\frac{\mathrm{d}W}{\mathrm{d}t} = -\int\mathbf{J}\cdot\mathbf{E}\ d^3x$ Change in energy due to EMF

$W = \frac{\mu_0}{2}\int|\mathbf{H}|^2\ d^3x = \frac{\mu_0}{2}\sum_{i=1}^{N}\sum_{j=1}^{N}\int\Phi_{M_j}(\mathbf{x})\rho_{M_i}(\mathbf{x})\ d^3x$ N ferromagnets (HW 8.2b)

$W = \frac{1}{2}\sum_{i=1}^{N}L_iI_i^2 + \sum_{i=1}^{N}\sum_{j>i}^{N}M_{ij}I_iI_j$ Inductive energy (5.152)

$M_{ij} = \frac{1}{I_j}F_{ij}$ Mutual inductance (5.156)

$\mathbf{A}_{\text{dip}} = \frac{\mu_0}{4\pi}\frac{m\sin\theta}{r^2} \Rightarrow \mathbf{B}_{\text{dip}} = \frac{\mu_0 m}{4\pi r^3}(2\cos\theta\hat{\mathbf{r}} + \sin\theta\hat{\boldsymbol{\theta}})$ Field of dipole (G 5.87,88)

$\mathbf{B}(z) = \frac{\mu_0 I}{2}\left[\frac{a^2}{(a^2+z^2)^{3/2}}\right]\hat{\mathbf{z}}$ On-axis magnetic field of current loop (G. 5.41)

$\mathbf{B} = \frac{\mu_0 NI}{L}\hat{\mathbf{z}}$ Magnetic field inside solenoid (5.59)

$\mathbf{B} = \frac{\mu_0 NI}{2\pi\rho}\hat{\boldsymbol{\phi}}$ Magnetic field inside toroidal coil (G. 5.60)

$\nabla\cdot\mathbf{J} + \frac{\partial\rho}{\partial t} = 0$ Continuity Equation (6.3)

$\mathbf{E} = -\nabla\Phi - \frac{\partial\mathbf{A}}{\partial t}$ Potentials in dynamic systems (6.9)

$\nabla^2\Phi - \frac{1}{c^2}\frac{\partial^2\Phi}{\partial t^2} = -\rho/\epsilon_0$ Inhomogenous wave equation in Φ (6.15)

$\nabla^2\mathbf{A} - \frac{1}{c^2}\frac{\partial^2\mathbf{A}}{\partial t^2} = -\mu_0\mathbf{J}$ Inhomogenous wave equation in $\mathbf{A}$ (6.16)

$\nabla\cdot\mathbf{A}' + \frac{1}{c^2}\frac{\partial\Phi}{\partial t} = 0$ Lorenz gauge condition (6.17)

$u = \frac{1}{2}(\mathbf{E}\cdot\mathbf{D} + \mathbf{B}\cdot\mathbf{H})$ Total energy density (6.106)

$\frac{\partial u}{\partial t} + \nabla\cdot\mathbf{S} = -\mathbf{J}\cdot\mathbf{E}$ Differential continuity equation (6.108)

$\mathbf{S} = \mathbf{E}\times\mathbf{H}$ Poynting vector definition (6.109)

$\mathbf{g} = \frac{1}{c^2}(\mathbf{E}\times\mathbf{H})$ Electromagnetic momentum density (6.118)

$\mathbf{J} = \sigma\mathbf{E}, \quad V = IR$ Ohm's Law (G. 7.3,4)

$P = IV = I^2R$ Joule heating law (G. 7.7)

$\frac{\partial^2 V}{\partial t^2} = \frac{1}{\mathcal{L}\mathcal{C}}\frac{\partial^2 V}{\partial z^2} = c^2\frac{\partial^2 V}{\partial z^2}$ Wave formulation of telegrapher's equations (L. 23)

$V(z,t) = f(t - z/c) + g(t + z/c)$ Voltage solutions to telegrapher's equations (L. 25)

$I(z,t) = \frac{1}{Z}[f(t - z/c) - g(t + z/c)]$ Current solutions to telegrapher's equations (L. 30)

$Z = c\mathcal{L} = \sqrt{\mathcal{L}/\mathcal{C}}$ Impedance definition (L. 31)

$V(\ell,t) = RI(\ell,t) \Rightarrow g(t + \ell/c) = \frac{R - Z}{R + Z}f(t - \ell/c)$ Resistive BC (L. 37,39)

$V(z,t) = |\tilde{A}_0|\cos[\omega(t \mp z/c) - \delta]$ Sinusoidal solutions to telegrapher's equation (L. 53)

$(a+x)^n = a^n + na^{n-1}x + \frac{n(n-1)}{2!}a^{n-2}x^2 + \ldots =$ Binomial Expansion

$f(x) \approx f(a) + \frac{f'(a)}{1!}(x-a) + \frac{f''(a)}{2!}(x-a)^2 + \ldots$ Taylor Series

$$\begin{pmatrix}\hat{\boldsymbol{\rho}}\\ \hat{\boldsymbol{\phi}}\\ \hat{\mathbf{z}}\end{pmatrix} = \begin{pmatrix}\cos\phi & \sin\phi & 0\\ -\sin\phi & \cos\phi & 0\\ 0 & 0 & 1\end{pmatrix}\begin{pmatrix}\hat{\mathbf{x}}\\ \hat{\mathbf{y}}\\ \hat{\mathbf{z}}\end{pmatrix}, \quad \begin{pmatrix}\hat{\mathbf{r}}\\ \hat{\boldsymbol{\theta}}\\ \hat{\boldsymbol{\phi}}\end{pmatrix} = \begin{pmatrix}\sin\theta\cos\phi & \sin\theta\sin\phi & \cos\theta\\ \cos\theta\cos\phi & \cos\theta\sin\phi & -\sin\theta\\ -\sin\phi & \cos\phi & 0\end{pmatrix}\begin{pmatrix}\hat{\mathbf{x}}\\ \hat{\mathbf{y}}\\ \hat{\mathbf{z}}\end{pmatrix}$$

$$\begin{pmatrix}\hat{\mathbf{r}}\\ \hat{\boldsymbol{\theta}}\\ \hat{\boldsymbol{\phi}}\end{pmatrix} = \begin{pmatrix}\sin\theta & 0 & \cos\theta\\ \cos\theta & 0 & -\sin\theta\\ 0 & 1 & 0\end{pmatrix}\begin{pmatrix}\hat{\boldsymbol{\rho}}\\ \hat{\boldsymbol{\phi}}\\ \hat{\mathbf{z}}\end{pmatrix}, \quad \begin{pmatrix}\hat{\boldsymbol{\rho}}\\ \hat{\boldsymbol{\phi}}\\ \hat{\mathbf{z}}\end{pmatrix} = \begin{pmatrix}\rho/\sqrt{\rho^2+z^2} & z/\sqrt{\rho^2+z^2} & 0\\ 0 & 0 & 1\\ z/\sqrt{\rho^2+z^2} & -\rho/\sqrt{\rho^2+z^2} & 0\end{pmatrix}\begin{pmatrix}\hat{\mathbf{r}}\\ \hat{\boldsymbol{\theta}}\\ \hat{\boldsymbol{\phi}}\end{pmatrix}$$

	Wiggly	Decaying
x, y, z	$e^{\pm ik_nx}$, $A\cos(k_nx) + B\sin(k_nx)$	$e^{\pm k_nx}$, $A\cosh(k_nx) + B\sinh(k_nx)$
ρ, ϕ, z	$e^{im\phi}$, $AJ_m(k_n\rho) + BY_m(k_n\rho)$	$AI_m(k_n\rho) + BK_m(k_n\rho)$
ρ, ϕ	$e^{im\phi}$	$A_0 + B_0\ln\rho + \sum A_m\rho^m + B_m\rho^{-m}$
r, θ	$P_\ell(\cos\theta)$	$A\left(\frac{r}{a}\right)^\ell + B\left(\frac{r}{a}\right)^{-(\ell+1)}$
r, θ, ϕ	$Y_{\ell m}(\theta,\phi)$	$A\left(\frac{r}{a}\right)^\ell + B\left(\frac{r}{a}\right)^{-(\ell+1)}$