Constants:

$$
\begin{aligned}
k_e &\equiv 1/4\pi\epsilon_o = 8.98755 \times 10^9\ \mathrm{N \cdot m^2 \cdot C^{-2}} \\
\epsilon_o &= 8.85 \times 10^{-12}\ \mathrm{C^2/N \cdot m^2} \\
\mu_o &\equiv 4\pi \times 10^{-7}\ \mathrm{T \cdot m/A} \\
c^2 &= 1/\mu_o\epsilon_o \\
e &= 1.60218 \times 10^{-19}\ \mathrm{C} \\
m_{e^-} &= 9.10938 \times 10^{-31}\ \mathrm{kg} \\
m_{p^+} &= 1.67262 \times 10^{-27}\ \mathrm{kg} \\
N_A &= 6.022 \times 10^{23}\ \text{things/mol} \\
g &= 9.81\ \mathrm{m/s^2}
\end{aligned}
$$

Basic Equations:

$$
\begin{aligned}
0 &= ax^2 + bx^2 + c \Longrightarrow x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \\
\vec{\mathbf{F}}_{\text{centr}} &= -\frac{mv^2}{r}\hat{\mathbf{r}}\ \text{ Centripetal}
\end{aligned}
$$

Electric Force & Field:

$$
\begin{aligned}
\vec{\mathbf{F}}_{12} &= k_e \frac{q_1 q_2}{r^2}\,\hat{\mathbf{r}} = q_2 \vec{\mathbf{E}}_1 \\
\vec{\mathbf{E}}_1 &= \vec{\mathbf{F}}_{12}/q_2 = k_e \frac{q_1}{r^2}\,\hat{\mathbf{r}} \\
\vec{\mathbf{E}} &= k_e \sum_i \frac{q_i}{r_i^2}\,\hat{\mathbf{r}}_i \rightarrow k_e \int \frac{dq}{r^2}\,\hat{\mathbf{r}} = k_e \int \frac{\rho \hat{\mathbf{r}}}{r^2}\,dV_{ol}
\end{aligned}
$$

Capacitors:

$$
\begin{aligned}
Q_{\text{capacitor}} &= C\Delta V \\
C_{\text{parallel plate}} &= \frac{\epsilon_0 A}{d} \\
U_{\text{capacitor}} &= \frac{1}{2}Q\Delta V = \frac{Q^2}{2C} = C\,(\Delta V)^2 \\
C_{\text{eq, par}} &= C_1 + C_2 + C_3 + \cdots \\
1/C_{\text{eq, series}} &= 1/C_1 + 1/C_2 + 1/C_3 + \cdots \\
C_{\text{with dielectric}} &= \kappa C_{\text{without}} \qquad \kappa_{\text{air}} = 1 \\
I &= dQ/dt = C\,dV/dt
\end{aligned}
$$

RC circuits

$$
\begin{aligned}
Q_C(t) &= Q_0\left[1 - e^{-t/\tau}\right] \qquad \text{charging} \\
Q_C(t) &= Q_0 e^{-t/\tau} \qquad \text{discharging} \\
Q(t) &= C\Delta V(t) \\
\tau &= RC
\end{aligned}
$$

ac Circuits

$$
\begin{aligned}
\tau &= L/R\ \text{ RL circuit} \\
\tau &= RC\ \text{ RC circuit} \\
X_C &= \frac{1}{2\pi f C}\ \text{ “resistance” of a capacitor for ac} \\
X_L &= 2\pi f L\ \text{ “resistance” of an inductor for ac} \\
\omega_{\text{cutoff}} &= \frac{1}{\tau} = 2\pi f
\end{aligned}
$$

Electric Potential (static case!):

$$
\begin{aligned}
\Delta V = V_B - V_A &= \frac{\Delta U}{q} = -\int_A^B \vec{\mathbf{E}} \cdot d\vec{\mathbf{l}} \\
V_{\text{point}} &= k_e \frac{q}{r} \\
V &= k_e \int \frac{dq}{r} \quad \text{continuous} \\
E_x &= -\frac{dV}{dx} \rightarrow \vec{\mathbf{E}} = -\vec{\boldsymbol{\nabla}} V \\
U_{\text{pair of point charges}} &= k_e \frac{q_1 q_2}{r_{12}} = V_1 q_2 = V_2 q_1 \\
U_{\text{system}} &= \text{sum over unique pairs} = \sum_{\text{pairs } ij} \frac{k_e q_i q_j}{r_{ij}} \\
U_{\text{field}} &= \frac{1}{2}\int \epsilon_o E^2\,dV_{ol} = \frac{1}{2}\int \rho V\,dV_{ol} \\
V &= k_e \int \frac{dq}{r} \quad \text{continuous} \\
E_x &= -\frac{dV}{dx} \rightarrow \vec{\mathbf{E}} = -\vec{\boldsymbol{\nabla}} V \\
\Delta PE &= q\Delta V = -q|\vec{\mathbf{E}}||\Delta\vec{\mathbf{x}}|\cos\theta = -qE_x\Delta x \\
&\uparrow \text{ constant E field}
\end{aligned}
$$

Other:

$$
\begin{aligned}
\left(\vec{\mathbf{E}}_2 - \vec{\mathbf{E}}_1\right) \cdot \hat{\mathbf{n}} &= 4\pi k_e \sigma \quad \text{sheet of charge with } \sigma \\
F_{\text{sheet}} &= \frac{\sigma}{2}\,(E_1 + E_2)
\end{aligned}
$$

Current & Resistance:

$$
\begin{aligned}
I &= \int_S \vec{\mathbf{J}} \cdot d\vec{\mathbf{A}} \xrightarrow{\text{uniform J}} I = \frac{dQ}{dt} = nqAv_d \\
J &= \sum_k n_k q_k v_k \xrightarrow{\text{uniform J}} J = \frac{I}{A} = nqv_d \\
\int_S \vec{\mathbf{J}} \cdot d\vec{\mathbf{A}} &= -\frac{d}{dt}\int_V \rho\,dV_{ol} \\
R &= \frac{\varrho l}{A} \quad \rho = 1/\sigma \\
\vec{\mathbf{v}}_d &= \frac{q\tau}{m}\vec{\mathbf{E}} \quad \tau = \text{scattering time} \\
\rho = 1/\sigma &= \frac{m}{nq^2\tau} \\
R &= V/I \quad \text{Ohm} \\
E &= \varrho J \quad \text{or} J = \sigma E \quad \text{Ohm} \\
\mathscr{P} &= dU/dt = I\Delta V \quad \text{power} \\
R_{\text{eq}} &= R_1 + R_2 + \ldots \quad \text{series} \\
1/R_{\text{eq}} &= 1/R_1 + 1/R_2 + \ldots \quad \text{parallel} \\
\sum I_{\text{in}} &= \sum I_{\text{out}} \quad \text{junction} \\
\sum_{\text{closed path}} \Delta V &= 0 \quad \text{loop}
\end{aligned}
$$

EM Waves:

$$
\begin{aligned}
c &= \lambda f = \frac{|\vec{\mathbf{E}}|}{|\vec{\mathbf{B}}|} \\
\mathcal{I} &= \left[\frac{\text{photons}}{\text{time}}\right]\left[\frac{\text{energy}}{\text{photon}}\right]\left[\frac{1}{\text{Area}}\right] \\
\mathcal{I} &= \frac{\text{energy}}{\text{time} \cdot \text{area}} = \frac{E_{\max}B_{\max}}{2\mu_0} = \frac{\text{power } (\mathscr{P})}{\text{area}} = \frac{E_{\max}^2}{2\mu_0 c}
\end{aligned}
$$

Magnetism:

$$\vec{\mathbf{F}}_B = q\vec{\mathbf{v}} \times \vec{\mathbf{B}}$$
$$d\vec{\mathbf{F}}_B = I d\vec{\mathbf{l}} \times \vec{\mathbf{B}} \quad \text{I-carrying wire}$$
$$d\vec{\mathbf{B}} = \frac{\mu_o}{4\pi}\frac{I d\vec{\mathbf{l}} \times \hat{\mathbf{r}}}{r^2} \quad \text{wire}$$
$$\vec{\mathbf{B}} = \frac{\mu_0 I}{2r}\hat{\theta} \quad \text{loop}$$
$$B = \frac{\mu_o N I}{l} = \mu_o n I \quad \text{solenoid}$$
$$\frac{F_B}{l} = \frac{\mu_o I_1 I_2}{2\pi d} \quad \text{2 wires}$$
$$\Phi_B = \oint \vec{\mathbf{B}} \cdot d\vec{\mathbf{A}}$$
$$\vec{\boldsymbol{\tau}} = \vec{\boldsymbol{\mu}} \times \vec{\mathbf{B}} \quad \text{with} \quad \vec{\boldsymbol{\mu}} = I\vec{\mathbf{A}} \quad \text{I loop}$$
$$U = -\vec{\boldsymbol{\mu}} \times \vec{\mathbf{B}} \quad \text{dipole}$$
$$U_{\text{field}} = \frac{1}{2\mu_o}\int B^2\, dV_{ol}$$

Induction & Maxwell

$$\Delta V = |\vec{\mathbf{v}}||\vec{\mathbf{B}}|l = |\vec{\mathbf{E}}|l \quad \text{motional voltage}$$
$$L = N\Phi_B/I$$
$$\Delta V_L = -L dI/dt$$
$$L = \mu_o N^2 A/l \quad \text{solenoid}$$
$$I = (\Delta V/R)\left(1 - e^{-t/\tau}\right) \quad \tau = L/R \quad LR \text{ close}$$
$$I = (\Delta V/R)\, e^{-t/\tau} \quad \tau = L/R \quad LR \text{ open}$$
$$U = \frac{1}{2}LI^2$$
$$M_{12} = N_2\Phi_{12}/I_1 = M_{21} = N_1\Phi_{21}/I_2 = M \quad \text{mutual}$$
$$\Delta V_2 = -M dI_1/dt - L dI_2/dt$$
$$\Delta V = \oint \vec{\mathbf{E}} \cdot d\vec{\mathbf{l}} = -\frac{d\Phi_B}{dt}$$
$$\Delta V = Blv \quad \text{motional}$$
$$\Phi_E = \oint \vec{\mathbf{E}} \cdot d\vec{\mathbf{A}} = 4\pi k_e q_{\text{encl}} = \frac{q_{\text{encl}}}{\epsilon_o}$$
$$\oint \vec{\mathbf{B}} \cdot d\vec{\mathbf{A}} = 0$$
$$\oint \vec{\mathbf{B}} \cdot d\vec{\mathbf{l}} = \mu_o I + \frac{1}{c^2}\frac{d\Phi_E}{dt}$$

Optics:

$$\mathscr{E} = hf = \frac{hc}{\lambda}$$
$$n = \frac{\text{speed of light in vacuum}}{\text{speed of light in a medium}} = \frac{c}{v}$$
$$\frac{\lambda_1}{\lambda_2} = \frac{v_1}{v_2} = \frac{c/n_1}{c/n_2} = \frac{n_2}{n_1} \quad \text{refraction}$$
$$n_1 \sin\theta_1 = n_2 \sin\theta_2 \quad \text{Snell's refraction}$$
$$\lambda f = c$$
$$M = \frac{h'}{h} = -\frac{q}{p}$$
$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q} = \frac{2}{R} \quad \text{mirror \& lens}$$
$$\frac{n_1}{p} + \frac{n_2}{q} = \frac{n_2 - n_1}{R} \quad \text{spherical refracting}$$
$$q = -\frac{n_2}{n_1}p \quad \text{flat refracting}$$
$$\frac{1}{f} = \left(\frac{n_2 - n_1}{n_1}\right)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \quad \text{lensmaker's}$$

Vectors:

$$|\vec{\mathbf{F}}| = \sqrt{F_x^2 + F_y^2} \quad \text{magnitude}$$
$$\theta = \tan^{-1}\left[\frac{F_y}{F_x}\right] \quad \text{direction}$$
$$\hat{\mathbf{r}} = \vec{\mathbf{r}}/|\vec{\mathbf{r}}|$$
$$d\vec{\mathbf{l}} = dx\,\hat{\mathbf{x}} + dy\,\hat{\mathbf{y}} + dz\,\hat{\mathbf{z}}$$
$$\text{let} \quad \vec{\mathbf{a}} = a_x\,\hat{\mathbf{x}} + a_y\,\hat{\mathbf{y}} + a_z\,\hat{\mathbf{z}} \quad \text{and} \quad \vec{\mathbf{b}} = b_x\,\hat{\mathbf{x}} + b_y\,\hat{\mathbf{y}} + b_z\,\hat{\mathbf{z}}$$
$$\vec{\mathbf{a}} \cdot \vec{\mathbf{b}} = a_x b_x + a_y b_y + a_z b_z = \sum_{i=1}^{n} a_i b_i = |\vec{\mathbf{a}}||\vec{\mathbf{b}}|\cos\theta$$
$$|\vec{\mathbf{a}} \times \vec{\mathbf{b}}| = |\vec{\mathbf{a}}||\vec{\mathbf{b}}|\sin\theta$$
$$\vec{\mathbf{a}} \times \vec{\mathbf{b}} = \begin{vmatrix} \hat{\mathbf{x}} & \hat{\mathbf{y}} & \hat{\mathbf{z}} \\ a_x & a_y & a_z \\ b_x & b_y & b_z \end{vmatrix} = (a_y b_z - a_z b_y)\,\hat{\mathbf{x}} + (a_z b_x - a_x b_z)\,\hat{\mathbf{y}} + (a_x b_y - a_y b_x)\,\hat{\mathbf{z}}$$

Derived unit	Symbol	equivalent to
newton	N	kg·m/s^2
joule	J	kg·m^2/s^2 = N·m
watt	W	J/s=m^2·kg/s^3
coulomb	C	A·s
V	W/A = m^2·kg/·s^3·A	
farad	F	C/V = A^2·s^4/m^2·kg
ohm	Ω	V/A = m^2·kg/s^3·A^2
tesla	T	Wb/m^2 = kg/s^2·A
electron volt	eV	1.6×10^{-19} J
-	1 T · m/A	1 N/A^2
-	1 T · m^2	1 V · s
-	1 N/C	1 V/m

Power	Prefix	Abbreviation
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T

Right-hand rule #1

1. Point the fingers of your right hand along the direction of $\vec{\mathbf{v}}$.
2. Point your thumb in the direction of $\vec{\mathbf{B}}$.
3. The magnetic force on a + charge points out from the back of your hand.

Right-hand rule #2:
Point your right thumb along the wire in the direction of the current. Your fingers curl around the direction of the magnetic field, which circulates around the wire.