Constants:

$$N_A = 6.022\times10^{23}\text{ things/mol}$$
$$k_e \equiv 1/4\pi\epsilon_o = 8.98755\times10^{9}\,\mathrm{N\cdot m^2\cdot C^{-2}}$$
$$\epsilon_o = 8.85\times10^{-12}\,\mathrm{C^2/N\cdot m^2}$$
$$\mu_o \equiv 4\pi\times10^{-7}\,\mathrm{T\cdot m/A}$$
$$e = 1.60218\times10^{-19}\,\mathrm{C}$$
$$h = 6.6261\times10^{-34}\,\mathrm{J\cdot s} = 4.1357\times10^{-15}\,\mathrm{eV\cdot s}$$
$$\hbar = \frac{h}{2\pi}$$
$$k_B = 1.38065\times10^{-23}\,\mathrm{J\cdot K^{-1}} = 8.6173\times10^{-5}\,\mathrm{eV\cdot K^{-1}}$$
$$c = \frac{1}{\sqrt{\mu_0\epsilon_0}} = 2.99792\times10^{8}\,\mathrm{m/s}$$
$$hc = 1240\,\mathrm{eV\cdot nm}$$
$$m_e = 9.10938\times10^{-31}\,\mathrm{kg}\qquad m_e c^2 = 510.998\,\mathrm{keV}$$
$$m_p = 1.67262\times10^{-27}\,\mathrm{kg}\qquad m_p c^2 = 938.272\,\mathrm{MeV}$$

Quadratic formula:

$$0 = ax^2 + bx^2 + c \Longrightarrow x = \frac{-b\pm\sqrt{b^2-4ac}}{2a}$$

Basic Equations:

$$\vec{F}_{net} = \frac{d\vec{p}}{dt} = m\vec{a}\qquad \text{Newton's Second Law}$$
$$\vec{F}_{centr} = -\frac{mv^2}{r}\,\hat{r}\qquad \text{Centripetal}$$

E & M

$$\vec{F}_{12} = k_e\frac{q_1 q_2}{r_{12}^2}\,\hat{r}_{12} = q_2\vec{E}_1\qquad \vec{r}_{12} = \vec{r}_1 - \vec{r}_2$$
$$\vec{E}_1 = \vec{F}_{12}/q_2 = k_e\frac{q_1}{r_{12}^2}\,\hat{r}_{12}$$
$$\vec{F}_B = q\vec{v}\times\vec{B}$$

EM Waves:

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

Oscillators

$$E = \left(n+\frac{1}{2}\right)hf$$
$$E = \frac{1}{2}kA^2 = \frac{1}{2}\omega^2 mA^2 = 2\pi^2 mf^2A^2$$
$$\omega = 2\pi f = \sqrt{k/m}$$

Approximations, $x \ll 1$

$$(1+x)^n \approx 1 + nx + \frac{1}{2}n(n+1)x^2\qquad \tan x \approx x + \frac{1}{3}x^3$$
$$e^x \approx 1 + x + \frac{1}{2}x\qquad \sin x \approx x - \frac{1}{6}x^3\qquad \cos x \approx 1 - \frac{1}{2}x^2$$

Radiation

$$P_{rad} = \frac{q^2a^2}{6\pi\epsilon_o c^3}\qquad \text{total emitted power, E and B fields}$$
$$E_{tot} = \sigma T^4\qquad \sigma = 5.672\times10^{-8}\,\mathrm{W\cdot m^{-2}\cdot K^{-4}}$$
$$T\lambda_{max} = 0.29\times10^{-2}\,\mathrm{m\cdot K}\qquad \text{Wien}$$
$$E_{quantum} = hf$$
$$\langle E_{oscillator}\rangle = hf/\left(e^{hf/k_BT}-1\right)$$
$$I(\lambda,T) = \frac{(\text{const})}{\lambda^5}\left[e^{\frac{hc}{\lambda k_b T}}-1\right]^{-1}$$
$$I(f,t) = (\text{const})\,f^3\left[e^{\frac{hf}{k_b T}}-1\right]^{-1}$$

Relativity

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$$
$$\Delta t'_{moving} = \gamma\Delta t_{stationary} = \gamma\Delta t_p$$
$$L'_{moving} = \frac{L_{stationary}}{\gamma} = \frac{L_p}{\gamma}$$
$$x' = \gamma(x - vt)$$
$$t' = \gamma\left(t - \frac{vx}{c^2}\right)$$
$$v_{obj} = \frac{v + v'_{obj}}{1+\frac{vv'_{obj}}{c^2}}\qquad v'_{obj} = \frac{v_{obj}-v}{1-\frac{vv_{obj}}{c^2}}$$
$$KE = (\gamma-1)mc^2 = \sqrt{m^2c^4 + c^2p^2} - mc^2$$
$$E_{rest} = mc^2$$
$$p = \gamma mv$$
$$E^2 = p^2c^2 + m^2c^4 = \left(\gamma mc^2\right)^2$$

Quantum

$$E = hf\qquad p = h/\lambda = E/c\qquad \lambda f = c\qquad \text{photons}$$
$$\lambda_f - \lambda_i = \frac{h}{m_e c}(1-\cos\theta)$$
$$\lambda = \frac{h}{|\vec{p}|} = \frac{h}{\gamma mv} \approx \frac{h}{mv}$$
$$\Delta x\Delta p \geqslant \frac{h}{4\pi}$$
$$\Delta E\Delta t \geqslant \frac{h}{4\pi}$$
$$eV_{stopping} = KE_{electron} = hf - \varphi = hf - W$$

Calculus of possible utility:

$$\int\frac{1}{x}\,dx = \ln x + c$$
$$\int u\,dv = uv - \int v\,du$$

Vectors:

$$|\vec{F}| = \sqrt{F_x^2+F_y^2}\quad \text{magnitude}\qquad \theta = \tan^{-1}\left[\frac{F_y}{F_x}\right]\quad \text{direction}$$
$$\hat{r} = \vec{r}/|\vec{r}|\quad \text{construct any unit vector}$$
$$\text{let}\quad \vec{a} = a_x\,\hat{x} + a_y\,\hat{y} + a_z\,\hat{z}\quad\text{and}\quad \vec{b} = b_x\,\hat{x} + b_y\,\hat{y} + b_z\,\hat{z}$$
$$\vec{a}\cdot\vec{b} = a_xb_x + a_yb_y + a_zb_z = \sum_{i=1}^{n} a_ib_i = |\vec{a}||\vec{b}|\cos\theta$$
$$|\vec{a}\times\vec{b}| = |\vec{a}||\vec{b}|\sin\theta$$
$$\vec{a}\times\vec{b} = \begin{vmatrix}\hat{x} & \hat{y} & \hat{z}\\ a_x & a_y & a_z\\ b_x & b_y & b_z\end{vmatrix} = (a_yb_z - a_zb_y)\,\hat{x} + (a_zb_x - a_xb_z)\,\hat{y} + (a_xb_y - a_yb_x)\,\hat{z}$$