<u>Constants</u>:

$$e = 1.602 \times 10^{-19}\ \mathrm{C} \qquad N_A = 6.02 \times 10^{23} \qquad k = \tfrac{1}{4\pi\epsilon_0} = 8.99 \times 10^{9}\ \mathrm{N \cdot m^2/C^2}$$

$$\epsilon_0 = 8.854 \times 10^{-12}\ \mathrm{C^2/N \cdot m^2} \qquad \mu_0 = 4\pi \times 10^{-7}\ \mathrm{T \cdot m/A} \qquad c = 2.998 \times 10^{8}\ \mathrm{m/s}$$

$$h = 6.626 \times 10^{-34}\ \mathrm{J \cdot s} \qquad hc = 1240\ \mathrm{eV \cdot nm} \qquad \frac{e^2}{4\pi\epsilon_0} = 1.44\ \mathrm{eV \cdot nm} \qquad (1\mathrm{u})c^2 = 931.5\ \mathrm{MeV}$$

<u>Definitions</u>:

$$1\ \mathrm{eV} = 1.602 \times 10^{-19}\ \mathrm{J} \qquad \hbar = h/2\pi$$

<u>Electricity</u>:

$$\vec{F}_{12} = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}\hat{r}_{12} \qquad \vec{E} = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}\hat{r} \qquad \vec{E} = \frac{1}{4\pi\epsilon_0}\int \frac{dq}{r^2}\hat{r} \qquad \Phi = \int \vec{E} \cdot \hat{n}\, dA \qquad \Phi_E = \frac{Q_{in}}{\epsilon_0}$$

$$\vec{F} = q\vec{E} \qquad V_b = V_a - \int_a^b \vec{E} \cdot d\vec{\ell} \qquad V = \frac{1}{4\pi\epsilon_0}\frac{q}{r} \qquad E_x = -\frac{dV}{dx} \qquad E_y = -\frac{dV}{dy} \qquad E_z = -\frac{dV}{dz}$$

$$U = qV \qquad U_{12} = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r} \qquad \vec{p} = q\vec{L} \qquad E_n = \sigma/\epsilon_0$$

$$Q = CV \qquad U = \tfrac{1}{2}QV = \tfrac{1}{2}CV^2 \qquad C = \epsilon_0 A/d \qquad C = \kappa C_0 \qquad u = \tfrac{1}{2}\epsilon_0 E^2$$

$$I = \frac{\Delta q}{\Delta t} \qquad I = qnAv_d \qquad V = IR \qquad R = \rho L/A \qquad \rho = \rho_0[1 + \alpha(T - T_0)]$$

$$P = \mathcal{E} I \qquad P = VI = I^2 R = V^2/R$$

$$\text{Series}: \quad R = R_1 + R_2 \qquad \frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} \qquad \text{Parallel}: \quad \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} \qquad C = C_1 + C_2$$

$$I(t) = I_0 e^{-t/RC} \qquad Q(t) = \begin{cases} Q\left(1 - e^{-t/RC}\right) & \text{charging} \\ Q\, e^{-t/RC} & \text{discharging} \end{cases}$$

<u>Magnetism</u>:

$$\vec{F} = q\,\vec{v} \times \vec{B} \qquad \vec{F} = I\, d\vec{l} \times \vec{B} \qquad r = \frac{mv}{qB} \qquad \vec{\mu} = NIA\hat{n} \qquad \vec{\tau} = \vec{\mu} \times \vec{B} \qquad U = -\vec{\mu} \cdot \vec{B}$$

$$\vec{B} = \frac{\mu_0}{4\pi}\frac{q\,\vec{v} \times \hat{r}}{r^2} \qquad \vec{B} = \frac{\mu_0}{4\pi}\frac{I\, d\vec{l} \times \hat{r}}{r^2} \qquad B = \frac{\mu_0}{4\pi}\frac{I}{R}(\cos\theta_1 + \cos\theta_2) \qquad B = \frac{\mu_0}{4\pi}\frac{2\pi R^2 I}{(x^2 + R^2)^{3/2}} \qquad B = \mu_0 n I$$

$$\oint_C \vec{B} \cdot d\vec{l} = \mu_0 I_C \qquad \vec{\mu} = \frac{q}{2m}\vec{L} \qquad \vec{M} = \frac{1}{V}\sum_i \vec{\mu}_i$$

$$\mathcal{E} = vB\ell \qquad \mathcal{E} = \oint_C \vec{E} \cdot d\vec{l} = -\frac{d\Phi_m}{dt} \qquad L = \Phi_m/I \qquad V_L = L\frac{dI}{dt} \qquad U = \frac{1}{2}LI^2 \qquad L = \mu_0 n^2 A\ell$$

$$u_m = \frac{1}{2\mu_0}B^2 \qquad \tau = L/R \qquad \omega = \frac{1}{\sqrt{LC}} \qquad V_H = v_d B w$$

$$\mathcal{E}_m = \omega NBA \qquad I_{\mathrm{rms}} = \frac{1}{\sqrt{2}}I_0 \qquad V_{\mathrm{rms}} = \frac{1}{\sqrt{2}}V_0 \qquad P_{\mathrm{av}} = I_{\mathrm{rms}}^2 R$$

EM Waves:

$$c = \frac{1}{\sqrt{\epsilon_0 \mu_0}} \qquad \lambda f = c \qquad E = cB \qquad \vec{S} = \frac{1}{\mu_0} \vec{E} \times \vec{B}$$

$$u_{av} = \tfrac{1}{2}\epsilon_0 E_0^2 \qquad I = u_{av} c \qquad P = I/c \qquad v = c/n \qquad \lambda = \lambda_{\text{vac}}/n$$

Optics:

$$\theta_r = \theta_i \qquad n_1 \sin\theta_1 = n_2 \sin\theta_2 \qquad \sin\theta_c = \frac{n_2}{n_1} \qquad I = 4I_0 \cos^2 \frac{\phi}{2}$$

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f} \qquad M = -\frac{q}{p} \qquad f = R/2 \qquad \frac{n_1}{p} + \frac{n_2}{q} = \frac{n_2 - n_1}{R} \qquad \frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

Magnifier: $m \simeq \frac{x_n}{f}$ Microscope: $m \simeq -\frac{x_n(L - f_o - f_e)}{f_e f_o}$ Telescope: $m \simeq -\frac{f_0}{f_e}$ $x_n \simeq 25\,\text{cm}$

$$\delta = \ell_2 - \ell_1 = m\lambda \qquad \phi = 2\pi\,\frac{\delta}{\lambda} \qquad d\sin\theta = m\lambda \qquad \sin\theta = m\lambda/a \qquad \sin\theta = 1.22\lambda/D$$

Modern Physics:

$$E = hf \qquad p = \frac{h}{\lambda} \qquad K_{\max} = hf - \phi \qquad I = \sigma T^4 \qquad \lambda_{\max} T = 2.898 \times 10^{-3}\text{m}\cdot\text{K}$$

$$-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}\psi(x) + U(x)\psi(x) = E\psi(x) \qquad P(x) = |\psi(x)|^2 \qquad \int_{\text{all x}} P(x)\,dx = 1 \qquad \langle x \rangle = \int_{\text{all x}} xP(x)\,dx$$

Square Well: $E_n = n^2 \frac{\pi^2 \hbar^2}{2mL^2}$ $\psi_n = \sqrt{\frac{2}{L}} \sin \frac{n\pi}{L} x$ Bohr: $L = n\hbar$ $r_n = a_0 n^2$ $a_0 = \left(\frac{4\pi\epsilon_0}{e^2}\right)\frac{\hbar^2}{m}$

$$T \simeq e^{-2\alpha L} \qquad \alpha = \left[\frac{2m(U-E)}{\hbar^2}\right]$$

Hydrogen: $E_n = -\frac{m}{2}\left[\frac{e^2}{4\pi\epsilon_0}\frac{1}{\hbar}\right]^2 \frac{1}{n^2}$ $\psi = \psi_{nlm}(r,\theta,\phi)$ $P(r) = 4\pi r^2 |\psi(r)|^2$ $L = \sqrt{\ell(\ell+1)}\,\hbar$ $L_z = m\hbar$

$$N = N_0 e^{-\lambda t} \qquad A = \lambda N \qquad \tau = \frac{1}{\lambda} \qquad t_{1/2} = \frac{\ln 2}{\lambda}$$

$$M = Zm_p + Zm_e + Nm_n - B/c^2 \qquad M_i c^2 = M_f c^2 + Q$$

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}} \qquad \Delta t = \gamma \Delta t_p \qquad L = L_p/\gamma \qquad u' = \frac{u - v}{1 - vu/c^2}$$

$$\vec{p} = \gamma m \vec{v} \qquad K = (\gamma - 1)mc^2 \qquad E_0 = mc^2 \qquad E = E_0 + K = \gamma mc^2 \qquad E^2 = (pc)^2 + (mc^2)^2$$