Possibly Useful Information

Electric Force and Electric Fields:

$$\vec{F}_{12} = \frac{kq_1q_2}{r^2}\hat{r} \qquad q = Ne \qquad \vec{F} = q\vec{E} \qquad \vec{E} = \frac{kq}{r^2}\hat{r}$$

$$\vec{E} = \sum_i \vec{E}_i = \sum_i \frac{kq_i}{r_i^2}\hat{r}_i \qquad \vec{E} = \int d\vec{E} = \int \frac{kdq}{r^2}\hat{r}$$

$$\vec{p} = q\vec{d} \qquad \vec{\tau} = \vec{p}\times\vec{E} \qquad U = -\vec{p}\cdot\vec{E}$$

$$\Phi = \int \vec{E}\cdot d\vec{A} \qquad \oint \vec{E}\cdot d\vec{A} = \frac{q_{enc}}{\varepsilon_0}$$

$$E = \frac{q}{4\pi\varepsilon_0 r^2} \qquad E = \frac{\lambda}{2\pi\varepsilon_0 r} \qquad E = \frac{\sigma}{2\varepsilon_0} \qquad E_{cond} = \frac{\sigma}{\varepsilon_0}$$

$$\lambda = \frac{Q}{L} = \frac{dq}{d\ell} \qquad \sigma = \frac{Q}{A} = \frac{dq}{dA} \qquad \rho = \frac{Q}{V} = \frac{dq}{dV}$$

Electric Fields and Potentials:

$$\Delta U = U_f - U_i = -W_{field} \qquad U = \frac{kq_1q_2}{r} \qquad V = \frac{kq}{r}$$

$$V = \sum_i V_i = \sum_i \frac{kq_i}{r_i} \qquad V = \int dV = \int \frac{kdq}{r}$$

$$\Delta V = V_f - V_i = -\frac{W_{firld}}{q} = -\int_i^f \vec{E}\cdot d\vec{s} \qquad \vec{E} = -\nabla V = -\left(\frac{\partial V}{\partial x}\hat{i} + \frac{\partial V}{\partial y}\hat{j} + \frac{\partial V}{\partial z}\hat{k}\right)$$

Capacitance:

$$q = C\Delta V \qquad C = \frac{\varepsilon_0 A}{d} \qquad C = 2\pi\varepsilon_0 \frac{L}{\ln(b/a)} \qquad C = 4\pi\varepsilon_0 \frac{ab}{b-a}$$

$$C = 4\pi\varepsilon_0 R \qquad C_{eq} = \sum_{j=1}^{n} C_j \qquad \frac{1}{C_{eq}} = \sum_{j=1}^{n} \frac{1}{C_j}$$

$$U = \frac{q^2}{2C} = \frac{1}{2}C(\Delta V)^2 \qquad u = \frac{1}{2}\varepsilon_0 E^2 \qquad C = \kappa C_0 \qquad \varepsilon_0 \oint \kappa\vec{E}\cdot d\vec{A} = q$$

Current, Resistance & Circuits:

$$I = \frac{dq}{dt} \qquad I = \int \vec{J}\cdot d\vec{A} \qquad I = JA \qquad \vec{J} = ne\vec{v}_d \qquad \vec{E} = \rho\vec{J}$$

$$R = \frac{V}{I} \qquad \sigma = \frac{1}{\rho} \qquad R = \frac{\rho L}{A} \qquad \rho - \rho_0 = \rho_0\alpha(T - T_0)$$

$$P = IV = I^2R = \frac{V^2}{R} \qquad P = \frac{\Delta E}{\Delta t} \qquad \mathcal{E} = \frac{dW}{dq} \qquad E = q\Delta V$$

$$R_{eq} = \sum_{j=1}^{n} R_j \qquad \frac{1}{R_{eq}} = \sum_{j=1}^{n} \frac{1}{R_j} \qquad \Delta V_{loop} = 0 \qquad \sum I_{junc} = 0$$

$$I = \left(\frac{\mathcal{E}}{R}\right)e^{-t/RC} \qquad V_C = \mathcal{E}\left(1 - e^{-t/RC}\right) \qquad q = q_0e^{-t/RC} \qquad I = -\left(\frac{q_0}{RC}\right)e^{-t/RC} \qquad \tau_C = RC$$

Possibly Useful Information

Magnetic Fields:

$$\vec{F}_B = q\vec{v} \times \vec{B} \qquad F_B = \frac{mv^2}{r} \qquad \vec{F}_B = I\vec{L} \times \vec{B}$$

$$\mu = NIA \qquad \vec{\tau} = \vec{\mu} \times \vec{B} \qquad U(\theta) = -\vec{\mu} \cdot \vec{B}$$

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{Id\vec{s} \times \hat{r}}{r^2} \qquad \oint \vec{B} \cdot d\vec{s} = \mu_0 I_{enc} \qquad \Phi_B = \int \vec{B} \cdot d\vec{A}$$

$$B = \frac{\mu_0 I}{2\pi r} \qquad B = \frac{\mu_0 I\phi}{4\pi R} \qquad B = \mu_0 nI \qquad B = \frac{\mu_0 IN}{2\pi r} \qquad B = \frac{\mu_0 IR^2}{2\left(R^2 + x^2\right)^{3/2}}$$

Magnetic Induction:

$$\varepsilon = -\frac{d\Phi_B}{dt} \qquad \oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi_B}{dt} \qquad L = \frac{N\Phi_B}{I} \qquad \varepsilon_L = -L\frac{dI}{dt}$$

$$I = \frac{\varepsilon}{R}\left(1 - e^{-t/\tau_L}\right) \qquad I = I_0 e^{-t/\tau_L} \qquad \tau_L = \frac{L}{R}$$

$$U_B = \frac{1}{2}LI^2 \qquad u_B = \frac{B^2}{2\mu_0} \qquad \oint \vec{B} \cdot d\vec{A} = 0$$

LC Oscillations:

$$\omega^2 = \frac{1}{LC} \qquad q = q_{\max}\cos(\omega t + \phi)$$

$$q = q_{\max} e^{-Rt/2L}\cos(\omega' t + \phi) \qquad \omega' = \sqrt{\omega^2 - (R/2L)^2}$$

$$X_C = \frac{1}{\omega_d C} \qquad X_L = \omega_d L \qquad V_R = I_R R \qquad V_C = I_C X_C \qquad V_L = I_L X_L$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2} \qquad \varepsilon = \varepsilon_{\max}\sin\omega_d t \qquad I = I_{\max}\sin(\omega_d t - \phi)$$

$$I_{\max} = \frac{\varepsilon_{\max}}{Z} \qquad \tan\phi = \frac{X_L - X_C}{R} \qquad I_{rms} = \frac{I_{\max}}{\sqrt{2}} \qquad \varepsilon_{rms} = \frac{\varepsilon_{\max}}{\sqrt{2}}$$

$$P_{ave} = I_{rms}^2 R \qquad P_{ave} = I_{rms}^2 R = \varepsilon_{rms} I_{rms}\cos\phi$$

$$\frac{V_{prim}}{N_{prim}} = \frac{V_{\sec}}{N_{\sec}} \qquad I_{prim}N_{prim} = I_{\sec}N_{\sec} \qquad R_{eq} = \left(\frac{N_{prim}}{N_{\sec}}\right)^2 R$$

EM Waves:

$$\Phi_B = \oint \vec{B} \cdot d\vec{A} = 0 \qquad \oint \vec{B} \cdot d\vec{s} = \mu_0\varepsilon_0\frac{d\Phi_E}{dt} + \mu_0 I_{enc} \qquad I_d = \varepsilon_0\frac{d\Phi_E}{dt}$$

$$E = E_{\max}\sin(kx - \omega t) \qquad B = B_{\max}\sin(kx - \omega t) \qquad \frac{E}{B} = c \qquad c = \frac{1}{\sqrt{\mu_0\varepsilon_0}} \qquad \vec{S} = \frac{1}{\mu_0}\vec{E} \times \vec{B}$$

$$I_{\text{point}} = \frac{P}{4\pi r^2} \qquad F = \frac{(2)IA}{c} \qquad p = \frac{F}{A} \qquad I = \frac{1}{2}I_0 \qquad I = I_0\cos^2\theta$$

Possibly Useful Information

Geometrical (Ray) Optics:

$\theta_1 = \theta_2$ $\quad n_1 \sin\theta_1 = n_2 \sin\theta_2$ $\quad \theta_c = \sin^{-1}\frac{n_2}{n_1}$ $\quad \theta_B = \tan^{-1}\frac{n_2}{n_1}$

$\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f} = \frac{2}{r}$ $\quad \frac{1}{f} = \left(\frac{n_{lens}}{n_{med}} - 1\right)\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$ $\quad m = -\frac{s_i}{s_o}$ $\quad M = m_1 m_2 \ldots$

$\frac{n_1}{p} + \frac{n_2}{i} = \frac{n_2 - n_1}{r}$ $\quad m = -\frac{n_1 s_i}{n_2 s_o}$

s_o, s_i, f, $r > 0$ in front of the mirror. $\quad$ s_o, s_i, f, $r < 0$ behind the mirror.

$s_o > 0$ and s_i, f, $r < 0$ in front of the lens or refracting surface. $\quad$ $s_o < 0$ and s_i, f, $r > 0$ behind the lens or refracting surface.

The radius of curvature of the lens surface first reached by the light rays is r_1.
The curvature of the surface reached after the light passes through the lens is r_2.

Interference and Diffraction:

$m\lambda = d\sin\theta$, m=0, 1, 2, …(Bright) $\quad (m + ½)\lambda = d\sin\theta$, m=0, 1, 2, …(Dark)

$2L = (m + ½)\frac{\lambda}{n}$, m=0, 1, 2, … $\quad 2L = m\frac{\lambda}{n}$, m=0, 1, 2, …

$\Delta\phi = \frac{2\pi}{\lambda}\Delta L$ $\quad$ Small θ: $\sin\theta \approx \tan\theta \approx \theta$

$a\sin\theta = m\lambda$, m=1,2,3,... (Dark)

$I(\theta) = I_m(\cos^2\beta)\left(\frac{\sin\alpha}{\alpha}\right)^2$ $\quad \beta = \frac{\pi d}{\lambda}\sin\theta$ $\quad \alpha = \frac{\pi a}{\lambda}\sin\theta$

$\sin\theta = 1.22\frac{\lambda}{d}$ $\quad \theta_R \approx 1.22\frac{\lambda}{d}$ $\quad D = \frac{\Delta\theta}{\Delta\lambda} = \frac{m}{d\cos\theta}$ $\quad R = \frac{\lambda}{\Delta\lambda} = Nm$

Constants & Conversions:

$g = 9.81\ \text{m/s}^2$ $\quad e = 1.60\times10^{-19}\ \text{C}$ $\quad \varepsilon_0 = 8.85\times10^{-12}\ \frac{\text{C}^2}{\text{Nm}^2}$

$m_p = 1.67\times10^{-27}\ \text{kg}$ $\quad m_e = 9.11\times10^{-31}\ \text{kg}$

$k = \frac{1}{4\pi\varepsilon_0} = 8.99\times10^9\ \frac{\text{Nm}^2}{\text{C}^2}$ $\quad \mu_0 = 4\pi\times10^{-7}\ \frac{\text{T}\cdot\text{m}}{\text{A}}$ $\quad c = 3.0\times10^8\ \frac{\text{m}}{\text{s}}$

1 eV = 1.60×10^{-19} J $\quad$ 1 V = 1 J/C $\quad$ 1 W = 1 J/s

$1\ \text{A} = 1\ \frac{\text{C}}{\text{s}}$ $\quad 1\ \text{T} = 1\ \frac{\text{N}}{\text{A}\cdot\text{m}}$ $\quad 1\ \text{H} = \frac{\text{T}\cdot\text{m}^2}{\text{A}} = 1\ \Omega\cdot\text{s}$ $\quad 1\ \text{F} = 1\ \frac{\text{C}}{\text{V}} = 1\ \frac{\text{s}}{\Omega}$

$C = 2\pi r$ $\quad A_{cir} = \pi r^2$ $\quad A_{sph} = 4\pi r^2$ $\quad V_{sph} = (4/3)\pi r^3$ $\quad 180^\circ$ in Δ