

Constants:  $e = 1.6 \times 10^{-19} C$        $m_p = 1.67 \times 10^{-27} kg$        $m_e = 9.1 \times 10^{-31} kg$   
 $\epsilon_o = 8.85 \times 10^{-12} C^2/N \cdot m^2$        $1/(4\pi\epsilon_o) = 9 \times 10^9 N \cdot m^2/C^2$        $\mu_o = 4\pi \times 10^{-7} T \cdot m/A$   
 $c = 3 \times 10^8 m/s$       nano =  $10^{-9}$       micro =  $10^{-6}$

Coulomb's Law:  $|\vec{F}| = \frac{|q_1||q_2|}{4\pi\epsilon_o r^2}$  (point charge)

Electric field:  $\vec{E} = \frac{\vec{F}}{q}$        $\vec{E} = \frac{q}{4\pi\epsilon_o r^2} \hat{r}$  (point charge)       $\vec{E} = \int \frac{dq}{4\pi\epsilon_o r^2} \hat{r}$  (general)

Gauss' law:  $\Phi_E = \hat{n} \cdot \vec{E} A = \oint \hat{n} \cdot \vec{E} dA = \frac{q_{enc}}{\epsilon_o}$

Energy:  $W = \int \vec{F} \cdot d\vec{s} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = K_f - K_i$

For conservative forces  $U_f - U_i = - \int \vec{F} \cdot d\vec{s} \rightarrow K_i + U_i = K_f + U_f$

Electric potential:  $V = \frac{U}{q}$        $V = \frac{q}{4\pi\epsilon_o r}$  (point charge)       $V = \int \frac{dq}{4\pi\epsilon_o r}$  (general)

$V_b - V_a = - \int_a^b E_x dx = - \int_a^b \vec{E} \cdot d\vec{s}$        $E_x = -\frac{\partial V}{\partial x}$ ,  $E_y = -\frac{\partial V}{\partial y}$ ,  $E_z = -\frac{\partial V}{\partial z}$

Capacitors:  $q = CV$        $C = \frac{\epsilon_o A}{d}$  (parallel-plate)       $C = C_1 + C_2$  (parallel)

$U_E = \frac{q^2}{2C}$        $u_E = \frac{1}{2}\epsilon_o E^2$        $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$  (series)

Resistors:  $i = \frac{dq}{dt} = jA$        $R = \frac{V}{i}$        $R = \frac{\rho L}{A}$  (wire)       $P = iV$

$R = R_1 + R_2$  (series)       $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$  (parallel)       $\tau_{RC} = RC$

Magnetism:  $\vec{F} = q\vec{v} \times \vec{B}$        $\vec{F} = i\vec{L} \times \vec{B}$        $\mu = NiA$        $\vec{\tau} = \vec{\mu} \times \vec{B}$        $U = -\vec{\mu} \cdot \vec{B}$

$d\vec{B} = \frac{\mu_o}{4\pi} \frac{id\vec{s} \times \hat{r}}{r^2}$        $\oint \vec{B} \cdot d\vec{s} = \mu_o i_{enc}$        $B = \frac{\mu_o i}{2\pi R}$  (wire),  $\frac{\mu_o i}{2R}$  (loop center),  $\frac{\mu_o i N}{L}$  (solenoid)

Induction:  $\Phi_B = \hat{n} \cdot \vec{B} A = \oint \hat{n} \cdot \vec{B} dA$        $\mathcal{E} = \oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi_B}{dt}$

$L = N\Phi_B/i$  (definition)       $L = \mu_o n^2 Al$  (solenoid)       $\mathcal{E} = -L \frac{di}{dt}$        $\mathcal{E}_1 = -M \frac{di_2}{dt}$

$U_B = \frac{1}{2}Li^2$        $u_B = \frac{B^2}{2\mu_o}$        $i = i_o e^{-t/\tau_L}$        $\tau_L = L/R$        $\frac{V_s}{V_p} = \frac{N_s}{N_p}$

AC Circuits:  $\omega = \frac{1}{\sqrt{LC}}$  (LC circuit)       $\mathcal{E} = \mathcal{E}_m \sin(\omega t)$        $i = I \sin(\omega t - \phi)$  (driven RLC)       $I = \frac{\mathcal{E}_m}{Z}$

$\tan \phi = \frac{\omega L - \frac{1}{\omega C}}{R}$        $Z = \sqrt{R^2 + (\omega L - \frac{1}{\omega C})^2}$        $v_L = L \frac{di}{dt}$        $v_C = \frac{q}{C}$        $P_{avg} = \frac{1}{2} I \mathcal{E}_m \cos \phi$

Maxwell's Eqs.:  $\oint \vec{B} \cdot \hat{n} dA = 0$        $\oint \vec{B} \cdot d\vec{s} = \mu_o \epsilon_o \frac{d\Phi_E}{dt} + \mu_o i_{enc}$        $i_d = \epsilon_o \frac{d\Phi_E}{dt}$

EM Waves:  $c = \frac{E}{B} = \frac{1}{\sqrt{\mu_o \epsilon_o}}$        $\vec{S} = \frac{1}{\mu_o} \vec{E} \times \vec{B}$        $I = S_{avg} = \frac{1}{c\mu_o} E_{rms}^2$        $E_{rms} = \frac{E_m}{\sqrt{2}}$        $I = \frac{P_s}{4\pi r^2}$

$I = I_o \cos^2 \theta$        $n_1 \sin \theta_1 = n_2 \sin \theta_2$        $\theta_c = \sin^{-1} \frac{n_2}{n_1}$        $\theta_B = \tan^{-1} \frac{n_2}{n_1}$        $p_r = \frac{I}{c}$  (absorp.),  $\frac{2I}{c}$  (refl.)

Images:  $\frac{1}{p} + \frac{1}{i} = \frac{1}{f} = \frac{2}{r}$        $\frac{n_1}{p} + \frac{n_2}{i} = \frac{n_2 - n_1}{r}$        $\frac{1}{p} + \frac{1}{i} = \frac{1}{f} = (n-1)(\frac{1}{r_1} - \frac{1}{r_2})$        $m = -\frac{i}{p}$

Interference:  $\lambda_n = \frac{\lambda}{n}$        $\Delta\phi = 2\pi m$  constructive       $\Delta\phi = 2\pi(m + \frac{1}{2})$  destructive       $\Delta\phi = 2\pi\Delta L/\lambda$

Diffraction:  $I = I_m \left( \frac{\sin \alpha}{\alpha} \right)^2$  (single)       $I = I_m \left( \frac{\sin \alpha}{\alpha} \right)^2 \cos^2(\beta)$  (double)       $\alpha = \frac{\pi a}{\lambda} \sin(\theta)$ ,  $\beta = \frac{\pi d}{\lambda} \sin(\theta)$

$d \sin(\theta) = m\lambda$  (grating)       $d \sin(\theta) = m\lambda$  (X-ray)