

Electric Forces and Fields: $\vec{F}_0 = q_0 \vec{E}$ $\vec{E} = k_e \frac{q}{r^2} \hat{r}$ $\vec{E} = k_e \int \frac{dq}{r^2} \hat{r}$ $\vec{\tau} = \vec{p} \times \vec{E}$

$U = -\vec{p} \cdot \vec{E}$ $\Phi_E = \oint \vec{E} \cdot d\vec{A}$ $\Phi_E = \frac{Q_{encl}}{\epsilon_0}$

Infinite sheet: $E = \frac{\sigma}{2\epsilon_0}$ $\sigma = \frac{Q}{A}$

Electric Potential: $U = q_0 V$ $V = k_e \frac{q}{r}$ $V = k_e \int \frac{dq}{r}$ $V_b - V_a = - \int_a^b \vec{E} \cdot d\vec{\ell}$

$\vec{E} = -\nabla V = -\left(\hat{i} \frac{\partial V}{\partial x} + \hat{j} \frac{\partial V}{\partial y} + \hat{k} \frac{\partial V}{\partial z}\right)$

Capacitance: $Q = C(\Delta V)$ $C = \frac{\epsilon_0 A}{d}$ $\frac{1}{C_{series}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots$

$C_{parallel} = C_1 + C_2 + C_3 + \dots$ $U = \frac{1}{2} Q(\Delta V)$ $u_e = \frac{1}{2} \epsilon_0 E^2$

Circuits: $i = \frac{dQ}{dt}$ $R = \frac{\rho L}{A}$ $\Delta V = IR$ $R_{series} = R_1 + R_2 + R_3 + \dots$

$\frac{1}{R_{parallel}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$ $P = I(\Delta V) = I^2 R = \frac{(\Delta V)^2}{R}$ $\tau = RC$

$q = Q_0 e^{-t/\tau}$ $q = Q_0(1 - e^{-t/\tau})$

Magnetic Forces and Fields: $\vec{F} = q\vec{v} \times \vec{B}$ $d\vec{F} = I d\vec{\ell} \times \vec{B}$ $\vec{\mu} = IA\hat{n}$ $\vec{\tau} = \vec{\mu} \times \vec{B}$

$U = -\vec{\mu} \cdot \vec{B}$ $d\vec{B} = \frac{\mu_0}{4\pi} \frac{Id\vec{\ell} \times \hat{r}}{r^2}$ $\mu_0 I_{encl} = \oint \vec{B} \cdot d\vec{\ell}$ **Long solenoid:** $B = \mu_0 n I$

Long straight wire: $B = \frac{\mu_0 I}{2\pi r}$ **Center of current loop:** $B = \frac{\mu_0 I}{2r}$

Induction: $\Phi_B = \int \vec{B} \cdot d\vec{A}$ $\varepsilon = -\frac{d\Phi_B}{dt}$ $\varepsilon = vBL$ $\oint \vec{E} \cdot d\vec{\ell} = -\frac{d\Phi_B}{dt}$

$\oint \vec{B} \cdot d\vec{\ell} = \mu_0 \left(i_c + \epsilon_0 \frac{d\Phi_E}{dt}\right)_{encl}$ $\varepsilon = -L \frac{di}{dt}$ $U = \frac{1}{2} LI^2$ $u = \frac{B^2}{2\mu_0}$ $\tau = \frac{L}{R}$

$\omega = \frac{1}{\sqrt{LC}}$

Electromagnetic Waves: $\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$ $c = 1/\sqrt{\epsilon_0 \mu_0}$ $E = cB$

$\vec{S} = \frac{1}{\mu_0} (\vec{E} \times \vec{B})$ $I = S_{ave} = \frac{1}{2} S_{max} = \frac{1}{2} \epsilon_0 c E_{max}^2$ $n = \frac{c}{v}$ $\lambda = \frac{\lambda_0}{n}$

$I = I_0 \cos^2 \theta$

Oscillations: $f = \frac{1}{T}$ $x = A \cos(\omega t + \phi)$ $\omega = 2\pi f = \frac{2\pi}{T}$

Waves: $y(x, t) = A \cos(kx - \omega t + \phi)$ $k = \frac{2\pi}{\lambda}$ $v = \lambda f = \frac{\omega}{k}$ $v = \sqrt{\frac{F_T}{\mu}}$

$\mu = \frac{M}{L}$ $v = \sqrt{\frac{\gamma RT}{M}}$ $P_{avg} = \frac{1}{2} \mu v \omega^2 A^2$ $I = \frac{P}{A}$ $y(x, t) = A_{sw} \sin(kx) \sin(\omega t)$

$f_n = n \frac{v}{2L}$ $f_n = n_{\text{odd}} \frac{v}{4L}$ $\phi = 2\pi \frac{\Delta r}{\lambda}$ $f_{beat} = |f_2 - f_1|$ $f_L = \left(\frac{v \pm v_L}{v \pm v_S} \right) f_S$

Interference: $\Delta r = m\lambda$ $\Delta r = \left(m + \frac{1}{2}\right)\lambda$ $\phi = \frac{2\pi \Delta r}{\lambda}$ $d \sin \theta = m\lambda$

$d \sin \theta = \left(m + \frac{1}{2}\right)\lambda$ $a \sin \theta = n\lambda$ $\lambda = \frac{\lambda_0}{n}$ $2nt = m\lambda$ $2nt = \left(m + \frac{1}{2}\right)\lambda$

Kinematics: $v = v_0 + at$ $x = x_0 + v_0 t + \frac{1}{2} at^2$ $v^2 = v_0^2 + 2a(x - x_0)$ $a_{rad} = \frac{v^2}{r}$

$T = \frac{2\pi r}{v}$ $\vec{v}_{P/A} = \vec{v}_{P/B} + \vec{v}_{B/A}$

Vectors: $A_x = A \cos \theta$ $A_y = A \sin \theta$ $A = \sqrt{A_x^2 + A_y^2}$ $\tan \theta = \frac{A_y}{A_x}$

$\vec{A} \cdot \vec{B} = AB \cos \phi_{AB}$ $\vec{A} \cdot \vec{B} = A_x B_x + A_y B_y + A_z B_z$ $\vec{A} \times \vec{B} = \hat{n} AB \sin \phi_{AB}$

Constants: $k_e = \frac{1}{4\pi\epsilon_0} = 8.988 \times 10^9 \text{ Nm}^2/\text{C}^2$ $\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2/\text{Nm}^2$

$e = 1.602 \times 10^{-19} \text{ C}$ $\mu_0 = 1.257 \times 10^{-6} \text{ Tm/A}$ $m_e = 9.109 \times 10^{-31} \text{ kg}$

$c = 2.998 \times 10^8 \text{ m/s}$ $v_{\text{sound}} = 343 \text{ m/s}$

Math: $ax^2 + bx + c = 0$ $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ $(1 + x)^n \approx 1 + nx$ for $x \ll 1$

$A = 4\pi r^2$ $V = \frac{4}{3}\pi r^3$
