Electric Forces and Fields: $\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}\hat{r}$ $\quad \vec{F_0} = q_0\vec{E}$ $\quad \vec{E} = \frac{1}{4\pi\epsilon_0}\int \frac{dq}{r^2}\hat{r}$

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

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

Electric Potential: $V = \frac{1}{4\pi\epsilon_0}\frac{q}{r}$ $\quad U = q_0 V$ $\quad V = \frac{1}{4\pi\epsilon_0}\int \frac{dq}{r}$ $\quad V_b - V_a = -\int_a^b \vec{E}\cdot d\vec{\ell}$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$I = I_0\cos^2\theta$

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

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

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

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

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

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

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

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

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

$\vec{A}\cdot\vec{B} = AB\cos\phi_{AB}$ $\quad \vec{A}\cdot\vec{B} = A_xB_x + A_yB_y + A_zB_z$ $\quad \vec{A}\times\vec{B} = \hat{n}AB\sin\phi_{AB}$

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

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

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

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

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