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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$I = I_0\cos^2\theta$

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

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

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

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

Optics: $\quad n_1\sin\theta_1 = n_2\sin\theta_2 \qquad \dfrac{1}{f} = \dfrac{1}{d_o} + \dfrac{1}{d_i} \qquad m = \dfrac{h_i}{h_o} = -\dfrac{d_i}{d_o}$

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

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

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

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

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

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

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

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

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

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

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