Formula Sheet

$$\vec{r} = \vec{r_0} + \vec{v_0}t + \frac{1}{2}\vec{a}t^2 \qquad \vec{v_f} = \vec{v_0} + \vec{a}t$$

$$v_f^2 = v_0^2 + 2\vec{a} \cdot \Delta\vec{r}$$

$$x = \frac{v_0^2}{g} \sin 2\theta_0 \qquad y = \frac{v_0^2}{2g} \sin^2 \theta_0$$

$$y = x \tan\theta_0 - \frac{g}{2v_0^2 \cos^2\theta_0} x^2$$

$$\vec{F} = m\vec{a} \qquad F = \frac{mv^2}{r}$$

$$f_k = \mu_k N \qquad f_s \leq \mu_s N$$

$$\vec{W} = m\vec{g} \qquad \vec{F} = -k\vec{x}$$

$$K = \frac{1}{2}mv^2 \qquad W = \vec{F} \cdot \Delta\vec{r}$$

$$\Delta K = W \qquad W = \int \vec{F} \cdot \Delta\vec{r}$$

$$P = \frac{dW}{dt} \qquad \vec{F} = -\frac{\partial U}{\partial x}\hat{i} - \frac{\partial U}{\partial y}\hat{j} - \frac{\partial U}{\partial z}\hat{k}$$

$$U = \frac{1}{2}kx^2 \qquad U = mgh$$

$$\vec{p} = m\vec{v} \qquad \vec{F} = \frac{d\vec{p}}{dt}$$

$$\vec{r}_{cm} = \frac{\sum_i m_i \vec{r}_i}{\sum_i m_i} \qquad v_f - v_i = v_{er} \ln \frac{M_i}{M_f}$$

$$\theta(t) = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2 \qquad \omega(t) = \omega_0 + \alpha t$$

$$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta \qquad W = \tau\Delta\theta$$

$$W = \int \tau \, d\theta \qquad I = \sum_i m_i r_i^2$$

$$I = \int r^2 \, dm \qquad \vec{L} = \vec{r} \times \vec{p} = I\vec{\omega}$$

$$\vec{\tau} = \frac{d\vec{L}}{dt} \qquad \vec{\tau} = I\vec{\alpha}$$

$$I_{solid-sphere} = \frac{2}{5}MR^2 \qquad I_{hollow-sphere} = \frac{2}{3}MR^2$$

$$K = \frac{1}{2}I\omega^2 \qquad K = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$mv\hat{i} - Mu\hat{i} = -mv'\hat{i} + Mu'\hat{i} \qquad u' = \frac{2mv + (m-M)u}{M+m}$$

$$v' = \frac{2Mu + (M-m)v}{M+m}$$

$$\vec{F} = -\frac{GmM}{r^2}\hat{r} \qquad U = -\frac{GmM}{r}$$

$$T^2 = \frac{4\pi^2}{G(M_1+M_2)}a^3 \qquad v = \sqrt{GM\left(\frac{2}{r} - \frac{1}{a}\right)}$$

$$m\frac{d^2x}{dt^2} + kx = 0 \qquad x(t) = A\cos(\omega t + \phi)$$

$$m\frac{d^2x}{dt^2} + b\frac{dx}{dt} + kx = 0 \qquad x(t) = Ae^{-bt/2m}\cos(\omega_D t + \phi)$$

$$m\frac{d^2x}{dt^2} + b\frac{dx}{dt} + kx = F_0\cos(\omega_{drive}t) \qquad x(t) = A_{drive}\cos(\omega_{drive}t + \phi_{drive})$$

$$A_{drive} = \frac{F_0}{\sqrt{m^2(\omega_{drive}^2 - \omega_0^2)^2 + b^2\omega_{drive}^2}} \qquad \phi_{drive} = \tan^{-1}\left(\frac{b\,\omega_{drive}}{m(\omega_{drive}^2 - \omega_0^2)}\right)$$

$$\omega_D = \sqrt{\frac{k}{m} - \left(\frac{b}{2m}\right)^2}$$

$$D(x,t) = A\sin(kx - \omega t + \phi) \qquad D(x,t) = A\sin(\frac{2\pi}{\lambda}x - 2\pi ft + \phi)$$

$$v = f\lambda \qquad f_r = \frac{v \pm v_r}{v \mp v_s}f_s$$

$$\vec{F} = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}\hat{r} \qquad \vec{F} = q\vec{E}$$

$$\vec{p} = q\vec{d} \qquad U = \frac{Qq}{4\pi\epsilon_0 r}$$

$$U = qV \qquad \vec{E} = -\frac{\partial V}{\partial x}\hat{i} - \frac{\partial V}{\partial y}\hat{j} - \frac{\partial V}{\partial z}\hat{k}$$

$$V_b - V_a = -\int_a^b \vec{E}\cdot d\vec{r} \qquad \oint \vec{E}\cdot d\vec{A} = \frac{1}{\epsilon_0}\sum q_{enc}$$

$$Q = CV \qquad C = \frac{\epsilon A}{d}$$

$$U = \frac{1}{2}CV^2 \qquad u_E = \frac{1}{2}\epsilon_0 E^2$$

$$C_{parallel} = \sum_{i=1}^{N} C_i \qquad \frac{1}{C_{series}} = \sum_{i=1}^{N}\frac{1}{C_i}$$

$$R_{series} = \sum_{i=1}^{N} R_i \qquad \frac{1}{R_{parallel}} = \sum_{i=1}^{N}\frac{1}{R_i}$$

$$I = \frac{V}{R} \qquad R = \rho\frac{l}{A}$$

$$P = I^2 R \qquad \vec{F} = q\vec{v}\times\vec{B}$$

$$\vec{F} = -I\int \vec{B}\times d\vec{l} \qquad \omega = \frac{qB}{m}$$

$$\vec{\mu} = I\vec{A} \qquad \vec{\tau} = \vec{\mu}\times\vec{B}$$

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I d\vec{l}\times\hat{r}}{r^2} \qquad \oint \vec{B}\cdot d\vec{l} = \mu_0 \sum I_{enc}$$

$$\frac{F_{12}}{l} = \frac{\mu_0 I_1 I_2}{2\pi R} \qquad \mu_n = \frac{e}{2m}\hbar n$$

$$\Phi_B = \int \vec{B}\cdot d\vec{A} \qquad \mathcal{E} = -\left(\frac{d\Phi_B}{dt}\right)$$

$$U_B = \frac{1}{2}LI^2 \qquad u_B = \frac{B^2}{2\mu_0}$$

$$X_L = \omega L \qquad X_C = \frac{1}{\omega C}$$

$$\omega_0 = \frac{1}{\sqrt{LC}} \qquad i_{max} = \frac{\mathcal{E}_{max}}{Z}$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2} \qquad \tan\phi = \frac{X_L - X_C}{R}$$

$$Q = \frac{f_0}{\Delta f} \qquad P_{R,avg} = i_{rms}^2 R$$

$$\vec{S} = \frac{1}{\mu_0}\vec{E} \times \vec{B}$$

Maxwell's Equations

$$\oint \vec{E} \cdot d\vec{A} = \frac{q}{\epsilon_0} \qquad \oint \vec{B} \cdot d\vec{A} = 0$$

$$\oint \vec{E} \cdot d\vec{l} = -\frac{d\Phi_B}{dt} \qquad \oint \vec{B} \cdot d\vec{l} = \mu_0 I + \mu_0 \epsilon_0 \frac{d\Phi_E}{dt}$$

Fundamental Constants

$G = 6.673 \times 10^{-11}\,\mathrm{m^3\,kg^{-1}\,s^{-2}}$

$c = 2.997 \times 10^{8}\mathrm{m\,s^{-1}}$

$N_A = 6.022 \times 10^{23}\,\mathrm{particles\,mol^{-1}}$

$e = 1.602 \times 10^{-19}\,\mathrm{C}$

$\epsilon_0 = 8.854 \times 10^{-12}\,\mathrm{C^2\,N^{-1}\,m^{-2}}$

$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{N\,A^{-2}}$

$\hbar = 1.055 \times 10^{-34}\,\mathrm{J \cdot s}$

Physical Constants

$R_e = 6.371 \times 10^{6}\,\mathrm{m}$

$M_e = 5.972 \times 10^{24}\,\mathrm{kg}$

$g = 9.81\,\mathrm{m\,s^{-2}}$

$v_{sound} = 343\,\mathrm{m\,s^{-1}}$