

$$\bar{v} = \frac{\Delta x}{\Delta t}, \quad v = \frac{dx}{dt}$$

$$\Delta x = v_0 t + \frac{1}{2} a t^2, \quad \Delta x = v_f t - \frac{1}{2} a t^2$$

$$a = \frac{\Delta v}{\Delta t}, \quad a = \frac{dv}{dt}$$

$$v_f^2 = v_0^2 + 2a\Delta x$$

$$\Delta x = \frac{1}{2}(v_0 + v_f)t$$

$$F = ma, \quad w = mg$$

$F_f = \mu F_N$ (μ_s is a maximum therefore can be less than calculated, and μ_k is constant)

$$W = Fd \cos \theta, \quad W = \int F dx \cos \theta$$

$$W = \Delta K, \quad W = -\Delta U$$

$$K = \frac{1}{2} m v^2$$

$$U_g = mgh, \quad U_g = -G \frac{m_1 m_2}{r}, \quad U_s = \frac{1}{2} k x^2$$

$$U_i + K_i + W_{nc} = U_f + K_f$$

$$F_s = -kx$$

$$P = \frac{W}{t}, \quad P = Fv$$

$$p = mv, \quad p_i = p_f, \quad F = \frac{dp}{dt}$$

$$J = \Delta mv, \quad J = Ft, \quad J = \int F dt$$

$$F_g = G \frac{m_1 m_2}{r^2}, \quad (G=6.67 \cdot 10^{-11})$$

$$v_{esc} = \sqrt{\frac{2GM_e}{R_e}}$$

$$F_c = \sum F_r, \quad F_c = ma_c, \quad F_c = m \frac{v^2}{r}, \quad F_c = m \omega^2 r$$

$$s = r\theta$$

$$v = r\omega$$

$$a_t = r\alpha$$

$$\Delta \theta = \omega_0 t + \frac{1}{2} \alpha t^2$$

$$\bar{\omega} = \frac{\Delta \theta}{\Delta t}, \quad \omega = \frac{d\theta}{dt}$$

$$\alpha = \frac{\Delta \omega}{\Delta t}, \quad \alpha = \frac{d\omega}{dt}$$

$$\Delta \theta = \frac{1}{2}(\omega_i + \omega_f)t$$

$$I = \sum mr^2, \quad I = \int r^2 dm, \quad I = \int r^2 \rho dV$$

$$I = mr^2, \quad I = \frac{1}{2} mr^2, \quad I = \frac{2}{5} mr^2, \quad I = \frac{2}{3} mr^2,$$

$$I = \frac{1}{12} ml^2, \quad I = \frac{1}{3} ml^2$$

$$I_p = I_{cm} + Md^2$$

$$x_{cm} = \frac{\sum mr}{\sum m}$$

$$K_r = \frac{1}{2} I \omega^2$$

$$\tau = I\alpha, \quad \tau = rF \sin \theta \quad (\text{RHR for direction})$$

$$L = I\omega, \quad L = mvr_{\perp}, \quad L = mvr \sin \theta$$

$$T^2 = k_s a^3, \quad k_s = \frac{4\pi^2}{Gm_s}, \quad (k=1 \text{ for AU's \& yrs})$$

$$T_p = 2\pi \sqrt{\frac{l}{g}}$$

$$T_s = 2\pi \sqrt{\frac{m}{k}}$$

$$T_{cp} = 2\pi \sqrt{\frac{I}{mgd}}$$

$$\omega = \frac{2\pi}{T}$$

$$x = A \cos(\omega t + \phi)$$

$$v = -A\omega \sin(\omega t + \phi)$$

$$a = -A\omega^2 \cos(\omega t + \phi), \quad a = \frac{d^2 x}{dt^2}, \quad a = -\omega^2 x$$

$$P = \frac{F}{A}$$

$$\rho = \frac{m}{V}$$

$$P = P_0 + \rho gh$$

$$F_{buoy} = \rho Vg$$

$$A_1 v_1 = A_2 v_2$$

$$P_1 + \rho gh_1 + \frac{1}{2} \rho v_1^2 = P_2 + \rho gh_2 + \frac{1}{2} \rho v_2^2$$

$$\Delta L = \alpha L_0 \Delta T$$

$$\Delta A = \gamma A_0 \Delta T, \gamma = 2\alpha$$

$$\Delta V = \beta V_0 \Delta T, \beta = 3\alpha$$

$$PV = nRT = Nk_B T$$

$$R = 8.31 \text{ J/(mol K)} = 0.0821 \text{ (L atm)/(mol K)}$$

$$U = K_{total} = \frac{3}{2} nRT = \frac{3}{2} Nk_B T$$

$$v_{rms} = \sqrt{\frac{3k_B T}{m}} = \sqrt{\frac{3RT}{M}}, k_B = 1.38 \cdot 10^{-23} \text{ J/K}$$

$$H = \frac{kA\Delta T}{L}, k = \text{J/(s m }^\circ\text{C)}$$

$$Q = mC\Delta T$$

$$Q = \pm mL$$

$$W_{sys} = -P\Delta V, W_{enviro} = P\Delta V$$

$$\Delta U = Q + W_{sys}$$

$$W_{engine} = |Q_h| - |Q_c|$$

$$e_c = 1 - \frac{T_c}{T_h} = \frac{W_{engine}}{|Q_h|} = \frac{|Q_h| - |Q_c|}{|Q_h|}$$

$$\Delta S = \frac{Q_R}{T}$$

$$COP_{engine} = \frac{|Q_h|}{W_{engine}}, COP_{pump} = \frac{|Q_c|}{W_{engine}}$$

$$v = f\lambda$$

$$v = \sqrt{\frac{F}{\mu}}, \mu = \frac{m}{L}$$

$$v = (331) \sqrt{\frac{T}{273}}$$

$$f_0 = f_s \left(\frac{v + v_0}{v - v_s} \right)$$

$$\lambda_0 = \lambda_s - \frac{v_s}{f_s}$$

$$f_b = |f_2 - f_1|$$

$$f_n = \frac{n}{2L} \sqrt{\frac{F}{\mu}}$$

$$f_{nopen} = n \frac{v}{2L}, f_{nclosed} = n \frac{v}{4L}$$

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$n \equiv \frac{c}{v}, n = \frac{\lambda_0}{\lambda_n}$$

$$E = hf, h = 6.63 \cdot 10^{-34} \text{ J s}$$

$$\sin \theta_c = \frac{n_2}{n_1}$$

$$\frac{1}{s_0} + \frac{1}{s_i} = \frac{1}{f}$$

$$M = \frac{-s_i}{s_0}, h_i = |M| h_0$$

$$\delta_{bright} = r_2 - r_1 = m\lambda = d \sin \theta_{bright}$$

$$\delta_{dark} = r_2 - r_1 = \left(m + \frac{1}{2} \right) \lambda = d \sin \theta_{dark}$$

$$Y_{bright} = \frac{\lambda L}{d} m, Y_{dark} = \frac{\lambda L}{d} \left(m + \frac{1}{2} \right)$$

$$2nt = \left(m + \frac{1}{2} \right) \lambda, 2nt = m\lambda$$

$$\sin \theta_{bright} = \left(m + \frac{1}{2} \right) \frac{\lambda}{a}, \sin \theta_{dark} = m \frac{\lambda}{a}$$

$$F = k \frac{|Qq|}{r^2}, k = \frac{1}{4\pi\epsilon_0}$$

$$E = k \frac{|Q|}{r^2} = \frac{F}{q}$$

$$\Delta V = \Delta k \frac{q}{r} = \frac{\Delta U}{q} = -Ed$$

$$U_e = -qEd = qV = k \frac{Qq}{r}$$

$$U_c = \frac{1}{2} C \Delta V^2 = \frac{1}{2} Q \Delta V = \frac{1}{2} \frac{Q^2}{C}$$

$$C = \frac{Q}{\Delta V} = \epsilon_0 \frac{A}{d}$$

$$\frac{1}{C_s} = \sum \frac{1}{C_n}$$

$$C_p = \sum C_n$$

$$R = \rho \frac{l}{A}$$

$$R_s = \sum R_n$$

$$\frac{1}{R_p} = \sum \frac{1}{R_n}$$

$$I = \frac{\Delta Q}{\Delta t}$$

$$V = IR$$

$$P = IV = I^2 R = \frac{V^2}{R}$$

$$F = qvB \sin \theta = IlB \sin \theta$$

$$B = \frac{\mu_0 I}{2\pi r}, k' = \frac{\mu_0}{2\pi} = 2 \times 10^{-7}$$

$$\phi = BA \cos \theta$$

$$\epsilon = -\frac{\Delta \phi}{\Delta t} = Blv$$

$$v = f\lambda, c = v = 3.0 \times 10^8 \text{ m/s}$$

$$E = hf = \frac{hc}{\lambda} = pc$$

$$\lambda = \frac{h}{p}$$

$$K = hf - \phi$$

$$E_{electron} = -2.178 \times 10^{18} \frac{Z^2}{n^2} \text{ Joules}$$

$$E_{electron} = 6.242 \times 10^{18} \frac{Z^2}{n^2} \text{ eV}$$

$$E = mc^2$$