

**Useful formulas:**

**Motion in the x, y or z-directions**

$$r_f = r_0 + v_{0r}t + \frac{1}{2}a_r t^2$$

$$v_{fr} = v_{0r} + a_r t$$

$$v_{fr}^2 = v_{0r}^2 + 2a_r \Delta r$$

**Vectors**

magnitude of a vector =  $\sqrt{v_x^2 + v_y^2}$

direction of a vector  $\rightarrow \phi = \tan^{-1}\left(\frac{v_y}{v_x}\right)$

**Linear Momentum/Forces**

$$\vec{p} = m \vec{v}$$

$$\vec{p}_f = \vec{p}_i + \vec{F} \Delta t$$

$$\vec{F} = m \vec{a}$$

$$\vec{F}_s = -k \vec{x}$$

$$F_f = \mu F_N$$

**Rotational Motion**

$$\theta_f = \theta_i + \omega_i t + \frac{1}{2} \alpha t^2$$

$$\omega_f = \omega_i + \alpha t$$

$$\omega_f^2 = \omega_i^2 + 2\alpha \Delta \theta$$

$$\tau = I\alpha = rF$$

$$L = I\omega$$

$$\Delta s = r\Delta \theta : v = r\omega : a_t = r\alpha$$

$$a_r = r\omega^2$$

**Sound**

$$v = f\lambda = (331 + 0.6T) \frac{m}{s}$$

$$\beta = 10 \log \frac{I}{I_0}; I_0 = 1 \times 10^{-12} \frac{W}{m^2}$$

$$f_n = nf_1 = n \frac{v}{2L}; f_n = nf_1 = n \frac{v}{4L}$$

**Uniform Circular Motion**

$$a_r = \frac{v^2}{r}$$

$$F_r = ma_r = m \frac{v^2}{r}$$

$$v = \frac{2\pi r}{T}$$

$$F_G = G \frac{m_1 m_2}{r^2}$$

**Useful Constants**

$$g = 9.8 \frac{m}{s^2} \quad G = 6.67 \times 10^{-11} \frac{Nm^2}{kg^2} \quad 1 \text{ rev} = 2\pi \text{ rad}$$

$$N_A = 6.02 \times 10^{23} \text{ atoms/mole} \quad k_B = 1.38 \times 10^{-23} \text{ J/K}$$

$$\sigma = 5.67 \times 10^{-8} \frac{W}{m^2 K^4} \quad v_{\text{sound}} = 343 \frac{m}{s} \quad P_{\text{air}} = 1.013 \times 10^5 \text{ N/m}^2$$

**Work/Energy**

$$K_t = \frac{1}{2} mv^2$$

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

$$U_g = mgh$$

$$U_s = \frac{1}{2} kx^2$$

$$W_T = Fd \cos \theta = \Delta E_T$$

$$W_R = \tau\theta = \Delta E_R$$

$$W_{\text{net}} = W_R + W_T = \Delta E_R + \Delta E_T$$

$$\Delta E_R + \Delta E_T + \Delta U_g + \Delta U_s = 0$$

$$\Delta E_R + \Delta E_T + \Delta U_g + \Delta U_s = -\Delta E_{\text{diss}}$$

**Fluids**

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

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

$$P_d = P_0 + \rho g d$$

$$F_B = \rho g V$$

$$P_1 + \frac{1}{2} \rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2} \rho v_2^2 + \rho g h_2$$

**Geometry /Algebra**

Circles      Triangles      Spheres

$$C = 2\pi r \quad A = \frac{1}{2}bh \quad A = 4\pi r^2$$

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

Quadratic equation:  $ax^2 + bx + c = 0$ ,

whose solutions are given by:  $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

**Heat**

$$T_C = \frac{5}{9}[T_F - 32]$$

$$T_F = \frac{9}{5}T_C + 32$$

$$L_{\text{new}} = L_{\text{old}}(1 + \alpha \Delta T)$$

$$A_{\text{new}} = A_{\text{old}}(1 + 2\alpha \Delta T)$$

$$V_{\text{new}} = V_{\text{old}}(1 + \beta \Delta T): \beta = 3\alpha$$

$$PV = Nk_B T$$

$$\frac{3}{2}k_B T = \frac{1}{2}mv^2$$

$$\Delta Q = mc\Delta T$$

$$P_C = \frac{\Delta Q}{\Delta t} = \frac{kA}{L} \Delta T$$

$$P_R = \frac{\Delta Q}{\Delta T} = \epsilon \sigma A \Delta T^4$$

$$\Delta U = \Delta Q - \Delta W$$

**Simple Harmonic Motion/Waves**

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

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

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

$$v = \pm \sqrt{\frac{k}{m}} A \left(1 - \frac{x^2}{A^2}\right)^{\frac{1}{2}}$$

$$x(t) = A \sin\left(\frac{2\pi t}{T}\right)$$

$$v(t) = A \sqrt{\frac{k}{m}} \cos\left(\frac{2\pi t}{T}\right)$$

$$a(t) = -A \frac{k}{m} \sin\left(\frac{2\pi t}{T}\right)$$

$$v = f\lambda = \sqrt{\frac{F_T}{\mu}}$$

$$f_n = nf_1 = n \frac{v}{2L}$$

$$I = 2\pi^2 f^2 \rho v A^2$$