

Formulas and Constants

$$\begin{aligned}
 g &= 9.80 \text{ m/s}^2 & G &= 6.67 \times 10^{-11} \text{ N m}^2/\text{kg}^2 \\
 \rho_{\text{water}} &= 1000 \text{ kg/m}^3 & P_{\text{atm}} &= 1.013 \times 10^5 \text{ Pa} & \text{Pa} &= \text{N/m} & k_B &= 1.38 \times 10^{-23} \text{ J/K} \\
 R &= 8.31 \text{ J/(mol K)} & \sigma &= 5.67 \times 10^{-8} \text{ J/(s m}^2 \text{ K}^4) & N_A &= 6.02 \times 10^{23} & 1 \text{ kcal} &= 4186 \text{ J} \\
 c_{\text{water}} &= 4186 \text{ J/(kg C)} & c_{\text{ice}} &= 2000 \text{ J/(kg C)} & L_{\text{f,water}} &= 33.5 \times 10^4 \text{ J/kg} & L_{\text{v,water}} &= 22.6 \times 10^5 \text{ J/kg}
 \end{aligned}$$

$$\begin{aligned}
 \vec{A} + \vec{B} &= \vec{C} \Rightarrow A_x + B_x = C_x & A_y + B_y &= C_y \\
 C_x &= C \cos \theta & C_y &= C \sin \theta & C &= \sqrt{C_x^2 + C_y^2} & \theta &= \arctan\left(\frac{C_y}{C_x}\right)
 \end{aligned}$$

$$\begin{aligned}
 \Delta(\text{thing}) &= \text{thing}_f - \text{thing}_i \\
 C_{\text{circle}} &= 2\pi R & A_{\text{disk}} &= \pi R^2 & A_{\text{sphere}} &= 4\pi R^2 & V_{\text{sphere}} &= \frac{4}{3}\pi R^3
 \end{aligned}$$

$$\bar{v} = \frac{\Delta x}{\Delta t} \quad v = v_0 + at \quad \Delta x = v_0 t + \frac{1}{2}at^2 \quad v^2 = v_0^2 + 2a\Delta x$$

$$\begin{aligned}
 \vec{F}_{\text{net}} &= m\vec{a} & F_{\text{grav}} &= \frac{Gm_1m_2}{r^2} & f_k &= \mu_k F_N & f_s &\leq \mu_s F_N \\
 \text{weight} &= mg & \vec{F}_{\text{cent}} &= m\vec{a}_{\text{cent}} & a_{\text{cent}} &= \frac{v^2}{r} & v &= \frac{2\pi r}{T}
 \end{aligned}$$

$$\begin{aligned}
 W &= F\Delta x \cos \theta = F\Delta x_{\parallel} & \text{KE} &= \frac{1}{2}mv^2 & \text{PE} &= mgh & E &= \text{KE} + \text{PE} \\
 \text{KE}_i + \text{PE}_i &= \text{KE}_f + \text{PE}_f & \Leftrightarrow & \Delta\text{KE} + \Delta\text{PE} &= 0 & W &= \Delta\text{KE} \\
 W_{\text{non-cons}} &= \Delta E = E_f - E_i & \text{average power} &= \frac{\Delta E}{\Delta t}
 \end{aligned}$$

$$\begin{aligned}
 \vec{p} &= m\vec{v} & \text{impulse} &= \vec{I} = \Delta\vec{p} = \vec{\bar{F}}_{\text{ext}}\Delta t \\
 \vec{p}_{1i} + \vec{p}_{2i} &= \vec{p}_{1f} + \vec{p}_{2f} & \Leftrightarrow & \Delta\vec{p}_1 + \Delta\vec{p}_2 &= 0
 \end{aligned}$$

$$\begin{aligned}
 \theta &= \frac{s}{r} & \bar{\omega} &= \frac{\Delta\theta}{\Delta t} & \bar{\alpha} &= \frac{\Delta\omega}{\Delta t} & \omega &= \omega_0 + \alpha t & \Delta\theta &= \omega_0 t + \frac{1}{2}\alpha t^2 & \omega^2 &= \omega_0^2 + 2\alpha\Delta\theta \\
 v_{\text{linear}} &= v_T = r\omega & a_{\text{linear}} &= a_T = r\alpha & a_c &= r\omega^2 & a_{\text{total}} &= \sqrt{a_T^2 + a_c^2}
 \end{aligned}$$

$$I_{\text{point}} = mr^2 \quad I_{\text{rod,axis at center}} = \frac{1}{12}m\ell^2 \quad I_{\text{sphere,axis at center}} = \frac{2}{5}mR^2 \quad I_{\text{system}} = I_1 + I_2 + \cdots$$

$$\text{torque} = \tau = F\ell \sin \theta = F\ell_{\perp} \quad \tau_{\text{net}} = I\alpha \quad \text{KE}_{\text{rot}} = \frac{1}{2}I\omega^2$$

$$L = I\omega \quad \tau_{\text{ext}} = \frac{\Delta L}{\Delta t} \quad \text{equilibrium : } \sum F = 0 \quad \text{and} \quad \sum \tau = 0$$

$$F = -kx \quad f = \frac{1}{T} \quad \omega = 2\pi f = \frac{2\pi}{T}$$

$$x(t) = A \cos(\omega t) \quad v_{\text{max}} = A\omega \quad a_{\text{max}} = A\omega^2 \quad \omega = \sqrt{\frac{k}{m}}$$

$$\text{PE}_{\text{spring}} = \frac{1}{2}kx^2 \quad E_{\text{tot}} = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 + mgh + \frac{1}{2}kx^2$$

$$\omega_{\text{simple pend}} = 2\pi f = \sqrt{\frac{g}{L}} \quad \omega_{\text{phys pend}} = 2\pi f = \sqrt{\frac{mgL}{I}}$$

$$\rho = \frac{m}{V} \quad P = \frac{F}{A} \quad P_2 = P_1 + \rho gh \quad F_B = W_{\text{displaced fluid}}$$

$$\text{mass flow rate} = \rho Av \quad \rho_1 A_1 v_1 = \rho_2 A_2 v_2 \quad (\text{if incompressible}) : A_1 v_1 = A_2 v_2$$

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$$

$$T_F = \frac{9}{5}T_C + 32 \quad T_C = \frac{5}{9}(T_F - 32) \quad T_K = T_C + 273.15 \quad \Delta L = \alpha L_0 \Delta T$$

$$Q = mc\Delta T \quad Q = mL \quad \frac{Q}{t} = \frac{kA\Delta T}{L} \quad \frac{Q}{t} = e\sigma T^4 A$$

$$PV = nRT = Nk_B T \quad KE = \frac{1}{2}mv_{\text{rms}}^2 = \frac{3}{2}k_B T \quad U = \frac{3}{2}Nk_B T = \frac{3}{2}nRT$$

$$\Delta U = Q - W \quad W_{\text{constant P}} = P\Delta V = P(V_f - V_i) \quad W_{\text{adiabatic}} = \frac{3}{2}nR(T_i - T_f)$$

$$W = Q_H - Q_C \quad e = \frac{W}{Q_H} = 1 - \frac{Q_C}{Q_H} \quad \left(\frac{Q_C}{Q_H}\right)_{\text{Carnot}} = \frac{T_C}{T_H} \quad e_{\text{Carnot}} = 1 - \frac{T_C}{T_H}$$