

PHY 2130 Equation Sheet

Constants and Unit Conversions

$$G = 6.67 \times 10^{-11} \frac{\text{N} \cdot \text{m}^2}{\text{kg}^2}$$

$$M_{\text{Earth}} = 5.97 \times 10^{24} \text{ kg}$$

$$R_{\text{Earth}} = 6.38 \times 10^6 \text{ m}$$

$$g = 9.8 \text{ N/kg}$$

$$k_B = 1.38 \times 10^{-23} \text{ J/K}$$

$$R = 8.31 \text{ J/(mol} \cdot \text{K)}$$

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

$$k_C = 8.99 \times 10^9 \frac{\text{N} \cdot \text{m}^2}{\text{C}^2}$$

$$1 \text{ mi} = 1609 \text{ m}$$

$$1 \text{ in} = 2.54 \text{ cm}$$

$$1 \mu\text{m} = 1 \times 10^{-6} \text{ m}$$

$$1 \text{ nm} = 1 \times 10^{-9} \text{ m}$$

$$1 \text{ N} = 1 \text{ kg} \cdot \text{m/s}^2$$

$$1 \text{ J} = 1 \text{ kg} \cdot \text{m}^2/\text{s}^2$$

Areas and Volumes

$$A = \pi r^2 \quad C = 2\pi r \quad [\text{circle}]$$

$$A = 4\pi r^2 \quad V = \frac{4}{3}\pi r^3 \quad [\text{sphere}]$$

Cylinder

$$A = 2\pi r h \quad [\text{curved surface area}]$$

$$A_{\text{total}} = 2\pi^2 + 2\pi r h \quad [\text{total surface area}]$$

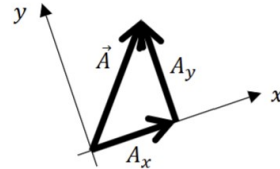
$$V = \pi r^2 h$$

Vector Summary

$$\sin \theta = \frac{\text{opp}}{\text{hyp}}, \quad \cos \theta = \frac{\text{adj}}{\text{hyp}}, \quad \tan \theta = \frac{\text{opp}}{\text{adj}},$$

$$\text{hyp}^2 = \text{opp}^2 + \text{adj}^2$$

Components:



$$\vec{A} = A_x \hat{i} + A_y \hat{j}, \quad A_x = A \cos \theta, \quad A_y = A \sin \theta$$

Motion

$$\vec{r} = x\hat{i} + y\hat{j}$$

$$\Delta \vec{r} = \vec{r}_f - \vec{r}_i = (\Delta x)\hat{i} + (\Delta y)\hat{j}$$

$$\text{average speed} = \frac{\text{distance}}{\text{time}}$$

$$\langle \vec{v} \rangle = \frac{\Delta \vec{r}}{\Delta t}$$

$$\langle \vec{a} \rangle = \frac{\Delta \vec{v}}{\Delta t}$$

Constant Acceleration

$$v_f = v_i + a\Delta t$$

$$\langle v \rangle = \frac{1}{2}(v_i + v_f)$$

$$\Delta x = \frac{v_i + v_f}{2} \Delta t$$

$$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

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

Momentum and Impulse

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

$$\vec{p}_{\text{tot}} = \vec{p}_1 + \vec{p}_2 + \dots$$

$$\Delta \vec{p} = \vec{p}_f - \vec{p}_i$$

$$\vec{I} = \langle \vec{F}_{\text{net}} \rangle \Delta t$$

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

Diffusion

$$\langle v_x \rangle = \frac{\lambda}{\Delta T}$$

$$D = \frac{\lambda \langle v_x \rangle}{2}$$

$$P(x, t) = \frac{1}{\sqrt{4\pi Dt}} e^{-x^2/4Dt}$$

$$x_{\text{rms}} = \sqrt{2Dt} \quad \text{one dimensional}$$

$$r_{\text{rms}} = \sqrt{4Dt} \quad \text{two dimensional}$$

$$r_{\text{rms}} = \sqrt{6Dt} \quad \text{three dimensional}$$

$$J = \frac{R}{A} = -D \frac{\Delta n}{\Delta x}$$

Forces and Newton's Laws

$$\vec{F}_{\text{net}} = \sum \vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \dots$$

$$\langle \vec{F}_{\text{net}} \rangle = m \langle \vec{a} \rangle$$

$$\vec{F}_{\text{net}} = m\vec{a}$$

$$|\vec{W}| = mg \quad [\text{weight force}]$$

$$|\vec{F}_{\text{sp}}| = k|\Delta x| \quad [\text{spring force}]$$

$$f_{s,\text{max}} = \mu_s n \quad [\text{static friction force}]$$

$$f_k = \mu_k n$$

Drag and Viscous Forces

$$|\vec{F}_{\text{viscous}}| = 6\pi\mu Rv \quad [\text{sphere}]$$

$$|\vec{F}_{\text{drag}}| = \frac{1}{2}c_D\rho Av^2$$

$$Re = \left(\frac{\rho}{\mu}\right)Rv$$

Gravity and Electric Force

$$|\vec{F}_{\text{grav}}| = G\frac{m_1m_2}{r^2}$$

$$Q_{\text{net}} = N_{\text{protons}}e - N_{\text{electrons}}e$$

$$|\vec{F}_{\text{elec}}| = k_C\frac{|q_1||q_2|}{r^2}$$

Center of Mass

$$x_{\text{CM}} = \left(\frac{m_A}{m_{\text{total}}}\right)x_A + \left(\frac{m_B}{m_{\text{total}}}\right)x_B + \dots$$

$$y_{\text{CM}} = \left(\frac{m_A}{m_{\text{total}}}\right)y_A + \left(\frac{m_B}{m_{\text{total}}}\right)y_B + \dots$$

Solids

$$\rho = \frac{m}{V} \quad [\text{density}]$$

$$|\vec{F}| = k_{\text{eff}}|\Delta L|$$

$$k_{\text{eff}} = \frac{EA}{L}$$

$$\sigma = E\epsilon$$

$$\sigma = \frac{|\vec{F}|}{A}$$

$$\epsilon = \frac{\Delta L}{L}$$

Fluids

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

$$P = P_0 + \rho gd$$

$$B = m_{\text{fl}}g = \rho_{\text{fl}}V_{\text{fl}}g$$

$$\gamma = \frac{|\vec{F}_{\text{tot}}|}{L}$$

$$\Delta P = \frac{2\gamma}{r}$$

$$Q = Av = Av_{\text{avg}} = \text{constant}$$

$$A_1v_1 = A_2v_2$$

$$\sum Q_{\text{in}} = \sum Q_{\text{out}}$$

$$|\Delta P| = \left(\frac{8\mu L}{\pi R^4}\right)Q$$

$$Q = \frac{\Delta V}{\Delta t} = \left(\frac{\pi R^4}{8\mu L}\right)|\Delta P|$$

$$P + \frac{1}{2}\rho v^2 + \rho gy = \text{constant}$$

Energy

$$E_{\text{tot}} = K + U + E_{\text{th}} + E_{\text{chem}} + \dots$$

$$\Delta E_{\text{tot}} = \Delta K + \Delta U + \Delta E_{\text{th}} + \Delta E_{\text{chem}} + \dots$$

$$= W + Q$$

$$W = F_{\parallel}d = |F||d|\cos\theta$$

$$K = \frac{1}{2}mv^2 \quad [\text{kinetic energy}]$$

$$U_g = mgy \quad [\text{gravitational potential energy}]$$

$$U_s = \frac{1}{2}k|\Delta x|^2 \quad [\text{spring potential energy}]$$

$$U_e = k_C\frac{q_1q_2}{r} \quad [\text{electrostatic potential energy}]$$

$$\Delta E_{\text{th}} = |\vec{f}_k||\Delta x|$$

$$|\vec{F}| = \left|\frac{\Delta U}{\Delta x}\right|$$

$$U = \frac{A}{r^{12}} - \frac{B}{r^6} \quad [\text{Molecular Potential}]$$

Thermal Physics

$$T(K) = T(^{\circ}\text{C}) + 273.15$$

$$\Delta E_{\text{th}} = Q = mc\Delta T$$

$$P = \frac{\Delta E}{\Delta t}$$

$$J = \frac{|P|}{A} = \kappa \left|\frac{\Delta T}{\Delta x}\right|$$

$$J = \frac{|P|}{A} = \sigma_e T^4$$

$$U_{\text{int}} = E_{\text{th}} + E_{\text{chem}}$$

Gases

$$\langle K \rangle = \frac{1}{2}m\langle v^2 \rangle = \frac{3}{2}k_B T$$

$$v_{\text{rms}} = \sqrt{\frac{3k_B T}{m}}$$

$$E_{\text{th}} = \frac{3}{2}Nk_B T$$

$$PV = Nk_B T$$

$$Nk_B = nR$$

$$\Delta U_{\text{int}} = W + Q$$