

Final Exam formulas

To be given on exam

Continued from exams 1-4

$$g=9.80 \text{ m/s}^2$$

$$\text{If } ax^2 + bx + c = 0, \quad x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

For constant a :

$$x = x_o + v_o t + \frac{1}{2} at^2$$

$$v^2 = v_o^2 + 2a(x - x_o)$$

gravity: $w = mg$, $PE_g = mgy$

friction: $f = \mu N$ (or $f \leq \mu N$, for static friction)

springs: $F = -kx$, $PE_s = \frac{1}{2} kx^2$

$$P = F_{\parallel} v = Fv \cos \theta$$

arc length: $s = r\theta$

$$v = r\omega$$

$$a_{tan} = r\alpha$$

$$a_c = v^2/r$$

$$\text{gravity: } F = \frac{GMm}{r^2}, \quad PE_g = -\frac{GMm}{r}$$

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

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

$$M_{\text{earth}} = 5.98 \times 10^{24} \text{ kg}$$

$$M_{\text{sun}} = 1.99 \times 10^{30} \text{ kg}$$

$$I_{\text{sphere}} = (2/5) MR^2$$

$$I_{\text{hoop}} = MR^2$$

$$I_{\text{disk}} = \frac{1}{2} MR^2$$

$$I_{\text{rod (center)}} = (1/12) ML^2$$

$$I_{\text{rod (end)}} = (1/3) ML^2$$

Constants

$$\rho_{\text{water}} = 1000 \text{ kg/m}^3$$

$$k_B = 1.381 \times 10^{-23} \text{ J/K}$$

$$N_A = 6.022 \times 10^{23}$$

$$R = k_B \cdot N_A = 8.314 \text{ J/mol}\cdot\text{K} = 0.08206 \text{ liter}\cdot\text{atm/mol}\cdot\text{K}$$

$$\sigma = 5.67 \times 10^{-8} \text{ W/m}^2\cdot\text{K}^4$$

Conversion factors:

$$1 \text{ atm} = 1.013 \times 10^5 \text{ Pa} = 14.7 \text{ psi}$$

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

$$T_K = T_C + 273.15$$

$$1 \text{ cal} = 4.186 \text{ J}$$

$$1 \text{ m}^3 = 1000 \text{ L}$$

$$\text{stress} = F/A; \text{ strain} = \Delta L/L$$

$$P = P_0 + \rho gh$$

$$A_1 v_1 = A_2 v_2$$

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

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

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

$$KE_{ave} = \frac{1}{2} m v_{ave}^2 = \frac{3}{2} k_B T$$

$$\frac{\Delta Q}{\Delta t} = kA \frac{T_2 - T_1}{L}$$

$$P = e\sigma AT^4$$

$$W_{on \text{ gas}} = -P\Delta V \quad (\text{constant pressure})$$

$$U = \frac{3}{2} nRT = \frac{3}{2} Nk_B T \quad (\text{monatomic ideal gas})$$

$$\text{Definition: } e = \frac{|W_{net}|}{Q_h} = 1 - \frac{Q_c}{Q_h}$$

$$\text{Carnot Theorem: } e_{max} = e_c = 1 - \frac{T_c}{T_h}$$

New for final exam

$$\text{spring } \omega = \sqrt{\frac{k}{m}}, \quad T = 2\pi \sqrt{\frac{m}{k}}$$

$$\text{pendulum } \omega = \sqrt{\frac{g}{L}}, \quad T = 2\pi \sqrt{\frac{L}{g}}$$

$$\text{wave speed } v = \sqrt{\frac{T}{\mu}}, \quad \mu = m/L \quad v = \sqrt{\frac{B}{\rho}} \quad v = \sqrt{\frac{Y}{\rho}}$$

$v_{air} = 340 \text{ m/s}$, unless otherwise specified

$$A_{sphere} = 4\pi r^2$$

$$\text{decibels } \beta = 10 \log\left(\frac{I}{I_0}\right) \quad I_0 = 10^{-12} \text{ W/m}^2$$

$$\text{Doppler: } f' = f \frac{v \pm v_0}{v \pm v_s}$$

$$\text{standing waves: } f_n = n \frac{v}{2L} \quad n = 1, 2, 3, \dots \quad f_n = n \frac{v}{4L} \quad n = 1, 3, 5, \dots$$

To be memorized

Continued from exams 1-4

Definition: $v_{ave} = \langle v \rangle = \frac{\Delta x}{\Delta t}$

Definition: $a_{ave} = \langle a \rangle = \frac{\Delta v}{\Delta t}$

For constant a :

$$v = v_o + at$$

$$v_{ave} = \langle v \rangle = \frac{v_i + v_f}{2}$$

Newton's 2nd Law: $\sum \vec{F} = m\vec{a}$

Newton's 3rd Law: $\vec{F}_{12} = -\vec{F}_{21}$

Definition: $W = F_{||} \Delta x = F \cos \theta \Delta x$

Definition: $KE = \frac{1}{2} m v^2$

Colton conservation of energy: $E_{before} + W_{net} = E_{after}$

Hess conservation of energy: $KE_i + PE_i + W_{in} = KE_f + PE_f + W_{out}$

Definition: $P = \Delta E / \Delta t$

Definition of momentum: $p = mv$

Conservation of momentum: $\sum p_{before} = \sum p_{after}$ (if no outside force)

Angular kinematics: replace x with θ , v with ω , and a with α in all the kinematics formulas

Quick derivation of satellite velocity: $\frac{GMm}{r^2} = m \frac{v^2}{r}$

Period: $T = 2\pi r / v$

Definition of torque: $\tau = r_{\perp} F = r F_{\perp} = r F \sin \theta$

Moment of inertia for point mass: $I = mr^2$

$I_{tot} = I_1 + I_2 + \dots$

Angular KE: $KE = \frac{1}{2} I \omega^2$

Newton's 2nd Law for torques: $\sum \tau = I\alpha$

Definition of angular momentum: $L = r_{\perp} p = rp_{\perp} = rp \sin \theta$, also $L = I\omega$

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

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

Archimedes' Principle: $F_B = w_{displaced\ fluid} = m_{displaced\ fluid} \times g = \rho_{fluid} V_{submerged} g$

Ideal gas law $PV = nRT = Nk_B T$

Calorimetry: $Q = mc\Delta T$; $Q = mL$

P-V diagram: $W_{on\ system} = \text{area under the curve}$, positive if decreasing volume

First Law of Thermodynamics: $\Delta U = Q_{added} + W_{on\ system}$

Definition: isothermal = no temperature change

Definition: adiabatic = no heat exchanged

Cycles: $\Delta U = 0$; $|W_{net}| = Q_{added} - Q_{exhausted} = Q_h - Q_c$; $|W_{net}| = \text{Area enclosed in P-V curve}$

New for final exam

$$f = \frac{1}{T}, \quad \omega = 2\pi f, \quad T = \frac{2\pi}{\omega}$$

Wave speed $v = f\lambda$

Intensity $I = P/A$