PHYS 223 **Formula Sheet** Fall 2011

In showing work, these formulas may be used without derivation.

FLUIDS

$$\Delta p = -\rho g \Delta y$$

$$F = \rho V g$$

$$Av = \text{const}$$

$$p + \tfrac{1}{2}\rho v^2 + \rho g y = \text{const}$$

CIRCUITS

$$E = \frac{q}{\kappa \epsilon_0 A} \qquad E = \frac{\Delta V}{d}$$

$$C = \kappa \epsilon_0 \frac{A}{d} \qquad i = \frac{dq}{dt}$$

ELECTROMAGNETISM

$$\vec{F} = q\vec{E} + q\vec{v} \times \vec{B} \qquad \vec{F} = i\vec{L} \times \vec{B}$$

$$\Delta V = -\int_i^f \vec{E} \cdot d\vec{s}$$

$$\vec{E} = -\left(\frac{\partial V}{\partial x}, \frac{\partial V}{\partial y}, \frac{\partial V}{\partial z}\right) \equiv -\vec{\nabla} V$$

$$d\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{dq}{r^3}\vec{r} \qquad d\vec{B} = \frac{\mu_0}{4\pi} i \frac{d\vec{s} \times \vec{r}}{r^3}$$

$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{\text{enc}}}{\epsilon_0} \qquad \oint \vec{B} \cdot d\vec{A} = 0$$

$$\oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi_B}{dt} \qquad \oint \vec{B} \cdot d\vec{s} = \mu_0 \epsilon_0 \frac{d\Phi_E}{dt} + \mu_0 i_{\text{enc}}$$

$$u_E = \frac{\epsilon_0}{2} E^2 \qquad u_B = \frac{1}{2\mu_0} B^2$$

ELECTROMAGNETIC WAVES

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}} \qquad \vec{S} = \frac{1}{\mu_0} \vec{E} \times \vec{B}$$

$$I = \frac{P}{4\pi r^2}$$

$$\Delta p = \frac{\Delta U}{c} \qquad p_r = (1 \text{ to } 2)\frac{I}{c}$$

$$I = I_0 \cos^2 \theta$$

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

INTERFERENCE AND DIFFRACTION

$$d\sin\theta = n\lambda \qquad d\sin\theta = \left(n - \tfrac{1}{2}\right)\lambda$$

$$I = 4I_0 \cos^2\left(\tfrac{1}{2}\Delta\phi\right) \qquad \Delta\phi = \frac{2\pi}{\lambda} d\sin\theta$$

$$a\sin\theta = m\lambda$$

$$a\sin\theta = 1.430297\lambda \quad \text{or} \quad 2.459024\lambda$$

$$I_0 = I_m \left(\frac{\sin\alpha}{\alpha}\right)^2 \qquad \alpha = \tfrac{1}{2}\phi = \frac{\pi}{\lambda} a \sin\theta$$

THERMODYNAMICS

$$\Delta L = L\alpha\,\Delta T \qquad \Delta V = V\beta\,\Delta T$$

$$\Delta E = C\,\Delta T = cm\,\Delta T = c_m n\,\Delta T$$

$$\Delta E = mL f$$

$$P = \frac{A}{R}(T_H - T_C) = kA\frac{T_H - T_C}{L}$$

$$P = \epsilon\sigma A T^4$$

$$pV = nRT = NkT$$

$$c_V = \frac{f}{2}R \qquad E_{\text{avg}} = \frac{f}{2}kT$$

$$p \propto \frac{1}{V^\gamma} \qquad T \propto V^{1-\gamma} \qquad p^{1-\gamma} \propto \frac{1}{T^\gamma}$$

$$v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$

$$P(v) = 4\pi\left(\frac{m}{2\pi kT}\right)^{3/2} v^2 e^{-mv^2/2kT}$$

QUANTUM LIGHT

$$u(f) = \frac{8\pi h f^3}{c^3}\left(\frac{1}{e^{hf/kT} - 1}\right)$$

$$\lambda_{\max} T = 2.898 \times 10^{-3}\ \text{mK}$$

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In showing work, these formulas may be used without derivation.

SPECIAL RELATIVITY

$$\gamma = \frac{1}{\sqrt{1-\beta^2}}$$

$$x' = \gamma(x - vt) = \gamma(x - \beta\, ct)$$

$$y' = y \qquad z' = z$$

$$t' = \gamma\left(t - \frac{vx}{c^2}\right) \qquad ct' = \gamma\,(ct - \beta x)$$

$$f_{\text{obs}} = \sqrt{\frac{1 \pm \beta}{1 \mp \beta}} f$$

$$u'_x = \frac{u_x - v}{1 - (u_x v/c^2)}$$

$$u'_y = \frac{u_y}{\gamma\,[1 - (u_x v/c^2)]}$$

$$\Delta s^2 = \Delta x^2 + \Delta y^2 + \Delta z^2 - (c\Delta t)^2$$

CONSTANTS

$$\epsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2/\text{Nm}^2$$

$$\mu_0 = 4\pi \times 10^{-7}\ \text{Tm/A}$$

$$\rho_{\text{air}} \approx 1.21\ \text{kg/m}^3$$

$$T_3 = 273.16\ \text{K}$$

$$\sigma = 5.6703 \times 10^{-8}\ \text{W/m}^2\text{K}^4$$

$$R = 8.314\ \text{J/mol}\cdot\text{K} \qquad k = 1.381 \times 10^{-23}\ \text{J/K}$$

$$N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$$

$$1e = 1.602 \times 10^{-19}\ \text{C}$$

$$1e\text{V} = 1.602 \times 10^{-19}\ \text{J}$$

$$h = 6.626 \times 10^{-34}\ \text{J s} = 4.136 \times 10^{-15}\ e\text{V s}$$

$$hc = 1239.8\ e\text{V nm}$$

PHYS 223 **NOT on the Formula Sheet** Fall 2011

To be memorized

FLUIDS

$$p = \frac{F}{A} \qquad p_g = p_a - p_{\text{atm}}$$

$\Delta p = \text{const}$ (Pascal's principle)

MECHANICS

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

$$\vec{x} = \vec{x}_0 + \vec{v}_0 t + \tfrac{1}{2}\vec{a}t^2$$

$$\vec{v} = \vec{v}_0 + \vec{a}t$$

WAVES

$$v = \lambda f$$

$$k = \frac{2\pi}{\lambda} \qquad f = \frac{\omega}{2\pi}$$

(Think of 2π as having units rad/cycle.)

ELECTROMAGNETISM, WITH WAVES

$$\Phi_E = \int \vec{E} \cdot d\vec{A} \qquad \Phi_B = \int \vec{B} \cdot d\vec{A}$$

$$\vec{E} = \vec{E}_m \sin(kx - \omega t)$$

$$\vec{B} = \vec{B}_m \sin(kx - \omega t)$$

$$E = Bc$$

$$I = \frac{P}{A} \qquad I = \left|\vec{S}_{\text{avg}}\right| = \tfrac{1}{2}\left|\vec{S}_{\text{max}}\right|$$

QUANTUM LIGHT

$$E = hf \qquad K_{\text{max}} = hf - \phi$$

SPECIAL RELATIVITY

$$\beta = \frac{v}{c} \qquad t = \gamma t_{\text{proper}} \qquad L = \frac{L_{\text{proper}}}{\gamma}$$

THERMODYNAMICS

$$T[^\circ\text{C}] = T[\text{K}] - 273.15\ \text{K}$$

Expansion coefficients: $\beta = 3\alpha$

$$dW = p\,dV \qquad \Delta E = Q - W$$

$$R_T = \sum R_i \text{ (in series)}$$

$$M = N_A m \qquad R = N_A k \qquad N = N_A n$$

$$K_{\text{avg}} = \frac{3}{2}kT \qquad E_{\text{int}} = NE_{\text{avg}}$$

$$c_p = c_V + R \quad \text{or} \quad c_p = c_V + k$$

$$\gamma = \frac{c_p}{c_V} = \frac{f+2}{f} = 1 + \frac{2}{f}$$

MATH

circle:	$C = 2\pi R$	$A = \pi R^2$
sphere:	$A = 4\pi R^2$	$V = \frac{4}{3}\pi R^3$
cylinder:	$A = 2\pi(RL + R^2)$	$V = \pi R^2 L$

$$\frac{d}{dx}(x^n) = nx^{n-1}$$

$$\frac{d}{dx}\sin(kx) = k\cos(kx)$$

$$\frac{d}{dx}\cos(kx) = -k\sin(kx)$$

...and the corresponding integrals

$$ds = r\,d\theta$$

$$\vec{A} \cdot \vec{B} = A_x B_x + A_z B_z + A_z B_z = AB\cos(\theta)$$

$$|\vec{A} \times \vec{B}| = AB\sin(\theta)$$

Right Hand Rule

$$P(x)dx = P(y)dy \quad \Rightarrow \quad P(y) = P(x(y))\frac{dx(y)}{dy}$$

Binomial approx. $(1 \pm x)^n \approx 1 \pm nx$

CONSTANTS

$$c \approx 3.00 \times 10^8\ \text{m/s}$$

$$p_{\text{atm}} \approx 100\ \text{kPa}$$

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