Instructor: Gus Hart

CID & NAME:

Show your work. Justify (in words) any non-obvious steps you make (that is, don't just write down the correct answer because it seems obvious to you). I want to know that you got the right answer for the *right reasons*. If you need to make any assumptions (perhaps for constants that the absent-minded instructor forgot to mention), specifically state your assumptions. Don't be afraid to explain things (in words) when your math fails you.

$0\,\mathrm{K} = -273.15°\,\mathrm{C}$ $\quad 0°\,\mathrm{C} = 32°\,\mathrm{F}$ $\quad 4.186\,\mathrm{J} = 1\,\mathrm{cal}$ $\quad \sigma = 5.67\,\mathrm{x}\,10^{-8}\,\mathrm{W/m^2K^4}$ $\quad 1.00\,\mathrm{atm} = 1.013\,\mathrm{x}\,10^5\,\mathrm{Pa}$
$R = 8.314\ \mathrm{J/(mol\cdot K)}$ $\quad k_\mathrm{B} = 1.38\,\mathrm{x}\,10^{-23}\,\mathrm{J/K}$ $\quad c = 4186\,\mathrm{J/kg}\cdot°\,\mathrm{C}$ (Specific Heat of Water) $\quad 1\,\mathrm{m}^3 = 1000\,\mathrm{L}$
$1\,\mathrm{atm} = 1.1013\,\mathrm{x}\,10^5\,\mathrm{Pa} = 14.7\,\mathrm{psi}$ $\quad c = 3\,\mathrm{x}\,10^8\,\mathrm{m/s}$ $\quad 1\,\mathrm{eV} = 1.60\,\mathrm{x}\,10^{-19}\,\mathrm{J}$

$$W = nRT\ln\left(\frac{V_i}{V_f}\right)\ \text{(isothermal)} \qquad P = \frac{\Delta Q}{\Delta t} = kA\left(\frac{T_h - T_c}{L}\right) \qquad N_v = 4\pi N\left(\frac{m}{2\pi k_\mathrm{B}T}\right)^{3/2} v^2 e^{-mv^2/2k_\mathrm{B}T}$$

$$P = \rho g h \qquad B = \rho_\text{fluid} g V_\text{disp} \qquad P + \frac{1}{2}\rho v^2 + \rho g h = \text{ constant} \qquad \Delta L = \alpha L_i \Delta T \qquad \Delta V = \beta V_i \Delta T \qquad \beta = 3\alpha$$

$$A_\text{sphere} = 4\pi r^2 \qquad V_\text{sphere} = \frac{4}{3}\pi r^3 \qquad PV = Nk_\mathrm{B}T = nRT \qquad Q = mc\Delta T \qquad Q = L\Delta m \qquad dW = -P\,dV$$

$$\Delta E_\text{int} = Q + W \qquad P = \frac{\Delta Q}{\Delta t} = \sigma A e T^4 \qquad K_\text{tot trans} = \frac{3}{2}Nk_\mathrm{B}T = \frac{3}{2}nRT \qquad Q = nC_V\Delta T \qquad Q = nC_P\Delta T$$

$$\gamma = \frac{C_P}{C_V} \qquad v_\text{rms} = \sqrt{\frac{3k_\mathrm{B}T}{m}} \qquad v_\text{avg} = \sqrt{\frac{8k_\mathrm{B}T}{\pi m}} \qquad v_\text{mp} = \sqrt{\frac{2k_\mathrm{B}T}{m}} \qquad \Delta S = nR\ln\left(\frac{V_f}{V_i}\right)$$

$$e \equiv \frac{W_\text{eng}}{|Q_h|} \qquad e_C = 1 - \frac{T_c}{T_h}\ \text{(Carnot engine efficiency)} \qquad e = 1 - \frac{1}{(V_1/V_2)^{\gamma-1}}\ \text{(Otto cycle)} \qquad dS = \frac{dQ_r}{T}$$

$$W_\text{eng} = |Q_h| - |Q_c \qquad S \equiv k_\mathrm{B}\ln \qquad f(x,t) = A\sin(kx - \omega t + \phi) \qquad \sin\theta = 1/\text{mach\#} \qquad f_2/f_1 = 2^{1/12}$$

$$\binom{n}{k} = \frac{n!}{k!(n-k)!} \qquad P = \frac{1}{2}\mu\omega^2 A^2 v \qquad \beta = 10\log\left(\frac{I}{I_0}\right) \qquad f' = \left(\frac{v \pm v_0}{v \pm v_s}\right) f \qquad \lambda_n = \frac{2L}{n} \qquad f_n = \frac{n}{2L}\sqrt{\frac{T}{\mu}}$$

$$f_n = n\frac{v}{2L} \qquad f_n = n\frac{v}{4L} \qquad a_n = \frac{2}{L}\int_0^L f(x)\sin\left(\frac{2\pi n x}{L}\right)dx \qquad n = \frac{c}{v} \qquad M = \frac{h'}{h} = \frac{-q}{p} \qquad \frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

$$f(x) = b_0 + \sum_{n=1}^{\infty} b_n\cos\left(\frac{2\pi n x}{L}\right) + \sum_{n=1}^{\infty} a_n\sin\left(\frac{2\pi n x}{L}\right) \qquad b_0 = \frac{1}{L}\int_0^L f(x)dx \qquad b_n = \frac{2}{L}\int_0^L f(x)\cos\left(\frac{2\pi n x}{L}\right)dx$$

$$n_1\sin\theta_1 = n_2\sin\theta_2 \qquad \theta_\text{Brewster} = \tan^{-1}(n_2/n_1) \qquad d\sin\theta_\text{bright} = m\lambda \qquad 2nt = m\lambda \qquad 2nt = (m + \frac{1}{2})\lambda$$

$$\frac{n_1}{p} + \frac{n_2}{q} = \frac{n_2 - n_1}{R} \qquad \frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \qquad m = \frac{\theta}{\theta_0} \qquad I = I_0\cos^2\left(\frac{\pi d}{\lambda}\sin\theta\right) \qquad P = \frac{F}{A}$$

$$I = I_0\,\mathrm{sinc}^2\left(\frac{\pi a}{\lambda}\sin\theta\right) \qquad \sin\theta_\text{dark} = m\frac{\lambda}{a} \qquad \theta_\text{min} = 1.22\frac{\lambda}{D} \qquad I = I_\text{max}\cos^2\theta \qquad R = Nm = \frac{\lambda_\text{ave}}{\lambda}$$

$$2d\sin\theta_\text{bright} = m\lambda\ \text{(Bragg)} \qquad n = \tan\theta_\mathrm{p} \qquad \Delta t_2 = \gamma\Delta t_1 \qquad L_2 = L_1/\gamma \qquad x' = \gamma(x - vt) \qquad p = \gamma m v$$

$$\gamma = \frac{1}{\sqrt{1-\beta^2}} \qquad \beta = \frac{v}{c} \qquad f' = f\sqrt{\frac{1\pm\beta}{1\pm\beta}} \qquad t' = \gamma\left(t - \frac{v}{c^2}x\right) \qquad K = (\gamma - 1)mc^2 \qquad E_\mathrm{R} = mc^2$$

$$E_\text{tot} = K + E_\mathrm{R} \qquad PV^\gamma = \text{constant} \qquad I \sim |E|^2 \qquad A\hat{p}\exp\{i\phi\}\exp\{i(\vec{k}\cdot\vec{r} - \omega t)\}$$