Fall 2011
Physics 123 section 2
Exam 1
Colton 2-3669 **Please write your CID here _____**

No time limit. No notes, no books. Student calculators OK.

Constants and conversión factors which you may or may not need:

$g = 9.8$ m/s^2
$G = 6.67 \times 10^{-11}$ N·m^2/kg^2
$k_B = 1.381 \times 10^{-23}$ J/K
$N_A = 6.022 \times 10^{23}$
$R = k_B \cdot N_A = 8.314$ J/mol·K
$\sigma = 5.67 \times 10^{-8}$ W/m^2·K^4
$c = 3 \times 10^8$ m/s
$m_{electron} = 9.11 \times 10^{-31}$ kg
Density of water: 1000 kg/m^3
1 inch = 2.54 cm
1 m^3 = 1000 L
1 atm = 1.013×10^5 Pa = 14.7 psi
1 eV = 1.602×10^{-19} J
$T_F = 9/5\ T_C + 32$
$T_K = T_C + 273.15$

Other equations which you may or may not need to know:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$A_{sphere} = 4\pi r^2$
$V_{sphere} = 4/3\ \pi r^3$
$(1 + x)^n \approx 1 + nx$
$\Delta L = \alpha L_0 \Delta T$, $\Delta V = \beta V_0 \Delta T$; $\beta = 3\alpha$

$$f(v) = 4\pi \left(\frac{m}{2\pi k_B T} \right)^{3/2} v^2 e^{-\frac{1}{2}mv^2/k_B T}$$

$$v_{most\ probable} = \sqrt{\frac{2k_B T}{m}}$$

$$v_{avg} = \int_0^\infty v\, f(v)\, dv = \sqrt{\frac{8k_B T}{\pi m}}$$

$$v_{rms} = \sqrt{\int_0^\infty v^2\, f(v)\, dv} = \sqrt{\frac{3k_B T}{m}}$$

Mean free path: $l = \frac{1}{\sqrt{2}\pi d^2 n}$

Ave time between collisions: $\tau = l/v_{avg}$

$$P = \frac{\Delta Q}{\Delta t} = \frac{kA\Delta T}{L} = \frac{A\Delta T}{R};\ R = L/k$$

$$P = \frac{\Delta Q}{\Delta t} = e\sigma A T^4$$

$$e_{Otto} = 1 - \frac{1}{r^{\gamma - 1}};\ r = V_{max}/V_{min}$$

$S = k_B \ln W$

$$\#\,microstates = \binom{N}{k} = \frac{N!}{k!(N-k)!}$$

$\#\ macrostates = 2^N$

$P = \frac{1}{2} m\omega^2 A^2 v$

$$r = \frac{v_2 - v_1}{v_2 + v_1} = \frac{n_1 - n_2}{n_1 + n_2};\ t = \frac{2v_2}{v_2 + v_1} = \frac{2n_1}{n_1 + n_2}$$

$R = |r|^2$; $T = 1 - R$

$$v_{string} = \sqrt{T/\mu};\ \mu = m/L$$

$$v_{rod} = \sqrt{Y/\rho};\ Y = \frac{stress}{strain} = \frac{F/A}{\Delta L/L}$$

$$v_{sound} = \sqrt{B/\rho}$$

$$v_{sound} = 343 \frac{\text{m}}{\text{s}} \sqrt{\frac{T}{293\text{K}}}$$

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

$$f' = f\, \frac{v \pm v_o}{v \pm v_s}$$

$\sin\theta = 1/\text{Mach}\#$

$\Delta x \Delta k \geq \frac{1}{2}$; $\Delta x \Delta p \geq \hbar/2$

$\Delta t \Delta \omega \geq \frac{1}{2}$; $\Delta t \Delta E \geq \hbar/2$

$$f(x) = a_0 + \sum_{n=1}^{\infty} a_n \cos\left(\frac{2\pi n x}{L} \right) + \sum_{n=1}^{\infty} b_n \sin\left(\frac{2\pi n x}{L} \right)$$

$$a_0 = \frac{1}{L} \int_0^L f(x) dx$$

$$a_n = \frac{2}{L} \int_0^L f(x) \cos\left(\frac{2\pi n x}{L} \right) dx$$

$$b_n = \frac{2}{L} \int_0^L f(x) \sin\left(\frac{2\pi n x}{L} \right) dx$$

musical half step: $f_2/f_1 = 2^{1/12}$

$\theta_{\text{Brewster}} = \tan^{-1}(\theta_1/\theta_2)$
$f = R/2$

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$

(R_1 = pos, R_2 = neg if convex-convex)

$$\frac{n_1}{p} + \frac{n_2}{q} = \frac{n_2 - n_1}{R}$$

(p = pos if object in front of surface, q = pos if image in back of surface, R = pos if center of curvature in back of surface)

$\phi = 2\pi \Delta PL/\lambda$
$\Delta PL = d\sin\theta$
$E = E_0\,(e^{i\phi 1} + e^{i\phi 2} + \ldots)$
$I \sim |E|^2$

2 narrow slit: $I = I_0 \cos^2\left(\frac{2\pi}{\lambda} \frac{d}{2} \sin\theta \right)$

1 wide slit: $I = I_0 \text{sinc}^2\left(\frac{\pi a \sin\theta}{\lambda} \right)$

circular: $\theta_{\text{min.resolve}} = 1.22\lambda/D$
grating: $R = \lambda_{ave}/\Delta\lambda = \#\text{slits} \times m$
Bragg: $2d\sin\theta_{\text{bright}} = m\lambda$ (θ from horizontal)

$$f' = f \sqrt{\frac{1 \pm \beta}{1 \mp \beta}}$$

$$x_{\text{frame}\,2} = \gamma x_{\text{frame}\,1} \pm \gamma\beta (ct)_{\text{frame}\,1}$$

$$(ct)_{\text{frame}\,2} = \pm\gamma\beta x_{\text{frame}\,1} + \gamma (ct)_{\text{frame}\,1}$$

$$\begin{pmatrix} x \\ ct \end{pmatrix}_{\text{frame}\,2} = \begin{pmatrix} \gamma & \pm\gamma\beta \\ \pm\gamma\beta & \gamma \end{pmatrix} \begin{pmatrix} x \\ ct \end{pmatrix}_{\text{frame}\,1}$$

$E^2 = (pc)^2 + (mc^2)^2$; $E = pc$
$1/p'_{photon} - 1/p_{photon} = 2/(m_{electron} c)$

Scores: (for grader to fill in). **100 total points.**

Problem 1 _____
Problem 2 _____
Problem 3 _____
Problem 4 _____
Problem 5 _____
Problem 6 _____
Problem 7 _____
Problem 8 _____
Problem 9 _____
Extra Credit _____
Total _____