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

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

$$\vec{\boldsymbol{x}} = \frac{1}{2}\left(\vec{\boldsymbol{v}}_{\boldsymbol{0}} + \vec{\boldsymbol{v}}\right) t$$

$$v^2 = v_0^2 + 2ad$$

$$R = \frac{v_0^2 \sin(2\theta)}{g} = \frac{2v_0^2 \sin(\theta)\cos(\theta)}{g}$$

$$g = 9.8\,\frac{\mathrm{m}}{\mathrm{s}^2} = 32\,\mathrm{ft/s^2}$$

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

$$F = G\frac{Mm}{r^2}$$

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

$$M_E = 5.98 \times 10^{24}\,\mathrm{kg}$$

$$M_m = 7.35 \times 10^{22}\,\mathrm{kg}$$

$$R_E = 6.38 \times 10^{6}\,\mathrm{m}$$

$$R_m = 1.74 \times 10^{6}\,\mathrm{m}$$

$$R_{E-m} = 3.85 \times 10^{8}\,\mathrm{m}$$

$$\text{apparent weight} = mg + ma$$

$$F_{fs} \leq \mu_s F_N$$

$$F_{fk} = \mu_k F_N$$

$$a_c = \frac{v^2}{r}$$

$$a_c = \omega^2 r$$

$$v = \frac{2\pi r}{T}$$

$$\left(\frac{T_1}{T_2}\right)^2 = \left(\frac{r_1}{r_2}\right)^3$$

$$T = \frac{2\pi r^{3/2}}{\sqrt{GM}}$$

$$v = \sqrt{\frac{GM}{r}}$$

$$W = Fd\cos(\theta)$$

$$GPE = mgh$$

$$GPE = -G\frac{Mm}{r}$$

$$KE = \frac{1}{2}mv^2$$

$$SPE = \frac{1}{2}kx^2$$

$$\vec{\boldsymbol{F}} = -k\vec{\boldsymbol{x}}$$

$$GPE_i + KE_i + RKE_i + SPE_i + W_{nc}$$
$$= GPE_f + KE_f + RKE_f + SPE_f$$

$$W_{net} = \Delta\left(KE\right)$$

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

$$P = Fv\cos(\theta)$$

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

$$\Delta\vec{\boldsymbol{p}} = \vec{\boldsymbol{F}}\Delta t$$

$$x_{cm} = \frac{\sum m_i x_i}{\sum m_i}$$

$$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\theta = \frac{1}{2}\left(\omega + \omega_0\right) t$$

$$\omega = \omega_0 + \alpha t$$

$$\omega^2 = \omega_0^2 + 2\alpha\left(\theta - \theta_0\right)$$

$$x = r\theta$$

$$v = r\omega$$

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

$$\tau = rF\sin(\theta)$$

$$\sum \tau = I\alpha$$

$$L = rp\sin(\theta) = I\omega$$

$$RKE = \frac{1}{2}I\omega^2$$

$$W = \tau\theta$$

$$\sum \tau = \frac{\Delta L}{\Delta t}$$

$$x_{cm} = \frac{\sum_i m_i x_i}{\sum_i m_i}$$

$$I_{hoop} = mr^2$$

$$I_{disk} = \frac{1}{2}mr^2$$

$$I_{thinrod} = \frac{1}{12}mL^2$$

$$I_{solidsphere} = \frac{2}{5}mr^2$$

$$I_{hollowsphere} = \frac{2}{3}mr^2$$

$$\frac{F}{A} = Y\frac{\Delta L}{L_0}$$

$$\frac{F}{A} = S\frac{\Delta x}{L_0}$$

$$\frac{F}{A} = -B\frac{\Delta V}{V_0}$$

$$x(t) = A\cos(\omega t)$$

$$v(t) = -A\omega\sin(\omega t)$$

$$a(t) = -A\omega^2\cos(\omega t)$$

$$\omega = \sqrt{\frac{k}{m}}$$

$$\omega = \sqrt{\frac{g}{l}}$$

$$\omega = \sqrt{\frac{mgL}{I}}$$

$$f = \frac{1}{T}$$

$$\omega = 2\pi f$$

$$F_{\mathrm{drag}} = b_1 v$$

$$F_{\mathrm{drag}} = b_2 v^2$$

$$b_1 = 6\pi\eta r$$

$$\eta_{\mathrm{glycerin}} = 1.5\,\mathrm{Pa\,s}$$

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

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

$$P_2 = P_1 + \rho gh$$

$$\Delta P_1 = \Delta P_2$$

$$F_B = W_{\mathrm{fluid}} = \rho V_{\mathrm{displaced}} g$$

$$\rho_1 A_1 v_1 = \rho_2 A_2 v_2$$

$$Q = Av$$

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

$$F = \eta A\frac{v}{y}$$

$$Q = \frac{\pi r^4 (P_1 - P_2)}{8\eta L}$$

$$\gamma = \frac{F}{L}$$

$$\rho_{H_2O} = 1000\,\frac{\text{kg}}{\text{m}^3}$$

$$P_{\text{atm}} = 1.013 \times 10^5\ \text{Pa}$$

$$T_K = T_C + 273.15$$

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

$$\Delta V = \beta V_0 \Delta T$$

$$Q = cm\Delta T$$

$$Q = mL$$

$$Q = \frac{(kA\Delta T)t}{L}$$

$$Q = e\sigma T^4 A t$$

$$\sigma = 5.67 \times 10^{-8}\,\frac{\text{J}}{\text{s}\,\text{m}^2\,\text{K}^4}$$

$$P_{net} = e\sigma A(T^4 - T_{env}^4)$$

$$n = \frac{N}{N_A} = \frac{m}{\text{mass per mole}}$$

$$N_A = 6.022\text{e}23$$

$$PV = nRT$$

$$R = 8.31\,\frac{\text{J}}{\text{mol}\,\text{K}}$$

$$PV = Nk_BT$$

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

$$P_iV_i = P_fV_f$$

$$\frac{V_i}{T_i} = \frac{V_f}{T_f}$$

$$\overline{KE}_1 = \frac{1}{2}mv_{rms}^2 = \frac{3}{2}k_BT$$

$$U_{mono} = \frac{3}{2}nRT$$

$$U_{dia} = \frac{5}{2}nRT$$

$$m = \frac{(DA\Delta C)t}{L}$$

$$\Delta U = Q - W_{\text{by}}$$

$$W = P\Delta V$$

$$W = nRT\ln\left(\frac{V_f}{V_i}\right)$$

$$|W| = |Q_H| - |Q_C|$$

$$e = \frac{|W|}{|Q_H|}$$

$$e = 1 - \frac{T_C}{T_H}$$

$$COP = \frac{|Q_C|}{|W|}$$

$$COP = \frac{T_C}{T_H - T_C}$$

$$COP = PF = \frac{|Q_H|}{|W|}$$

$$COP = PF = \frac{T_H}{T_H - T_C}$$

$$\Delta S = \frac{Q}{T}$$

$$W_{\text{unavailable}} = T_{\text{min}}(\Delta S)_{\text{universe}}$$

$$P_iV_i^\gamma = P_fV_f^\gamma$$

$$Q = nC\Delta T$$

$$C_V = \frac{3}{2}R$$

$$C_P = \frac{5}{2}R$$

$$C_P - C_V = R$$

$$\frac{C_P}{C_V} = \gamma$$

$$v = f\lambda$$

$$v = \sqrt{\frac{F_T}{m/L}}$$

$$v = 343\,\frac{\text{m}}{\text{s}} + 0.6\,\frac{\text{m}}{\text{s}\,^\circ\text{C}}\,(T - 20\,^\circ\text{C})$$

$$v = 331\,\frac{\text{m}}{\text{s}} + 0.6\,\frac{\text{m}}{\text{s}\,^\circ\text{C}}T$$

$$v = \sqrt{\frac{\gamma k_B T}{m}}$$

$$v = \sqrt{\frac{B_{ad}}{\rho}}$$

$$v = \sqrt{\frac{Y}{\rho}}$$

$$I = \frac{P}{A}$$

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

$$\beta_2 - \beta_1 = 10\,\text{dB}\log\left(\frac{I_2}{I_1}\right)$$

$$I_0 = 10 \times 10^{-12}\,\frac{\text{W}}{\text{m}^2}$$

$$y = A\sin\left(2\pi ft \pm \frac{2\pi x}{\lambda}\right)$$

$$\frac{f_O}{f_E} = \frac{v_s \pm v_O}{v_s \pm v_E}$$

$$f_n = n\frac{v}{2L}$$

$$f_n = n\frac{v}{4L}$$

$$L = L_0 + n0.3D$$

$$f = |f_1 - f_2|$$

$$\frac{|L_1 - L_2|}{\lambda_n} = m + \begin{cases} 0 \\ \frac{1}{2} \end{cases}$$

$$|L_1 - L_2| = 2t$$

$$|L_1 - L_2| = d\sin(\theta)$$

use $\frac{1}{2}$ if odd number true

- destructive
- single slit
- $n_2 > n_1$ per interface
- sources out of phase

$$n = \frac{c}{v}$$

$$c = 3.00 \times 10^8 \, \frac{\mathrm{m}}{\mathrm{s}}$$

$$n_{inc} \sin(\theta_{inc}) = n_{refr} \sin(\theta_{refr})$$

$$\theta_{inc} = \theta_{refl}$$

$$|f| = \frac{R}{2}$$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$M = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

$$\tan(\theta_P) = \frac{n_{refr}}{n_{inc}}$$

$$\frac{1}{f} = \frac{n_{lens} - n_{env}}{n_{env}} \left[\frac{1}{r_1} - \frac{1}{r_2} \right]$$

r_1 is radius of side closest to object; r's are positive for convex surfaces from perspective of object

$$F = k\frac{q_1 q_2}{r^2}$$

$$\vec{\boldsymbol{E}} = \frac{\vec{\boldsymbol{F}}}{q}$$

$$E = k\frac{q}{r^2}$$

$$EPE = U = k\frac{q_1 q_2}{r}$$

$$V = k\frac{q}{r}$$

$$\vec{\boldsymbol{F}} = q\vec{\boldsymbol{E}}$$

$$U = qV$$

$$E = -\frac{\Delta V}{d}$$

$$F = -\frac{\Delta U}{d}$$

$$e = 1.6 \times 10^{-19} \, \mathrm{C}$$

$$k = 8.99 \times 10^9 \, \frac{\mathrm{N\,m^2}}{\mathrm{C^2}}$$

$$\epsilon_0 = 8.85 \times 10^{-12} \, \frac{\mathrm{C^2}}{\mathrm{N\,m^2}}$$

$$m_e = 9.11 \times 10^{-31} \, \mathrm{kg}$$

$$m_p = 1.67 \times 10^{-27} \, \mathrm{kg}$$

$$\sum E_\perp A = \frac{q_{encl}}{\epsilon_0}$$

$$\Phi = E_\perp A$$

$$E = \frac{\sigma}{2\epsilon_0} = \frac{q/A}{2\epsilon_0}$$

$$C = \frac{q}{V}$$

$$C = K\epsilon_0 \frac{A}{d}$$

$$R = \rho\frac{L}{A}$$

$$\rho = \rho_0 \left[1 + \alpha \left(T - T_0\right)\right]$$

$$R = R_1 + R_2$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$C = C_1 + C_2$$

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$U = EPE = \frac{1}{2}qV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{q^2}{C}$$

$$u = \frac{1}{2}\epsilon_0 E^2$$

$$I = \frac{\Delta q}{\Delta t}$$

$$I = \frac{dq}{dt}$$

$$V = IR$$

$$P = I^2 R = IV = \frac{V^2}{R}$$

$$F = qvB \sin(\theta)$$

$$F = ILB \sin(\theta)$$

$$\sum B_\parallel \Delta l = \mu_0 I$$

$$\oint \vec{\boldsymbol{B}} \cdot d\vec{\boldsymbol{s}} = \mu_0 I$$

$$B = \mu_0 \frac{I}{2\pi r}$$

$$B = \mu_0 \frac{NI}{2r}$$

$$B = \mu_0 \frac{N}{L} I$$

$$\mu_0 = 4\pi \times 10^{-7} \frac{\mathrm{T\,m}}{\mathrm{A}}$$

$$\Phi_B = BA\cos(\theta)$$

$$\mathcal{E} = -\frac{d\Phi_B}{dt}$$

$$\mathcal{E} = -\frac{\Delta\Phi_B}{\Delta t}$$

$$\mathcal{E} = BLv$$

$$\mathcal{E} = NAB\omega \sin(\omega t)$$

$$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$$

$$\mathcal{E}_2 = -\mathcal{M}\frac{dI_1}{dt}$$

$$\mathcal{E} = -\mathcal{L}\frac{dI}{dt}$$

$$\mathcal{E}_2 = -\mathcal{M}\frac{\Delta I_1}{\Delta t}$$

$$\mathcal{E} = -\mathcal{L}\frac{\Delta I}{\Delta t}$$

$$\tau = NIAB \sin(\phi)$$

$$IR = V - \mathcal{E}$$

$$\Delta W = \mathcal{L}I\left(\Delta I\right)$$

$$U = \frac{1}{2}\mathcal{L}I^2$$

$$u = \frac{1}{2}\frac{B^2}{\mu_0}$$

$$I = I_{max} e^{-\frac{t}{RC}}$$

$$V_R = V_{max} e^{-\frac{t}{RC}}$$

$$V_C = V_{max} e^{-\frac{t}{RC}}$$

$$V_C = V_{max}\left(1 - e^{-\frac{t}{RC}}\right)$$

$$I = I_{max}\left(1 - e^{-\frac{tR}{\mathcal{L}}}\right)$$

$$I = I_{max} e^{-\frac{tR}{\mathcal{L}}}$$

$$V_R = V_{max}\left(1 - e^{-\frac{tR}{\mathcal{L}}}\right)$$

$$V_R = V_{max} e^{-\frac{tR}{\mathcal{L}}}$$

$$V_{\mathcal{L}} = V_{max} e^{-\frac{tR}{\mathcal{L}}}$$

$$\sqrt{2}V_{rms} = V_{peak}$$

$$X_{\mathcal{L}} = 2\pi f\mathcal{L}$$

$$X_C = \frac{1}{2\pi fC}$$

$$Z = \sqrt{R^2 + (X_{\mathcal{L}} - X_C)^2}$$

$$\tan(\phi) = \frac{X_{\mathcal{L}} - X_C}{R}$$

$$\cos(\phi) = \frac{R}{Z}$$

$$\overline{P} = I_{rms}V_{rms}\cos(\phi)$$

$$c = 3.00 \times 10^8 \,\frac{\mathrm{m}}{\mathrm{s}}$$

$$c = \frac{1}{\sqrt{\epsilon_0\mu_0}}$$

$$\overline{I} = \frac{E_{rms}B_{rms}}{\mu_0}$$

$$E = cB$$

$$I = \frac{P}{A}$$

$$\omega = \frac{1}{\sqrt{\mathcal{L}C}}$$

$$E = hf = pc$$

$$\lambda = \frac{h}{p}$$

$$L = \frac{nh}{2\pi}$$

$$E_n = -13.6\,\mathrm{eV}\frac{Z^2}{n^2}$$

$$hf = KE + W_0$$

$$\lambda_p T = 2.90 \times 10^{-3}\,\mathrm{m\,K}$$

$$\lambda' = \lambda + \frac{h}{mc}\left(1 - \cos(\phi)\right)$$

$$N = N_0 e^{-\lambda t}$$

$$Q = \left(\sum m_{in} - m_{out}\right)c^2$$

T ?? Ch ?? AP Phys – Dr. Horner 2013-14 **NAME**____________________________

Directions: Show as much detail as possible (including among other things symbolic forms of equations you use, an explicit choice for the coordinate system and positive directions, and diagrams where relevant). Place final answers in a box and be sure your presentation is in a clear, logical format. In order to be correct, final answers must include correct units.

- (graphing) calculator: yes
- open book: no
- open notes: no
- equation sheet: provided
- duration of whole test: 40 min

1)

(**a**)

(**b**)