PHYSICS 101B

MIDTERM I

PUT YOUR NAME ON THE EXAM RIGHT AWAY!

PLEASE SHOW ALL OF YOUR WORK. You may use the back of the page if necessary. Please clearly mark all problems for which you have information on the back of the page that you would like to be considered during the grading of the exam.

EQUATIONS AND FORMULAE

$x' = x - vt;\ y' = y;\ z' = z$

$ct' = \gamma(ct - \beta x);\ x' = \gamma(x - \beta ct)$

$\beta = v/c$

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

$\Delta t = \gamma \Delta t'$

$L = L_P/\gamma$

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

$\Delta\tau = \Delta s/c$

$u'_x = (u_x - v)/[1 - (vu_x/c^2)]$

$u'_y = u_y/\gamma[1 - (vu_x/c^2)]$

$u'_z = u_z/\gamma[1 - (vu_x/c^2)]$

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

$E = \gamma mc^2$

$E'/c = \gamma(E/c - \beta p_x);\ p'_x = \gamma(p_x - \beta E/c)$

$p = (E/c, p_x, p_y, p_z)$

$M = |p|/c;\ |p|^2 = (E/c)^2 - p_x^2 - p_y^2 - p_z^2$

$E^2 = (mc^2)^2 + (pc)^2$

$pc = \beta E$

$\nu = c/\lambda$

$E = h\nu$

$R = \sigma T^4;\quad \sigma = 5.67 \times 10^{-8}\ \mathrm{W/m^2\text{-}K^4}$

$\lambda_{max}T = 2.898 \times 10^{-3}$ m-K

$n(\lambda) = 8\pi\lambda^{-4}$

$\overline{E} = kT$

$u(\lambda) = \frac{8\pi hc\lambda^{-5}}{\exp(hc/\lambda kT)-1}$

$\overline{E} = \frac{h\nu}{\exp(hc/\lambda kT)-1}$

$eV_{stop} = h\nu - \phi$

$\lambda_2 - \lambda_1 = \lambda_c(1-\cos\theta)$

$\lambda_c = 2.43 \times 10^{-12}$ m

$b = \frac{kzZe^2}{2E_k}\cot\frac{\theta}{2}$

$\Delta N = \frac{I_0 A_{sc} nt}{r^2}\frac{kzZe^2}{4E_k}^2\frac{1}{\sin^4(\theta/2)}$

$d\Omega = \sin\theta\, d\theta\, d\phi$

$\frac{d\sigma}{d\Omega} = \frac{kzZe^2}{4E_k}^2\frac{1}{\sin^4(\theta/2)}$

$r_d = \frac{kzZe^2}{E_k}$

$U_E = \frac{kq_1q_2}{r}$

$E_n = -hcR\frac{Z^2}{n^2}$

$\frac{1}{\lambda_{Nn}} = Z^2R\left(\frac{1}{N^2} - \frac{1}{n^2}\right)$

$\mu = \frac{mM}{m+M}$

$L = n\hbar$

$\sqrt{\nu} = A_n(Z-b)$

$\lambda = h/p$

$\omega = 2\pi\nu = E/\hbar$

$n\lambda = D\sin\theta$

$\lambda = h/\sqrt{2mE_k}$

$p = \hbar k$

$KE = p^2/2m$

$v = \omega/k$

$v_g = d\omega/dk$

$\Delta x\Delta p_x \geq \hbar/2$

$\Delta t\Delta E \geq \hbar/2$

$P(x) = |\psi(x,t)|^2$

$\int P(x)dx = 1$

$\Delta x^2 = \sum(x-\bar{x})^2/N$

$\phi(t) = \exp(-i\omega t)$

$$-\frac{\hbar^2}{2m}\frac{\partial^2\psi(x,t)}{\partial x^2} + V(x,t)\psi(x,t) = i\hbar\frac{\partial\psi(x,t)}{\partial t}$$

$$-\frac{\hbar^2}{2m}\frac{d^2\psi(x)}{dx^2} + V(x)\psi(x) = E\psi(x)$$

$k = \frac{\sqrt{2m(E-V)}}{\hbar}$

$K = \frac{\sqrt{2m(V-E)}}{\hbar}$

$E_n = (h^2n^2)/(8mL^2)$

$\psi_n(x) = \sqrt{2/L}\sin(n\pi x/L)$

$\langle O\rangle = \int\psi(x)^*O\psi(x)dx$

$p_x^{op} = \frac{\hbar}{i}\frac{\partial}{\partial x}$

$V(x) = (1/2)m\omega^2x^2$

$\psi_{nm}(x_1,x_2) = \psi_n(x_1)\psi_m(x_2)$

$E_{n_1n_2n_3} = \frac{h^2}{8mL^2}(n_1^2+n_2^2+n_3^2)$

$-\frac{\hbar^2}{2\mu}\nabla^2\psi + V\psi = E\psi$

$\nabla^2 = \frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}+\frac{\partial^2}{\partial z^2}$

$\nabla^2 = \frac{1}{r^2}\frac{\partial}{\partial r}(r^2\frac{\partial}{\partial r}) - L_{op}^2/\hbar^2$

$L_{op}^2 = -\hbar^2[\frac{1}{\sin\theta}\frac{\partial}{\partial\theta}(\sin\theta\frac{\partial}{\partial\theta}) + \frac{1}{\sin^2\theta}\frac{\partial^2}{\partial\phi^2}]$

$L_z^{op} = -i\hbar\frac{\partial}{\partial\phi}$

$f_{lm}(\theta) = \sin\theta^{|m|}\frac{d^{|m|}P_l(\theta)}{d\cos\theta^{|m|}}$

$P_l(\theta) = (\frac{d}{d\cos\theta})^l(\cos^2\theta-1)^l$

$Y_{lm}(\theta,\phi) = C_{lm}f_{lm}(\theta)g_m(\phi)$ and $g_m(\phi) = e^{im\phi}$

$R(r) = r^lL_{nl}(\frac{2r}{na_0})e^{-r/(na_0)}$

$L_{nl}(\rho) = (\frac{d}{d\rho})^{2l+1}[e^\rho(\frac{d}{d\rho})^{n+l}(\rho^{n+l}e^{-\rho})]$

$E_n = -\frac{Z^2E_1}{n^2}$

$E_1 = \frac{k^2e^4\mu}{2\hbar^2} \simeq 13.6$ eV

$\int_0^\infty x^ne^{-x}dx = n!$

Let $I_n = \int_0^{+\infty}x^ne^{-\lambda x^2}dx$

$I_0 = \frac{1}{2}\sqrt{\frac{\pi}{\lambda}}\quad I_1 = \frac{1}{2\lambda}$

$I_2 = \frac{1}{4}\sqrt{\frac{\pi}{\lambda^3}}\quad I_3 = \frac{1}{2\lambda^2}$

$I_4 = \frac{3}{8}\sqrt{\frac{\pi}{\lambda^5}}\quad I_5 = \frac{1}{\lambda^3}$

c $= 2.998\times10^8$ m/s

$\hbar = h/2\pi$

$\hbar = 1.054\times10^{-34}$ J-s $= 6.582\times10^{-16}$ eV-s

$h = 6.626\times10^{-34}$ J-s

$hc = 1240$ eV-nm

$k = 1.381\times10^{-23}$ J/K $= 8.617\times10^{-5}$ eV/K

$e = 1.602\times10^{-19}$ C

There are 1.602×10^{-19} J per eV

$m_e = 5.110\times10^5$ eV/c^2 $= 9.109\times10^{-31}$ kg

$a_0 = \bar{h}^2/mke^2 = 0.0529$ nm

$R_\infty = 1.097\times10^7$ m^{-1}

$k = 8.99\times10^9$ N-m^2/C^2 (electrostatic constant)

$G(x;\sigma) = 1/(\sqrt{2\pi}\sigma)*\exp[-1/2(x^2/\sigma^2)]$

$e^{i\phi} = \cos\phi + i\sin\phi$