

PHYS-201 Equation Sheet for Final Exam
(12/14/2012, MAIN AUDITORIUM, 08:00 AM - 10:00 AM)

Periodic Motion

$$\begin{array}{ll} F_x = -kx & x(t) = A \cos(\omega t + \Phi) \\ \omega = \sqrt{\frac{k}{m}} & T = \frac{2\pi}{\omega} = \frac{1}{f} \\ E = K + U & E = \frac{1}{2}mv^2 + \frac{1}{2}kx^2 = \frac{1}{2}kA^2 \\ \omega = \sqrt{\frac{g}{L}} & \omega = \sqrt{\frac{mgd}{I}} \\ x(t) = A \exp\left(-\frac{bt}{2m}\right) \cos(\omega t + \Phi) & \omega = \sqrt{\frac{k}{m} - \left(\frac{b}{2m}\right)^2} \end{array}$$

Mechanical Waves

Note that F is a tension in a string.

$$\begin{array}{ll} y(x, t) = A \cos(kx - \omega t) & k = \frac{2\pi}{\lambda} \\ \omega = \frac{2\pi}{T} = 2\pi f & v = \frac{\omega}{k} = \lambda f \\ v = \sqrt{\frac{F}{\mu}} & P_{av} = \frac{1}{2}\mu\omega^2 A^2 v = \frac{1}{2}\sqrt{F\mu}\omega^2 A^2 \\ f_n = \frac{n}{2L} \sqrt{\frac{F}{\mu}} & (n = 1, 2, 3, \dots) \\ f_n = n \frac{v}{2L} & (n = 1, 2, 3, \dots) \end{array}$$

Sound Waves

$$\begin{aligned}
 y(x, t) &= A \cos(kx - \omega t) & p(x, t) &= -B \frac{\partial y(x, t)}{\partial x} \\
 p_{max} &= BkA & v &= \sqrt{\frac{B}{\rho}} \\
 I &= \frac{1}{2} B \omega k A^2 = \frac{1}{2} \sqrt{\rho B} \omega^2 A^2 & I &= \frac{p_{max}^2}{2\rho v} = \frac{p_{max}^2}{2\sqrt{\rho B}} \\
 f_n &= n \frac{v}{2L} & & (n = 1, 2, 3, \dots) \\
 f_n &= n \frac{v}{4L} & & (n = 1, 3, 5, \dots)
 \end{aligned}$$

Electromagnetic Waves

$$\begin{aligned}
 \oint \vec{E} \cdot d\vec{A} &= \frac{q}{\epsilon_0} & \oint \vec{B} \cdot d\vec{A} &= 0 \\
 \oint \vec{E} \cdot d\vec{s} &= -\frac{d\Phi_B}{dt} & \oint \vec{B} \cdot d\vec{s} &= \mu_0 I + \epsilon_0 \mu_0 \frac{d\Phi_E}{dt} \\
 \vec{F} &= q\vec{E} + q\vec{v} \times \vec{B} & \omega &= \frac{1}{\sqrt{LC}} \\
 \frac{E}{B} &= c & c &= \frac{1}{\sqrt{\epsilon_0 \mu_0}} \\
 c &= \lambda f & f' &= f \sqrt{\frac{c+v}{c-v}} \\
 \vec{S} &= \frac{1}{\mu_0} \vec{E} \times \vec{B} & u &= \frac{U}{V} = \epsilon_0 E^2 = \frac{B^2}{\mu_0} \\
 p &= \frac{U}{c} & & \text{radiation momentum} \\
 I &= S_{avg} = cu_{avg} & P_{rad} &= \frac{(2)S_{avg}}{c} = \frac{(2)I}{c} \\
 \epsilon_0 &= 8.85 \times 10^{-12} \text{ As/Vm} & \mu_0 &= 4\pi \times 10^{-7} \text{ Vs/Am}
 \end{aligned}$$

Interference on Thin Films

$$2nt = (m + \frac{1}{2})\lambda \quad 2nt = m\lambda$$

Diffraction on a Single Slit or Circular Apertures

$$\begin{aligned} \sin \theta_{dark} &= m \frac{\lambda}{a} & (m = \pm 1, \pm 2, \pm 3, \dots) \\ \theta_{min} &= \frac{\lambda}{a} & \theta_{min} = 1.22 \frac{\lambda}{D} \end{aligned}$$

Diffraction—Interference on Double & Multiple Slits

$$\begin{aligned} \delta &= d \sin \theta_{bright} = m\lambda & (m = 0, \pm 1, \pm 2, \dots) \\ \delta &= d \sin \theta_{dark} = (m + \frac{1}{2})\lambda & (m = 0, \pm 1, \pm 2, \dots) \\ y_{bright} &= L \tan \theta_{bright} & y_{dark} = L \tan \theta_{dark} \end{aligned}$$

Blackbody Radiation

$$\begin{aligned} \mathcal{P} &= \sigma AT^4 & \sigma &= 5.7 \times 10^{-8} \text{Wm}^{-2}\text{K}^{-4} \\ \lambda_{max}T &= 2.898 \times 10^{-3} \text{m} \cdot \text{K} & E_n &= nhf \\ R(\lambda, T) &= \frac{2\pi hc^2}{\lambda^5 [\exp(hc/\lambda k_B T) - 1]} & h &= 6.626 \times 10^{-34} \text{J} \cdot \text{s} \end{aligned}$$

Photoelectric Effect

$$\begin{aligned} K_{max} &= hf - \Phi = e\Delta V_S & \lambda_c &= \frac{c}{f_c} = \frac{hc}{\Phi} \\ e &= 1.602 \times 10^{-19} \text{As} & hc &= 1240 \text{eV} \cdot \text{nm} \\ \hbar &= \frac{h}{2\pi} = 1.055 \times 10^{-34} \text{J} \cdot \text{s} & c &= 2.998 \times 10^8 \text{ms}^{-1} \\ 1 \text{ eV} &= 1.602 \times 10^{-19} \text{J} \end{aligned}$$

Discrete Spectra of Atomic Gases: Rydberg Formula

$$\frac{1}{\lambda} = R_H \left(\frac{1}{2^2} - \frac{1}{n^2} \right) \quad (n = 3, 4, 5, \dots) \quad R_H = 1.097 \times 10^7 \text{m}^{-1}$$
$$E_i - E_f = hf$$

Bohr Model of the Hydrogen Atom

$$E = V + K = -\frac{k_e e^2}{2r} \quad m_e v_n r_n = n\hbar \quad (n = 1, 2, 3, \dots)$$
$$r_n = n^2 a_0 \quad E_n = -\frac{k_e e^2}{2a_0 n^2} \quad (n = 1, 2, 3, \dots)$$
$$k_e = \frac{1}{4\pi\epsilon_0} = 8.988 \times 10^9 \text{N} \cdot \text{m}^2 (\text{As})^{-2} \quad e = 1.602 \times 10^{-19} \text{As}$$
$$a_0 = \frac{\hbar^2}{m_e k_e e^2} = 5.292 \times 10^{-11} \text{m} \quad m_e = 9.109 \times 10^{-31} \text{kg} = 0.511 \text{MeV} \cdot c^{-2}$$
$$\frac{1}{\lambda} = R_H \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right) \quad (n_f = 1 : \text{Lyman}, 2 : \text{Balmer}, 3 : \text{Paschen})$$

Compton Effect; De Broglie Waves; Uncertainty Principle

$$\lambda' - \lambda_0 = \frac{h}{m_e c} (1 - \cos \theta) \quad \lambda_C = \frac{h}{m_e c} = 0.00243 \text{nm}$$
$$\lambda = \frac{h}{p} = \frac{h}{mv}$$
$$v_{\text{phase}} = \frac{\omega}{k} \quad v_g = \frac{d\omega}{dk} = \frac{dE}{dp}$$
$$\Delta x \cdot \Delta p_x \geq \frac{\hbar}{2} \quad \Delta E \cdot \Delta t \geq \frac{\hbar}{2}$$

Wave Function

$$\int_{-\infty}^{+\infty} |\psi(x)|^2 dx = 1 \quad P_{ab} = \int_a^b |\psi(x)|^2 dx$$
$$\langle x \rangle = \int_{-\infty}^{+\infty} \psi^*(x) x \psi(x) dx \quad \langle f(x) \rangle = \int_{-\infty}^{+\infty} \psi^*(x) f(x) \psi(x) dx$$

Particle in a Box; Schrödinger Equation; Tunneling

$$\psi_n(x) = A \sin(k_n x) = A \sin\left(\frac{n\pi x}{L}\right) \quad E_n = \frac{p_n^2}{2m} = \frac{\hbar^2}{2m\lambda_n^2} = \frac{n^2\hbar^2}{8mL^2}$$

$$-\frac{\hbar^2}{2m} \frac{d^2\psi}{dx^2} + U\psi = E\psi$$

$$T \approx 16 \frac{E}{U} \left(1 - \frac{E}{U}\right) \exp^{-2CL} \quad C = \frac{\sqrt{2m(U-E)}}{\hbar}$$

Special Theory of Relativity

$$\Delta t = \frac{\Delta t_p}{\sqrt{1 - \frac{v^2}{c^2}}} = \gamma \Delta t_p \quad L = L_p \left(1 - \frac{v^2}{c^2}\right)^{1/2} = \frac{L_p}{\gamma}$$

$$x' = \gamma(x - vt) \quad x = \gamma(x' + vt')$$

$$y' = y \quad y = y'$$

$$z' = z \quad z = z'$$

$$t' = \gamma\left(t - \frac{vx}{c^2}\right) \quad t = \gamma\left(t' + \frac{vx'}{c^2}\right)$$

$$u'_x = \frac{u_x - v}{1 - \frac{u_x v}{c^2}} \quad u_x = \frac{u'_x + v}{1 + \frac{u'_x v}{c^2}}$$

$$u'_y = \frac{u_y}{\gamma\left(1 - \frac{u_x v}{c^2}\right)} \quad u_y = \frac{u'_y}{\gamma\left(1 + \frac{u'_x v}{c^2}\right)}$$

$$u'_z = \frac{u_z}{\gamma\left(1 - \frac{u_x v}{c^2}\right)} \quad u_z = \frac{u'_z}{\gamma\left(1 + \frac{u'_x v}{c^2}\right)}$$

$$\vec{p} = \frac{m\vec{u}}{\sqrt{1 - \frac{u^2}{c^2}}} = \gamma m\vec{u} \quad E = E_R + K$$

$$E_R = mc^2 \quad K = (\gamma - 1)mc^2$$

$$E = \gamma mc^2 \quad E^2 = p^2 c^2 + (mc^2)^2$$