PHYS-201 Equation Sheet for Final Exam
(17 March 2010, Disque 108, 13:00-15:00 AM)

Simple Harmonic Oscillator; Simple and Physical Pendulum

$$F_S = -kx \qquad x(t) = A\cos(\omega t + \Phi)$$

$$\omega = \sqrt{\frac{k}{m}} \qquad T = \frac{2\pi}{\omega} = \frac{1}{f}$$

$$E = K + U \qquad E = \frac{1}{2}mv^2 + \frac{1}{2}kx^2 = \frac{1}{2}kA^2$$

$$\omega = \sqrt{\frac{g}{L}} \qquad \omega = \sqrt{\frac{mgd}{I}}$$

Damped Harmonic Oscillator

$$x(t) = A\exp\left(-\frac{bt}{2m}\right)\cos(\omega t + \Phi) \qquad \omega = \sqrt{\frac{k}{m} - \left(\frac{b}{2m}\right)^2}$$

Travelling Waves; Standing Waves in Strings and Air Columns

$$y(t) = A\sin(kx - \omega t) \qquad k = \frac{2\pi}{\lambda}$$

$$\omega = \frac{2\pi}{T} = 2\pi f \qquad v = \frac{\omega}{k} = \lambda f$$

$$v = \sqrt{\frac{T}{\mu}} \qquad \mathcal{P} = \frac{1}{2}\mu\omega^2 A^2 v$$

$$f_n = \frac{n}{2L}\sqrt{\frac{T}{\mu}} \qquad (n = 1, 2, 3, ...)$$

$$f_n = n\frac{v}{2L} \qquad (n = 1, 2, 3, ...)$$

$$f_n = n\frac{v}{4L} \qquad (n = 1, 3, 5, ...)$$

Maxwell Equations

$$\oint \vec{\mathbf{E}} \cdot d\vec{\mathbf{A}} = \frac{q}{\varepsilon_0} \qquad \oint \vec{\mathbf{B}} \cdot d\vec{\mathbf{A}} = 0$$

$$\oint \vec{\mathbf{E}} \cdot d\vec{\mathbf{s}} = -\frac{d\Phi_B}{dt} \qquad \oint \vec{\mathbf{B}} \cdot d\vec{\mathbf{s}} = \mu_0 I + \varepsilon_0 \mu_0 \frac{d\Phi_E}{dt}$$

$$\vec{\mathbf{F}} = q\vec{\mathbf{E}} + q\vec{\mathbf{v}} \times \vec{\mathbf{B}}$$

$$\epsilon_0 = 8.8542 \times 10^{-12}\,\mathrm{A^2 s^2 N^{-1} m^{-2}} \qquad \mu_0 = 4\pi \times 10^{-7}\,\mathrm{N\,A^{-2}}$$

Electromagnetic Waves; Poynting Vector; Radiation Pressure

$$\frac{E}{B} = c \qquad c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}$$

$$c = \lambda f \qquad f' = f\sqrt{\frac{c + v}{c - v}}$$

$$\vec{\mathbf{S}} = \frac{1}{\mu_0}\vec{\mathbf{E}} \times \vec{\mathbf{B}} \qquad u = \varepsilon_0 E^2 = \frac{B^2}{\mu_0}$$

$$I = S_{avg} = c u_{avg} \qquad P = \frac{S}{c}$$

Diffraction & Interference on a Double Slit or Multiple Slits

$$\delta = d \sin\theta_{bright} = m\lambda \qquad (m = 0, \pm 1, \pm 2, ...)$$

$$\delta = d \sin\theta_{dark} = (m + \frac{1}{2})\lambda \qquad (m = 0, \pm 1, \pm 2, ...)$$

$$y_{bright} = L \tan\theta_{bright} \qquad y_{dark} = L \tan\theta_{dark}$$

Diffraction & Interference on Thin Films

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

Diffraction & Resolution of Single Slit or Circular Apertures

$$\sin\theta_{dark} = m\frac{\lambda}{a} \qquad (m = \pm 1, \pm 2, \pm 3, ...)$$

$$\theta_{min} = \frac{\lambda}{a} \qquad \theta_{min} = 1.22\frac{\lambda}{D}$$

Blackbody Radiation

$$\mathcal{P} = \sigma A e T^4 \qquad \sigma = 5.7 \times 10^{-8}\mathrm{Wm^{-2}K^{-4}}$$

$$\lambda_{max}T = 2.898 \times 10^{-3}\mathrm{m \cdot K} \qquad E_n = nhf$$

$$e = 1\,(\text{emissivity of the blackbody}) \qquad h = 6.626 \times 10^{-34}\mathrm{J \cdot s}$$

Photoelectric Effect

$$K_{max} = hf - \Phi = e\Delta V_S \qquad \lambda_c = \frac{c}{f_c} = \frac{hc}{\Phi}$$

$$e = 1.602 \times 10^{-19}\,\mathrm{As} \qquad hc = 1240\mathrm{eV \cdot nm}$$

$$\hbar = \frac{h}{2\pi} = 1.055 \times 10^{-34}\mathrm{J \cdot s} \qquad c = 2.998 \times 10^{8}\mathrm{ms^{-1}}$$

$$1\ \mathrm{eV} = 1.602 \times 10^{-19}\,\mathrm{J}$$

Discrete Spectra of Atomic Gases: Rydberg Formula

$$\frac{1}{\lambda} = R_H\left(\frac{1}{2^2} - \frac{1}{n^2}\right) \quad (n = 3, 4, 5, ...) \qquad R_H = 1.097 \times 10^{7}\mathrm{m^{-1}}$$

$$E_i - E_f = hf$$

Bohr Model of the Hydrogen Atom

$$E = V + K = -\frac{k_e e^2}{2r} \qquad m_e v_n r_n = n\hbar \quad (n = 1, 2, 3, ...)$$

$$r_n = n^2 a_0 \qquad E_n = -\frac{k_e e^2}{2a_0 n^2} \quad (n = 1, 2, 3, ...)$$

$$k_e = \frac{1}{4\pi\epsilon_0} = 8.988 \times 10^9 \mathrm{N} \cdot \mathrm{m}^2 (\mathrm{As})^{-2} \qquad e = 1.602 \times 10^{-19} \mathrm{As}$$

$$a_0 = \frac{\hbar^2}{m_e k_e e^2} = 5.292 \times 10^{-11} \mathrm{m} \qquad m_e = 9.109 \times 10^{-31} kg = 0.511\,\mathrm{MeV} \cdot c^{-2}$$

$$\frac{1}{\lambda} = R_H \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right) \qquad (n_f = 1 : \mathrm{Lyman}, 2 : \mathrm{Balmer}, 3 : \mathrm{Paschen})$$

Compton Effect; De Broglie Waves; Uncertainty Principle

$$\lambda' - \lambda_0 = \frac{h}{m_e c}(1 - \cos\theta) \qquad \lambda_C = \frac{h}{m_e c} = 0.00243 \mathrm{nm}$$

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

$$v_{phase} = \frac{\omega}{k} \qquad v_g = \frac{d\omega}{dk} = \frac{dE}{dp}$$

$$\Delta x \cdot \Delta p_x \geq \frac{\hbar}{2} \qquad \Delta E \cdot \Delta t \geq \frac{\hbar}{2}$$

Wave Function

$$\int_{-\infty}^{+\infty} |\psi(x)|^2 dx = 1 \qquad P_{ab} = \int_a^b |\psi(x)|^2 dx$$

$$\langle x \rangle = \int_{-\infty}^{+\infty} \psi^*(x) x \psi(x) dx \qquad \langle f(x) \rangle = \int_{-\infty}^{+\infty} \psi^*(x) f(x) \psi(x) dx$$

Particle in a Box; Schrödinger Equation; Tunneling

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

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

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

Special Theory of Relativity

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

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

$$y' = y \qquad y = y'$$

$$z' = z \qquad z = z'$$

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

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

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

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

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

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

$$E = \gamma\, mc^2 \qquad E^2 = p^2c^2 + \left(mc^2\right)^2$$