Phys 208 – Homework (HW01) – SP13  (Due Monday, January 28, 2013)

Read/Peruse Chapter 1, Sections 1 through 15.

Problems:  1.10.10, 1.10.11, 1.13.2, 1.13.3, 1.13.4

Phys 208 – Homework (HW02) – SP13  (Due Wednesday, January 30, 2013)

Problems:  1.13.13, 1.13.19, 1.15.29, 1.15.33, 1.16.2, 1.16.13

Answers:  1.16.2  \( d_n = \frac{L}{2n} \)

Phys 208 – Homework (HW03) – SP13  (Due Friday, February 1, 2013)

Read Chapter 2, Sections 1 through 9.

HW3.1  Blackbody Radiation:  The energy per unit volume per unit of frequency is given by
\[ \rho, d\nu = \frac{8\pi\nu^2}{c^3} E_{\text{avg}} d\nu, \]
where \( \nu \) is the frequency and \( c \) is the speed of light in a vacuum.

Classically one finds \( E_{\text{avg}} = kT \), where \( k \) is the Boltzmann constant and \( T \) is the absolute temperature. Planck assumed that the radiated energy was quantized in units of \( h\nu \) so that \( E_n = n h\nu \), where \( n = 0, 1, 2, 3, \ldots. \)

The average energy is defined as\[ E_{\text{avg}} = \frac{\sum_{n=0}^{\infty} E_n e^{-E_n/kT}}{\sum_{n=0}^{\infty} e^{-E_n/kT}} = kT \sum_{n=0}^{\infty} \frac{n \alpha e^{-n\alpha}}{\sum_{n=0}^{\infty} e^{-n\alpha}}, \]
where \( \alpha = \frac{h\nu}{kT} \). Also note
\[ \frac{d e^{-n\alpha}}{d\alpha} = -n e^{-n\alpha}, \]
so that you can interchange the derivative and the sum in the numerator.

HW3.2  The energy per unit volume per unit of wavelength is given by
\[ \rho, d\lambda = \frac{8\pi\nu^2}{\lambda^5} \frac{d\lambda}{e^{hc/\lambda kT} - 1}. \]
Define \( x = \frac{hc}{\lambda kT} \) to obtain \( g(x) = \frac{x^5}{e^x - 1} \) so that \( \rho, (\text{constant}) g(x) \). Show that the maximum value for \( x \) is given by the equation \( x = 5(1 - e^{-x}) \). The solution is close to 5, so make an expansion about 5. Set \( x = 5 - \epsilon \) and solve for \( x \) up to order \( \epsilon^2 \). Show that \( x = 4.965 \) and thus \( \lambda_{\text{max}} T = 2.897 \times 10^{-5} \text{ K}\cdot m \). This is called Wien’s Law for blackbody radiation.
HW3.3 The relativistic momentum is defined as \( p = \frac{mv}{\sqrt{1 - v^2/c^2}} \), where \( m \) is the mass of a particle, \( v \) its speed, and \( c \) is the speed of light. Thus the relativistic force is written as \( F = \frac{dp}{dt} \).

The work done on a particle is its kinetic energy if the particle starts from rest at time \( t = 0 \). Use this fact to derive an expression for the relativistic kinetic energy \( K \). Use the work-energy theorem to calculate \( W = \Delta K = K = \int_0^x F \, dx \) if \( K = 0 \) at \( t = 0 \). Note that \( v = dx/dt \), so that

\[
K = \int_0^t v \frac{dp}{dt} \, dt.
\]

Hint: Show that \( v \frac{dp}{dt} = \frac{d}{dt} \left( \frac{mc^2}{\sqrt{1 - v^2/c^2}} \right) \). Expand your result for \( v/c \ll 1 \) to show that it yields the classical result for kinetic energy.

Problems: 2.5.5, 2.5.10, 2.5.27, 2.5.34, 2.5.42