Problem Set 1
Phy 211 - Fall 2003
Assigned: Thursday, Aug. 28 Due: Thursday, September 4

Problem 1: Blackbody Radiation

Liboff, 2.37.

Problem 2: Uncertainty Principle vs. Bohr's Model of the Atom

In Bohr's model of the atom, electrons move in well defined orbits, which is not allowed by the Uncertainty Principle. Such a semiclassical description is an acceptable approximation only when

$$\frac{\Delta r}{r}\frac{\Delta p}{p} \ll 1$$

where r is the distance from the origin and p is the total momentum. For what values of the quantum number n can this condition be satisfied?

Problem 3: Diffraction and Bohr-Sommerfeld Quantization

In class we derived the diffraction law for x-rays scattering off a crystal by assuming that light is a wave. The geometry is depicted in Fig 2.12 (p. 46) of Liboff. Call the vertical axis of Fig 2.12 the x-direction and the horizontal axis the y-direction.

a) Apply the Bohr-Sommerfeld quantization rule to the crystal motion in the x-direction to show that the p_x momentum of the crystal is quantized.

b) Now assume a **particle** with momentum p reflects off the crystal. (For simplicity assume the crystal does not recoil in the y-direction.) Show that momentum conservation implies that the particle can only scatter at certain angles. How is the momentum of the particle related to the wavelength appearing in the diffraction law?

Problem 4: Compton Scattering (Required for Graduate Students Only)

a) Derive the Compton formula for the change in wavelength of a photon scattering off an electron:

$$\lambda' - \lambda = \frac{h}{mc}(1 - \cos\theta). \tag{1}$$

The electron, whose mass is m, starts out at rest. The photon incident on the electron has momentum $p = h/\lambda$ and after the collision the momentum of the photon is $p' = h/\lambda'$. θ is the angle of the scattered photon with the incident photon.

b) Suppose the photon has a tiny mass, m_γ. What is the correction to Eq. (1)? You may expand your answer to lowest order in m_γ.