

Worksheet 3. From Newton and Maxwell, to Schrödinger.
 (This is mostly based off Randy's book)

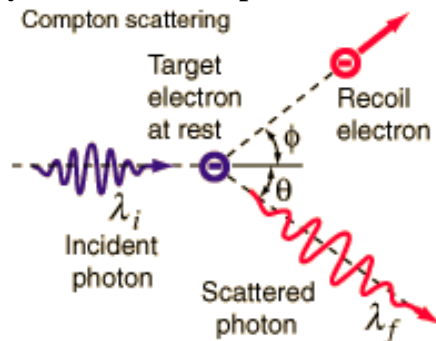
1. The Wien displacement law states that the most wavelength of the most intense radiation from a black body is inversely proportional to the temperature,

$$\lambda_{\max} = \frac{b}{T}.$$

That is, the location of the peak in the blackbody radiation curve is inversely proportional to the temperature. **Derive the Wien displacement law from Planck's law for the intensity of blackbody radiation,**

$$\rho_T(\lambda) d\lambda = \frac{8\pi hc}{\lambda^5 \left(e^{\frac{hc}{\lambda kT}} - 1 \right)} d\lambda.$$

2. Sketch the dependence of the kinetic energy of the electrons emitted due to the photoelectric effect versus the wavelength of the incident light for cesium metal, which has a work function of 2.14 eV. (1 electron volt is 1.60218×10^{-19} J) Label (a) the largest wavelength, $\lambda_{\text{threshold}}$, at which electrons are emitted and (b) indicate the functional form of $T(\lambda)$ for $\lambda < \lambda_{\text{threshold}}$.
3. What is the de Broglie wavelength of a major-league fastball. (velocity = 100 miles-per-hour; mass = 145 g.) The diameter of a baseball is 7.50 cm. What is the probability that a swing of the bat that would have made contact with the pitch misses due to quantum mechanics?
4. In the simplest case of Compton scattering, one starts with an electron at rest and shines a light, with wavelength λ_i , on the electron. After contact, the electron and the photon that hits it scatters through an angle, θ , and emerges with a larger wavelength, $\lambda_f > \lambda_i$, as shown in the following diagram. **Derive the dependence of the wavelength on the scattering angle. What is the minimum wavelength that can be observed at a given energy? Is it possible to have a process where the frequency of the scattered photon is zero (infinite wavelength)?**



5. I have a high-power green laser pointer (532 nm; 100 mW) that I use for astronomy. If I shine this laser pointer on you, how much momentum, per second, will be transferred to you.