Recitation 2

1. **Fun with units**

   (a) We have our formula for energy in a photon, $E = \hbar\omega$. Find out what are the units of $\hbar$ in MKS system. Also argue that you can express the numerical value of $\hbar$ in units of J.s.

   (b) A volt is defined as the potential difference such that a charge of 1 coulomb will gain or lose 1J of energy in passing through this potential difference. So we can write,

   $$1\text{J} = 1\text{C} \cdot 1\text{V}$$

   In other words 1J is a unit of energy that 1C charge gains in passing a potential difference of 1V. Keeping this in mind we can define another much smaller unit of energy, called electron volt (eV), as the energy that an electron, with its charge of 1.6×10^{-19} C, gains in passing 1V. Find how many joules, 1eV is equal to.

2. We perform the photo electric effect using the light of wavelength 700nm and find that the stopping potential i.e., the reverse potential when electrons completely stop reaching the anode, is 1.27 volts. Now we change the light and instead use a light of 500nm and find that the stopping potential is 1.48 volts.

   From these observations, find the value of Planck's constant. Express your answer in J.s as well as in electron volts.

3. Consider an interaction of a light photon and an electron as a collision of two particles. Since photon is always relativistic, and we are considering situations where electron is recoiled with relativistic velocities, we must treat the problem relativistically.

   (a) From the relativistic formula,

   $$E^2 = p^2c^2 + {m_0}^2c^4,$$

   and the fact that electron's rest mass is zero, show that photon must have a momentum whose magnitude is given by $p = \hbar k$

(b) take the electron to be at rest initially in the frame you are working in and take x-axis to be the initial direction of photon's path.

Write down the equations describing momentum conservation along x and y axis (z-axis is irrelevant here) as well as energy conservation in relativistic language and eliminate electron's recoil velocity from these equations to get a relation describing shift in scattered photon's wavelength as a function of scattering angle.