Modern Physics

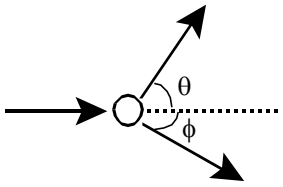
Fall 2018

Assignment 5: Due Monday, October 29?

1. A light bulb has a filament of surface area $2.7 \times 10^{-5} m^2$. The bulb is a 60W bulb. Assume the filament is a perfect blackbody. If all that power is emitted as radiation,
   a) What is the temperature of the bulb?
   b) What is the wavelength of the radiation at which the distribution $\mathcal{I}(\lambda,T)$ or $S(\lambda,T)$ peaks?
2. A light bulb filament is at a temperature of 2500K and can be considered a perfect blackbody.
   a) How much energy does it emit per unit area per second?
   b)* What fraction of that is in the visible range of 400nm to 700nm? (You will probably have to use Maple or go to Hyper Physics for this problem.)
3. A medium sized person can be approximated as a cylinder of height 1.6m and diameter 0.25m. If the person's temperature is 35°C and it is assumed that $\varepsilon = 1$,
   a) How much energy do they radiate away per second?
   b)* What fraction of this is in the visible range? (This part will probably require Maple or a good feel for approximations. You can also look at Hyper Physics – see the class web page.)
4. Lithium has a work function of about 2.9eV.
   a) What is the threshold frequency for the production of photoelectrons?
   b) What is the stopping potential if the wavelength of light striking the photocathode is 350nm?
5. An FM station at 100MHz radiates at 50,000W. How many photons does it emit per second?
6. A photon of wavelength 0.01nm encounters and scatters from a free electron.
   a) What is the maximum wavelength of the scattered photon?
   b) What are the energies of the original photon and the scattered photon?
   c) What is the maximum energy that can be given to the scattered electron by this photon?
7. A photon of energy 1MeV scatters off a free electron through an angle of 37°.
   a) How much energy does the scattered photon have?
   b) What fraction is that of its original energy?
8. The data at the right represent a measurement of the photoelectric effect. It gives the stopping potential, V, in volts as a function of the frequency of the incoming radiation in Hz. Find Plank's constant from this data by making a plot and calculating Plank's constant h from the slope of the line. Note that there is some scatter in the data and the slope may not yield the "correct" h. (**Show Your Work!** You may use a spreadsheet for this.)

f(Hz)	V_s(V)
5.00E+14	0.72
6.25E+14	1.12
7.50E+14	1.76
1.00E+15	2.50
1.25E+15	3.29

9. A photon scatters off an electron and loses 1/3 of its energy in the process. If the scattered angle is 53°, what was the initial energy of the photon?
10. A photon scatters off an electron and the electron's KE is 100keV and its velocity makes an angle of $\phi = 37°$ from the direction of the original photon.
    a) What is the wavelength of the original photon?
    b) What is the angle, θ, through which the photon is scattered?



Note on 10. This is harder. They have to go back to conservation of E and p and use

$E_{\gamma o} = E_{\gamma f} + 100\text{kev}$;

$p_e \sin\phi = (E_{\gamma f}/c) \sin\theta$;

and

$(E_{\gamma o})/c = p_e \cos\phi + (E_{\gamma f}/c) \cos\theta$

and eliminate the θ's instead of the ϕ's. It is not a quadratic in $E_{\gamma o}$, so it's not too bad. For the problem given, $E_{\gamma o} \approx 302\text{kev}$ and the final is 202kev. The angle is about 82^o.