Modern Physics 330: HW # 4

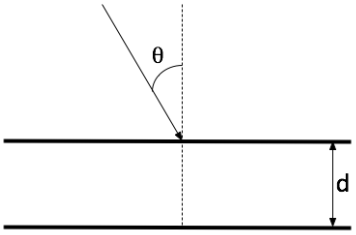
#1) The mean energy loss of a charged particle passing through matter is given as $\langle dE/dx \rangle$ with units of eV/g $\cdot$ cm^2. The dependence on density has been removed, so that the average $\Delta E = \Delta\ell \cdot \rho \cdot \langle dE/dx \rangle$ where ρ is the density and $\Delta\ell$ is the path length through the material. Frisch and Smith used 2.5 ft of iron as a their velocity filter. Take $\langle dE/dx \rangle = 2$ MeV/g $\cdot$ cm^2 for muons through iron. What is the minimum velocity of muons that will make it through the iron?

#2) Photons of energy 0.1 MeV are Compton scattered. Find the energy of the photon scattered at 60°, the recoil angle of the electron and the recoil kinetic energy of the electron.

#3) Consider an electron confined to a box of size L^3. Assume that the particle is equally likely to be anywhere in the box. Show that the uncertainty in any of the three cartesian coordinates is $L/\sqrt{12}$. What is the minimum value of the kinetic energy for the electron in the box? Take $L = 0.1$ nm.

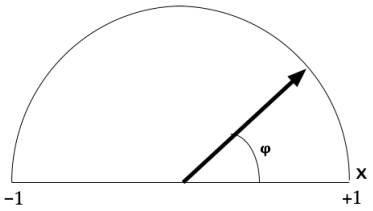
#4) Calculate the de Broglie wavelength corresponding to a nitrogen molecule at room temperature. Compare this to the molecular size of ~ 0.1 nm. Note: the atomic mass unit, defined as (mass ^{12}C atom)/12, is m_u = 931.494 MeV/c^2.

#5) Thermal neutrons having kinetic energy $E_k = 1/40$ eV are produced by nuclear reactors modulated (multiply scattered) by graphite. Consider thermal neutrons scattering as shown in the Figure. If $d = 15$ nm, at what angle would the first interference maximum occur? Suppose strong interference is observed at $\theta = 45°$, what is the lattice spacing d?



#6) A rock is dropped off of a cliff and falls a total distance h. Find the time averaged distance dropped, ignoring air resistance.

#7) Consider a game where a pointer is spun as shown below. It is equally likely to be anywhere between $\phi = 0$ and $\phi = \pi$. Find the PDF for the projection of the pointer onto the x-axis, $p_x(x)$. Be sure to express this in terms of x. Comment on the divergence of the PDF at $x = \pm 1$. Do this numerically for 1000 events, making histograms of the values of ϕ, x.



#8) The Black Body energy spectrum as a function of frequency $u_f(f)$ is:

$$u_f(f) = h(8\pi)\left(\frac{kT}{hc}\right)^3 \frac{(\frac{hf}{kT})^3}{e^{\frac{hf}{kT}} - 1}$$

Change variables from frequency to wavelength and find $u_\lambda(\lambda)$