Homework 2

Due: Mar.29th   Submit: Blackboard

1. For Molybdenum, the binding energy for K, L, M-shell are -20 keV, -2.5keV, and -0.4keV respectively.
   (1) Please calculate the characteristic X-ray for Molybdenum which can be used for the X-ray imaging;
   (2) Plot the energy spectra from a Molybdenum tube with the following kVp values: 30 keV, 20 keV, 18 keV.

2. A digital radiograph is acquired but the CNR in the region of interest is insufficient. Calculate the relative CNR of the following options and explain:
   (1) Double the mAs;
   (2) Take four radiographs and calculate the average image;
   (3) Change the kVp.

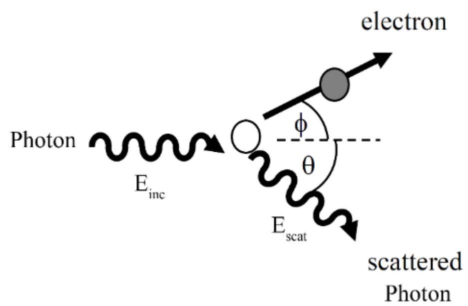
3. Sketch the LSF and MTF for the computed radiography
   (1) with a thick or a thin phosphor layer of CR plate respectively, and explain;
   (2) with a small or large X-ray focal spot respectively and explain .

4. When wide X-ray beams transmit through a matter, part of scattered x-ray photons will be received by the detectors. Therefore we can modify the equation to calculate number of transmitted X-ray photons as $N = BN_0e^{-\mu x}$, where B is the accumulation factor. The HVL of aluminum is 2.1mm. In the case of a wide X-ray beam with intensity I_0 passed through an aluminum sheet with thickness of HVL (2.1mm), the intensity of the scattered x-ray photons received by the detectors is equivalent to $0.1I_0$. Please calculate the HVL for a wide X-ray beam.

5. Figure shows the Compton scattering effect. In the case of incident photons with low energy, please prove that the wavelength change of between the incident and scattered photon is

$$\Delta\lambda = \frac{h}{m_e c}(1 - \cos\theta)$$

   where $\mathbf{m_e}$ is the mass of electron, **c** is the speed of light**,** and **h** is the plank's constant (**Tip**: the energy loss of photon during scattering is very small comparing to the energy of incident photon, you may use approximation to simplify your deduction)



6. In digital subtraction angiography by combination of sequencing and energy, four images are acquired, the images before injection of the contrast agent under high and low energy, I_{0H} and I_{0L}, the images after injection of the contrast agent under high and low energy, I_{1H} and I_{1L}.Given the mass attenuation coefficient for bone and soft tissue under high and low energy, μ_{BL}, μ_{BH}, μ_{TL}, and μ_{TH}. Derive the expression for the final subtraction image.