Homework #4

Special Topics in Signals & Systems: Biomedical Imaging

ECEn 682R, Section 3

Due: Thursday 10/8/2009 by midnight in the box outside Dr. Bangerter's office.

Homework help sessions: I will be holding a homework help session (in addition to my regularly scheduled office hours) for each homework assignment. For Homework #4, the help session will be Tuesday 10/6 from 5-6pm in 460 CB (the ECE conference room). If you need help and cannot make the help session, please see me during office hours or contact me to arrange an alternate time.

Problems from Prince & Links:

4.2

4.3 Recall that $(1 + \varepsilon)^x \approx 1 + \varepsilon x$ for $\varepsilon << 1$. (This is just the first two terms in the Taylor series expansion.)

4.4 (Note: Describe each in your own words with a short paragraph, with diagrams to help clarify.)

4.5

4.6

4.8 (a)

4.11

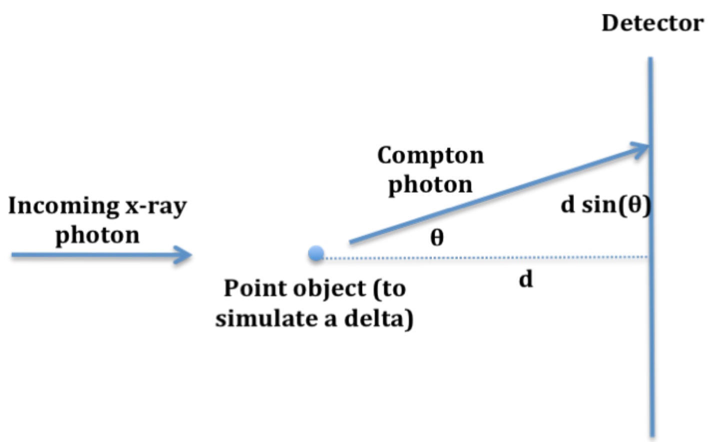
Extra Credit MATLAB Exercise:

Note: The grade curve in the class will be set prior to inclusion of any extra credit points. Thus, doing the extra credit can only help your grade, but you won't be penalized for not doing it. That said, I would strongly encourage everyone to at least attempt this and other extra credit problems.

Monte-Carlo Simulation of PSF from Compton Scattering: In problem 4.11, you determined what range of x-ray photon energies a detector in an x-ray system would need to accept in order to reject any incoming x-rays that had been Compton scattered by an angle greater than 25 degrees. However, allowing scattering angles up to 25 degrees will still introduce significant blurring into your image. The goal of this problem is to create a Monte-Carlo simulation to simulate the expected PSF of your system.

In class (and the book), we gave a formula for the energy of the x-ray photon if it was scattered by an angle θ. However, we didn't discuss how *likely* it is that any given x-ray photon will be scattered by an angle θ (or, more precisely, how likely it is that any given x-ray photon will be scattered at an angle between θ and $\theta+\delta\theta$). This angular probability distribution is actually given by the Klein-Nishina formula, which is more complicated than we want to deal with right now. For our purposes, let's assume that the angular probability distribution of Compton scattering is roughly Gaussian for -25 degrees < θ < 25 degrees. Let's further assume that the PSF is circularly symmetric (i.e., that the distribution of rotational angles ϕ around the normal to the detector is uniform).

Assume that your detector is 1m from the point object (i.e., d = 1m in the diagram shown below). Generate a Monte-Carlo simulation of your PSF by simulating at least 1,000,000 incoming x-ray photons scattered through an angle θ and rotational angle ϕ. Assume a Gaussian distribution of zero mean and variance of 25 degrees for θ and uniform distribution between 0 and 180 degrees for rotational angle ϕ. Recall that we are rejecting any incoming photons with scattering angle larger than ±25 degrees. Display the PSF, and show a large enough area to see the abrupt edges of the PSF (at scattering angles greater than 25 degrees).



We will briefly discuss Monte-Carlo simulation and how to set this problem up at the beginning of class on Tuesday. You are welcome to come see me before then if you would like to get started earlier or need further clarification.