Memorandum:

To: 22:54 students
From: Jacquelyn C.Yanch
Re: Sample term paper topics and sample midterm exam questions
Date: 15 March 2002

(i) Term Paper:

Here are some guidelines for your term paper.

First, the paper should be a thoughtful and in-depth investigation of some aspect of neutron interactions, detection or applications. It should not simply be a survey of the literature in one topic. In addition, you should show some critical judgement/thinking about the topic. For instance, this make take the form of your own investigation of the error analysis of some experimental work, or you may find two opposing views on a given subject that you could critically evaluate, or you could investigate the validity of certain assumptions made in the treatment of neutron scattering. [etc. etc. etc….]

The list below includes some suggestions but another topic you find more interesting that is not on the list may be perfectly suitable. You'll just need to get approval for the topic from Professor Yip or myself before proceeding.

Please come up with a topic by Tuesday so that you can make a start on the term paper before or during Spring Break.

(ii) Samples of Topics for 22.54 Term Paper

- Generation of (and spectrum shifting of?) spallation neutrons
- Physics and chemistry of ^{252}Cf production
- Physics and applications of neutron radiography/neutron tomography
- Neutron production via modern cyclotrons
- Body composition studies using neutrons
- Physics (and radiobiology?) of fast neutron therapy
- Generation of pulsed neutron sources
- Neutron detection via bubble detectors
- The "discovery" of neutrons – what was the state of knowledge prior to discovery, detection methods employed, confirmation studies, etc.

- Difficulties of and approaches to neutron spectroscopy (or dosimetry) in the intermediate energy region (1 eV – several hundred keV).

- Calculation of neutron emission characteristics (energy and yield as a function of angle) as a function of energy for one charged particle reaction; discussion of uncertainties.

- Monte-Carlo-based design and evaluation of shielding for a low energy, high current accelerator facility used for neutron production.

(iii) Sample exam Questions:

Below is a list of sample exam questions. This list supplements that you've already received from Professor Yip. Note that you will not be asked any questions specifically on the MCNP program. However, the concept of Monte Carlo calculations will still be fair game.

1. Define 'accuracy'. Define 'precision'. Discuss the differences between these concepts in terms of experimental measurement and in terms of Monte Carlo based calculations. Provide an expression of precision in terms of the standard normal distribution.

2. (a) Measurements of energy deposition in a sample material have been obtained as follows:

2.60 2.62 2.65 2.58 2.61 2.62 2.59 2.59 2.60 2.63 (MeV)

What are the average deposited energy and the standard deviation of this series of measurements?

(b) Define standard error. Why can we use the standard normal distribution to generate estimates of standard error in measurements of, say, average energy deposition, neutron flux across a surface etc.?

3. Define and describe the physical forces involved in the instability of heavy nuclides for nuclear fission. Define the activation energy (E_A) and discuss the role E_A and S_N (the binding energy of the last neutron) have in evaluating the probability of fission.

4. Thoroughly discuss the nuclear reaction, approximate yield, approximate neutron energy spectrum and physical construction/fabrication of an (α,n) source of neutrons.

5. Below is a section of the table of isotopes at very high Z and N. Generate an expression to quantify the production of ^{252}Cf from ^{244}Cm feed stock. Define all parameters used. (see copy of the overhead handed out in class; you'd be given this on the exam if this question were to be asked.)

6. In a cylindrical BF_3 proportional counter with a central anode radius equal to 25 μm, outer radius 25 mm, and 1000 V applied between anode and cathode, what is the distance from the center of the counter at which an electron gains enough energy in 1 mm of travel to ionize BF_3 gas? (assume 23 eV is the ionization potential of BF_3).

7. Use order of magnitude arguments to show that a prompt neutron released in nuclear fission initiates a further nuclear fission in a time of about 10^{-12} seconds. A thermal neutron travels a distance of the order of 10^2 atomic diameters before initiating a fission.

8. The ^{9}Be(p,n)^{9}Be reaction has a negative reaction energy, Q= -1.851 MeV. What is the minimum kinetic energy (laboratory system) of protons that can make this reaction go? [Use integral masses.] Describe, in words, how you would estimate the neutron yield from this reaction.

9. A thermal neutron detector is placed at the center of a spherical moderator that is exposed to a source of 5 MeV neutrons. If the moderator diameter is varied while holding all other conditions constant, sketch the corresponding expected variation in the counting rate. Provide physical explanations for the behavior of this curve at both large and small diameters.

10. Show that the sensitivity of a neutron counter (eg. BF_3 or fission counter) decreases with time as $\exp(-\sigma_a \phi t)$.