NE-104A: Nuclear Engineering Laboratory

Department of Nuclear Engineering
University of California
Berkeley

Spring Semester, 2009

Teachers

	Location/phone/e-mail	Office Hours
Kai Vetter, Instructor	4171 Etcheverry Hall/642-7071 LBNL/510 486-4295 kvetter@nuc.berkeley.edu	Tue 11:00-12:00, Wed 11:00-12:00
Daniel Chivers, Teaching Assistant	4171 Etcheverry Hall/642-7071 dchivers@berkeley.edu	TBA
TBA		

General Course Information

Lecture:	Mondays and Wednesdays, 9:00-10:00 in 7 Evans Hall (No Monday lectures starting April 7)
Laboratory:	Section 101: Mondays 2:00 --6:00 in 1110B Etcheverry Hall Section 102: Wednesdays 2:00 – 6:00 in 1110B Etcheverry Hall
Text (required):	G. F. Knoll, *Radiation Detection and Measurement*, 3rd ed., John Wiley and Sons, New York (2000).
Class web site:	http://www.nuc.berkeley.edu/dept/Courses/NE-104A/NE104A.html. Announcements, useful course information, and downloadable documents will be available on the web site. Some experiments may also require the use of databases and programs available through the web site.
Prerequisite:	NE-101A or an upper-division course in nuclear physics

This is an introductory lecture and laboratory course on (a) the principles of radiation detection and measurement, (b) experimental radiation detection and neutronics. The lectures will cover the theoretical bases of detectors, signal-processing electronics, and experimental measurement. Laboratory work will emphasize the practical aspects of radiation detection using a variety of sources, detectors, and signal-processing components.

Assigned homework will include reading for both lecture and laboratory, preparation of laboratory reports, and weekly problem sets. (Laboratory reports will not be required for experiments 2 and 4) The final examination will cover material on principles and applications as described in the lectures and utilized in the experiments.

The course grade will be based 50% on the laboratory reports, 10% on the weekly problem sets, 10% on laboratory log books, 5% on laboratory performance, and 25% on the final exam.

Laboratory Procedure

Each student will be assigned a laboratory partner for experiments 1-7. For experiments 8-9, students will work in a single group with an assigned, rotating leader. Data is recorded in lab books by the partnership or group, but each student prepares and submits his or her own report of each experiment. (At the end of each experiment, the department photocopier can be used to make copies of pages in the log

book, so that each student has a copy.) *The Data Log*, a separate handout, provides information on how to record data in the laboratory.

Write-ups of each experiment will be handed out the week before the experiment. ***They should be read carefully before coming to the laboratory***.

Experiment Reports

Experiment reports are due from each student ***at the beginning of the laboratory period one week following the completion of the experiment***. Please turn reports in on time, so that corrected reports can be returned to you on schedule. There is a heavy penalty for late reports, 5% of the maximum possible score per day. The report should be concise but self-contained. It should begin with an abstract: a few-sentence summary of the objective of the experiment, and the most important results and conclusions. The body of the report should include (1) a brief (one paragraph) introduction describing the purpose experiment and the experimental method, (2) experimental results and analysis; the contents of this section are specified in the experiment write-up (3) a brief statement of conclusions, and (4) answers to any questions in the writeup that are not already answered in parts 2 or 3.

Reports should be typed, or written ***in ink***. Graphs, tables, and figures should be neat, accurately drawn, and clearly labeled and titled. Almost all students use computers (word processing, spread sheets, graphics programs) to prepare reports, and this is recommended. However, the software must be capable of handling the special requirements of a scientific report, such as uncertainties on numbers, error bars on data in graphs, proper labeling and scaling of graphs, correct rounding of calculated results. Most "general purpose" programs (e.g., spreadsheets) will serve the purpose ***if they are used intelligently***.

Experiment reports should be prepared independently. Discussion the contents of the report with your partner, the instructor, or other members of the class is encouraged ***after*** attempting to do the assignment. Do not simply divide up the work and copy each other.

Reports will not be required for experiments 2 and 4. Results and analysis of for these experiments will be reviewed when the log books are graded at the end of the semester.

Laboratory Safety

Laboratory sessions will be held in room 1110B Etcheverry Hall. As required by state law and University policy, all students will be issued film badges, which should be worn at all times when in the laboratory and returned to the storage rack in 1110B at the end of the period.

You will be handling various sealed radioactive sources throughout the semester. Although most sources are weak (a few microcuries), care should be exercised when handling them. It is desirable to minimize exposure and, in particular, to avoid damage to the sources that could contaminate the laboratory and spread radioactivity outside the lab. (It is a good practice to check hands and feet for contamination with a portable survey instrument before leaving the laboratory.) All sources must be returned to their storage location at the end of each laboratory session. A one-Curie Pu-Be neutron source will be used in experiments 3, 7, and 8. This source should be handled only by the instructor or someone designated by the instructor. Additional radiation safety instructions will be given prior to the first use of radioactive sources. If any questions arise, consult your instructors or the Radiation Safety Officer, Paul Lavely (643-7976, LavelyP@berkeley.edu).

Other potential hazards in the laboratory include high-voltage power supplies and heavy items. Common sense, awareness, and simple preventive measures (such as not balancing a lead brick near the edge of a table, checking for frayed cables when connecting to a high-voltage supply) will ensure safety.

Experiments

There will be 10 experiments. Each will be completed in one week except the first:

1. Oscilloscopes and pulse-detection electronics (2 weeks)
2. Geiger counters--voltage plateau and dead time
3. Silicon semiconductor detectors--counting statistics, beta-ray attenuation, half-life measurement
4. Stopping power and range of alpha particles
5. Gamma-ray spectroscopy with germanium detectors – Characterization
6. Gamma-ray coincidences, timing, and Compton scattering kinematics with germanium detectors
7. Neutron activation analysis employing a germanium detector
8. Neutron detection
9. Subcritical assembly
10. McClellan Nuclear Radiation Center field trip

Schedule of Experiments

		Lab Partners[1]			
Week	Date	a	b	c	d
1	January 21	No laboratory			
2	January 28[2]	Orientation and safety lecture			
3	February 4	1	1	1	1
4	February 11	1	1	1	1
5	February 18	2	2	5	5
6	February 25	5	5	2	2
7	March 4	3	3	6	6
8	March 11	6	6	3	3
9	March 18	4	4	7	7
10	March 25	Spring Recess			
11	April 1	7	7	4	4
12	April 8	8	8	8	8
13	April 15	9	9	9	9
14	April 18 (Sa, 8:00 - 16:00)	10	10	10	10
15	April 22	No laboratory			
16	April 29	No laboratory			

[1] Lab partners are grouped into pairs designated a, b, c, and d for experiments 1 through 7.
[2] All lab sections.

Lecture Outline

Week	Date	Subject	Chapter Reference In Text (Knoll unless otherwise noted)
1	January 19	No lecture (MLK Holiday)	
	January 21	Course introduction; general principles of radiation detection	4 (I-VI)
2	January 26	Sources of radiation	1
	January 28	Radiation Interactions	2 (I-IV)
3	February 2	Pulse processing electronics – I.	16, 17
	February 4	Pulse processing electronics – II.	16, 17
4	February 9	Uncertainty (error) analysis, data reporting	3 (I, IV)
	February 11	Counting statistics, dead time	3 (II,III), 4 (VII)
5	February 16	Gas-filled detectors: introduction, ion chambers	5
	February 18	No lecture (President's Day Holiday)	
6	February 23	Proportional counters, GM counters	6, 7
	February 25	Semiconductor detectors, p-n junction diodes	11
7	March 2	Si(Li) and Ge(Li) detectors, HP Ge detectors	13 (I), 12(I-III)
	March 4	Alternative solid-state detectors	13 (II-V)
8	March 9	Miscellaneous detector types	14
	March 11	Gamma-ray spectrometry and applications	12 (IV)
9	March 16	Scintillation detectors	8, 9 (I-IV), 10 (IV)
	March 18	Slow neutron detection	14, 15
10	March 23, 25	No lectures (spring recess)	
11	April 1	Fast neutron detection	15
	April 6	Neutron detection and dosimetry	14, 15
12	April 8	Subcritical assembly	Profio 9, 10, Lamarsh 6
13	April 15	Preparation for MNRC field trip (reactor flux determination)	
14	April 22	Invited lecture	
15	April 29	Review for final exam	

Final Exam

The final exam will be given on Saturday, May XY, 8:00 to 11:00 a.m
Exact time and location TBA.