



NPRE Laboratory

NPRE 451

Instructor Info —



Prof. Di Fulvio, Dr. Fang



by appointment



Talbot 116, Talbot 225E



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Course Info —



Prereq: NPRE 445



Mon & Wed



09:00AM - 09:50AM



1038 CIF

Lab Info —



Thu/Fri



05:00-08:50PM/12:00-3:50PM



101B Talbot Laboratory

TA Info —



Gregory Romanchek, Md Fazlul
Huq



Office Hrs: by appointment



Talbot 224, Talbot 225A

Overview

Last edited on 2024/01/14. Radiation detection and instrumentation; radiation dosimetry and shielding; basic measurements in nuclear engineering; engineering applications; digitizer data acquisition and experimental control.

Reading Material

Required Text

Tsoufanidis, N., & Landseberger, S. *Measurement and Detection of Radiation* ("MDR"). Fourth Edition. CRC Press. 2015.

Recommended Texts

Knoll, G. F., *Radiation Detection and Measurement*. Fourth Edition. John Wiley & Sons Inc. 2010. ("Knoll")

Leo, W. L., *Techniques for Nuclear and Particle Physics Experiments: A How-To Approach*. Springer Verlag. 1994. ("Leo")

Evans, R. *The Atomic Nucleus*, Krieger Publishing Company, Inc. 1955

Slides and papers presented during the lectures are available on Canvas.

Grading Scheme

30 Lab Reports (28)—these are required work products and the course cannot be passed without submission of all the reports, and lab notebook (2)

25 Open Lab Presentation (10) and Paper (15)

15 Midterm Exam

20 Final Exam

10 In-class quizzes (8)—these are required work products and the course cannot be passed without submission of 70% of the quizzes; List of deliverables (2)

Grades will follow the standard scale: A+ = 97.5-100; A = 93.5-97.4; A- = 89.5-93.4; B+ = 86.5-89.4; B = 82.5-86.4; B- = 79.5-82.4; C+ = 76.5-79.4; C = 72.5-76.4; C- = 69.5-72.4; D+ = 66.5-69.4; D = 64.5-66.4; E/F <65. Curving is at the discretion of the instructor.

Notes

Make sure you enable notifications on Canvas to receive notifications of assignments.

Requirements to pass this course: submit with positive outcome (1) at least 70% of the quizzes. Collect all the lab data and submit all the lab reports.

Learning Objectives

- Become familiar with radiation detection principles and techniques.
- Gain skills in conducting experiments and interpreting the results.
- Learn data processing techniques applied to radiation detection.
- Learn to critically review a technical paper and provide helpful criticism to your peers' work and improve scientific writing skills.

Homeworks: Laboratory Reports

After completing each laboratory session, students are expected to write a report on each experiment. Although you are encouraged to discuss the report with fellow students, all lab reports need to be written individually. Report writing guidelines are available on Canvas. **The deadline for submitting the lab reports is 8 days after the day of the lab**, e.g., on Thursday if the lab was on Wednesday, unless announced otherwise. In a case of extenuating circumstances, please contact the instructor as soon as you are aware of them. Ten points will be subtracted per day (the highest possible score is 100 points), for all late reports. **Lab reports are to be submitted electronically on the Canvas portal** (in .pdf).

FAQs

? Do we use radioactive sources in this course?

! Yes, we do. We will use mostly low-activity check sources, therefore radiation dosimeters are not required. However, please take the general **Laboratory Safety Training** and the **Radiation Safety Awareness Training** courses at this link: <https://www.drs.illinois.edu/> after enrolling, and before 01/25/24.

? Why do we measure radiation?

! A precise measurement of radiation is important for many applications. A few examples are the radiation protection of operators working in nuclear power plants, or the characterization of nuclear reactions for physics or astronomy studies.

? What is the *Open Lab* section of the course?

! The *Open Lab* gives students a unique hands-on opportunity to creatively experiment with radiation detection concepts. Further details about the *Open Lab* will be discussed in class.

? What is the schedule of the first week of class?

! During the first week, instead of the lab session, we will have a regular class.

? How do I attend lectures and labs online?

! Classes and labs will be in person

Laboratory Reports (cont'd)

Plagiarism prevention software will be used to compare submitted reports against a database of academic papers to identify areas of overlap between the submitted assignment and existing papers. **Reports will be graded separately for the writing.** Report writing guidelines are available on Canvas, please review them before writing your first report.

Laboratory Notebook and Quizzes

A laboratory notebook needs to be maintained by the students. It will be graded by the TA during the last lab session (lab 10). Students need to be ready to show all the lab notebooks to the TA (electronic and paper versions of the notebook are acceptable).

To reinforce concepts learned in class, you will submit answers to assigned quizzes in class. The quizzes can be multiple choice or numerical (please bring a calculator) and will concern past topics discussed in class and (on Wed only) the subject of the upcoming lab. The grade will be either pass (1) or fail (0). To get a pass grade you need to answer correctly to at least 55% of the questions in the quiz. The quiz grade P is $P = 10 \times (N_P/N)$, where N_P is number of submitted quizzes evaluated as a *pass*, N is the total number of assigned quizzes.

Open lab Presentation and Paper

Small groups of students (up to 4 students per group) will plan and design an experiment to address a radiation detection problem of their interest. Each group will describe the problem, the methods used in their experiment, and the main findings in an oral presentation (10 out of 25 points) and a written paper (15 out of 25 points). The paper will also include a brief review of the relevant literature.

Each group will also review the paper of, at least, one other group, and receive at least one review by fellow students. Students will incorporate their edits into the final draft, to be submitted to the instructor three days after the date of the final exam, unless otherwise stated. The *Open Lab* reports will be submitted and uploaded on Canvas in one electronic copy. The *Open Lab* talks will be entirely graded by the students, who evaluate the oral presentations given by their fellow students according to a rubric provided by the instructor and available on Canvas.

Extra credit

One extra credit (EC) will be assigned to each student in class using the following criterion if $F \geq 95\%$ $EC=1$ else $EC=0$ where F is the percentage of students who submit course evaluation.

Diversity and Inclusivity Statement

All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class.

Accommodations for Students with Disabilities

Students with learning needs that require special accommodation are encouraged to contact the instructor and the **Disability Resources and Educational Services (DRES)** at +1 (217)333-4603 or disability@illinois.edu, as soon as possible, to make an appointment to discuss your learning needs and to obtain an accommodation letter, if needed. Accommodations are not retroactive, but begin the day you contact your professor with a current letter of accommodation from DRES.

Academic Integrity

The Code of Policies and Regulations Applying to All Students will be applied in all instances of academic misconduct committed by students. This applies to all exams, presentations, assignments and materials distributed in this course. Students are expected to present and submit original written reports, which truthfully represent the time and effort devoted into the work. **Plagiarism is an ethical violation in which students copy text, HW solutions, and/or tables/graphs from other sources.** Students caught plagiarizing will be subject to an academic integrity violation that can result in reduced or failing grade for a lab or the class, and expulsion from UIUC.

Class Schedule

MODULE 1: Introduction to Nuclear Measurements

01/17 W	Introduction, Radiation Safety, Instrument Overview	MDR Ch. 1
01/22 M	Radioactive Decay and Counting Statistics	MDR Ch. 2 (2.1-2.14), 3.7, NPRE451-Handout1
01/24 W	Uncertainty propagation and dead time	MDR Ch. 2 (2.15-2.18), 2.21, 5.6.2

MODULE 2: Electron and Gamma-ray Detection

01/29 M	Review of Nuclear Physics, Radioactive Sources	MDR Ch. 3, NPRE451-Handout2
01/31 W	Charged-particle interactions with matter	MDR Ch. 4 (4.1-4.7)
02/05 M	Charged-particle interactions with matter II, Intro to Gas detectors	MDR Ch. 4 (4.1-4.7)
02/07 W	Gas detectors	MDR Ch. 5.1 - 5.6
02/12 M	Gamma-ray radiation interactions with matter (I)	MDR Ch. 4.8
02/14 W	Gamma-ray radiation interactions with matter (II)	MDR Ch. 4.8 Knoll 3.III
02/19 M	Inorganic Scintillators	MDR 6.1-2 Knoll 8.II
02/21 W	Semiconductor Diode Detectors	Knoll Ch. 11 MDR Ch 7.1-4
02/26 M	Klein Nishina equation	
02/28 W	From Detection to Measurement: Concepts and Definitions (Efficiency, Solid angle)	MDR Ch. 8.
03/04 M	TBD and Midterm preparation	
03/06 W	MID TERM 1 EXAM	
03/09 M	Spring Break - end Fang's section	
03/17 W	Spring Break	
03/18 M	Neutron Detection Principles	

MODULE 3: Neutron detection

03/20 W	Exam correction	
03/25 M	Neutron Detection Principles (II)	MDR 3.9 MDR 4.9
03/27 W	Neutron Detection Principles (III)	MDR 3.9 MDR 4.9
04/01 M	Slow Neutron Detection (I)	MDR Ch. 14.1-14.4
04/03 W	Fast Neutron Detection (I)	MDR Ch. 14.5-14.10
04/08 M	Fast Neutron Detection (II)	MDR Ch. 14.5-14.10
04/10 W	Neutron Spectroscopy	MDR 6.10 13.7

04/15 <i>M</i>	Neutron activation and time-of-flight	MDR 14.8 14.11
04/17 <i>W</i>	Dosimetry and Passive Detectors	Knoll 19.VII 19.VIII
04/22 <i>M</i>	Feedback on open lab presentation GROUPS TH1 and TH2 Readout Devices (PMTs and SiPMs)	SignalMDR Ch 7
04/24 <i>W</i>	Feedback on open lab presentation GROUPS TH3 and TH4 Electronics readout	Electron-slides
04/29 <i>M</i>	Feedback on open lab presentation GROUPS FRI1 and FRI2 Final exam preparation	Final
05/01 <i>W</i>	Feedback on open lab presentation GROUPS FRI3 and FRI4 Final Exam	Final
05/03	Open lab presentations 7:00pm-10:00pm, 1038 Campus Instructional Facility.	
05/10	Submit the final version of open lab report by midnight via the Canvas submission link on the homepage	Send the report to your peers for review by 05/07. Send comments back by 05/09.

Lab Schedule

Lecture	01/18-01/19	R-F	Counting Statistics and Report Writing (1.5 hour lecture)
Lab #1	01/25-01/26	R-F	Introduction to Lab Equipment and Counting Statistics
Examples of <i>Open Lab</i> Projects			
Lab #2	02/01-02/02	R-F	Proportional Counters and Geiger-Mueller Counters
Lab #3	02/08-02/09	R-F	Gas Flow Detectors
Lab #4	02/15-02/16	R-F	Demonstration of Compton Scattering Using Coincidence Measurements
Lab #5	02/22-02/23	R-F	PMTs and Inorganic Scintillation Detectors and Preliminary
Lab #6	02/29-03/01	R-F	Alpha Spectroscopy
Lab #7	03/07-03/08	R-F	HPGe Detectors: Efficiency Calibration and spectroscopy
No lab	03/14-03/15	R-F	Spring Break
Lab #8	03/21-03/22	R-F	<i>Open Lab</i> presentations: motivations and planned objectives. Groups of students present an outline of their proposed open lab project and review one or more papers relevant to their project. By the end of the lab, they discuss an outline of the open lab with the instructor. The assignment for the following week is a literature review relevant to the open lab project.
Lab #9	03/28-03/29	R-F	Neutron Radiation Shielding. Thermal Neutron Detection.
Lab #10	04/04-04/05	R-F	Fast Neutron Detection: Organic Scintillators, Pulse Shape Discrimination and Spectroscopy
<i>Open Lab</i>	04/11-04/12	R-F	Working time
<i>Open Lab</i>	04/18-04/19	R-F	Working time
<i>Open Lab</i>	04/25-04/26	R-F	Preliminary open lab presentations (agenda below) & Working time

04/25

5:00-5:30 pm Group TH1
 5:30-6:00 pm Group TH2
 6:30-7:00 pm Group TH3
 7:00-7:30 pm Group TH4

04/26

12:00-12:30 pm Group FRI1
 12:30-1:00 pm Group FRI2
 1:00-1:30 pm Group FRI3
 1:30-2:00 pm Group FRI4

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