University of Maryland  
Department of Material Engineering  
College Park, Maryland

ENME 432/632 Experimental Radiation Measurements  
Three Credits

Spring 2016

SYLLABUS

Class Schedule

• Lectures are Thursdays 9:30 to 10:20 a.m. in room TBD  
• Laboratory are Thursdays 2:00 to 6:00 in room 1306 CHE Building (090)

Instructors

M. Coplan  
Office: CSS 4201 (Computer Space Sciences Building)  
Office Hours: Monday 10:00-12:00 and by appointment  
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Office: CHE 2303 (Chemical and Nuclear Engineering Building)  
Office Hours: Wednesday 2:00 to 4:00  
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E-Mail: koeth@umd.edu

Prerequisites

ENME430 or PHYS274 or permission of the instructors.

Course Description

Methods of radiation measurements using modern radiation detectors and processing electronics. Lectures emphasize the principles upon which the measurements are based.

Catalog Description

Methods of radiation measurements using modern radiation detectors and processing electronics. Lectures emphasize the principles upon which the measurements depend.
Textbooks/Manuals

Required


ENME 432 *Laboratory Manual*, on line course site.

Recommended


http://www.digikey.com/schemeit/#m6c

Course Goals

The objective of the class is teach students the measurements required to characterize radiation emitted from active nuclear materials. Emphasis is placed on laboratory measurements using modern radiation detectors and processing electronics and analysis software. Understanding the principles of nuclear radiation and detector technology underlying measurements and the critical thinking skills necessary to effectively assess experimental results is emphasized. Students satisfactorily completing the class will:

- Understand and be able to apply the design of experiments for radiation measurements.
- Be familiar with basic nuclear processes and the interaction of radiation with matter.
- Understand the principles of radiation detector operation.
• Be able to assess the uncertainty of experimental results and the reliability of radiation measurements.

**Student Outcomes Covered by the Course**

- Ability to apply mathematics, science and engineering principles
- Ability to design a radiation measurement system with modern detectors and electronics
- Appreciation of measurement uncertainties
- Ability to identify, formulate and solve, engineering, scientific, and technical problems
- Understanding and following radiation safety practices
- Understanding of professional and ethical responsibility
- Ability to communicate effectively
- Recognition of the importance of life-long learning
- Knowledge of contemporary issues
- Ability to use the techniques, skills and modern engineering tools necessary for engineering practice

**Reading Assignments**

The text (Knoll) will be used principally as a reference. Materials will be distributed in class and posted on the course website. These materials are intended to supplement the lectures. There will also be reading assignments from the text, Laboratory Manual, and notes in preparation for the laboratory work and lectures.

**Homework**

Homework will be assigned at approximately two-week intervals and will be due approximately two weeks from date assigned.

There will be a final examination at the end of the semester.

**Laboratory Work**

During the laboratory period there will be often be discussions of the theory and design of the experiments. Everyone is expected to participate. Each student
must obtain a bound laboratory notebook in which all data and descriptive information about each experiment is to be recorded. Notes and calculations on separate pieces of paper are not permitted. The laboratory notebook must have a Table of Contents in the beginning to aid in locating the different experiments. The notebooks will be periodically collected and checked. It should be possible to reconstruct the experiment and the data from the information in the laboratory notebook. All entries in the notebook are to be made with pen, not pencil. Errors should be crossed out with a single line rather than erased or obliterated. Often an incorrect calculation will contain information that is useful later on. The laboratory experiments will routinely be discussed in lecture before the laboratory, and it is recommended that the laboratory notebook be brought to lecture.

There are ten experiments during the semester. The experiments are flexible by design allowing students latitude in pursuing individual interests. Descriptions of the experiments are given in the on-line Laboratory Manual along with data sheets for the instruments used in the experiments. Operation manuals for all the laboratory equipment are available in the laboratory and on-line.

**Laboratory Reports**

Separate written laboratory reports for each experiment will be due either at the lecture period (Monday) 11 days after the last scheduled laboratory session for that experiment or at the laboratory 14 days after the last scheduled laboratory session for that experiment (see Semester Schedule). The reports should contain a description of procedures, tables and graphs showing results, and a discussion explaining the results. The laboratory reports should consist of four sections; **Introduction, Experimental Procedure, Results, Discussion, and Conclusions**.

The **Introduction** should contain a clear statement of the purpose of the experiment. The material for this section may be based on material in the laboratory manual. Relevant circuit theory should be included in this section. Detailed derivations are not necessary.

The **Experimental Procedure** should contain all the information required to reproduce the experiment as it was done in the laboratory. A list of components and equipment along with schematic circuit diagrams should be part of this section. The measurement procedures should be clearly described and may be derived from material in the laboratory manual.

The **Results** section contains the experimental data. Effective presentation of data is an essential engineering and scientific skill. The usual ways of presenting data are in tables and graphs. When tables are used, columns should be clearly labeled with units. Graphs should have both axes clearly labeled. All experimental data should be presented with estimates of errors or uncertainties.
The errors can be systematic as well as random and can be due to limitations of
the measuring instruments as well as uncertainties in the values of the
components. A discussion of the errors should accompany the data. It is not
necessary to include specification sheets, but reference to them should be given
where appropriate.

The Discussion section should contain comparisons between the predicted and
measured properties of the systems under study. Suggestions for improving the
experiment can be included in this section.

Conclusions should be based on the data and comparisons with calculations
based on the theory of the measurements and the systems studied. Applications
of the results of the experiment should also be included here. Clarity rather than
length or complexity is the goal of the reports. It should be possible to reproduce
your results from the information in the report.

The Introduction and Experimental Procedure sections are graded on a scale of
0 to 2. The Results, Discussion, and Conclusions sections are graded on a scale
from 0 to 4 where a grade of 4 means that the section fully meets the criteria
listed above, and a grade of 0 means that none of the criteria were met. The
maximum grade for a report is 16.

Unless prior arrangements are made with the staff, late reports will be subject to
a penalty of one point (out of a maximum grade of 16 points) per day late.

Grades

For both the laboratory reports and homework, there is a penalty of one point for
every day late.

The semester grade for the course will be determined approximately in the
following way:

<table>
<thead>
<tr>
<th>Average laboratory grade</th>
<th>45%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>20%</td>
</tr>
<tr>
<td>Final Examination</td>
<td>35%</td>
</tr>
</tbody>
</table>

The University of Maryland, College Park has a nationally recognized Code of Academic
Integrity, administered by the Student Honor Council. This Code sets standards for academic
integrity at Maryland for all undergraduate and graduate students. As a student you are
responsible for upholding these standards for this course. It is very important for you to be
aware of the consequences of cheating, fabrication, facilitation, and plagiarism. For more
information on the Code of Academic Integrity or the Student Honor Council, please visit

To further exhibit your commitment to academic integrity, remember to sign the Honor Pledge
on all examinations and assignments: "I pledge on my honor that I have not given or received
any unauthorized assistance on this examination (assignment)."

Absence Policy

Attendance at the lectures and laboratory periods is mandatory. Absence from lectures may result in missing quizzes and discussions of experimental work. Laboratory absences will result in incomplete reports that directly affect report grades.

University policies excuse the absences of students for
• illness,
• religious observances,
• participation in University activities at the request of university authorities and compelling circumstances beyond the student's control.

It is the student's responsibility to inform the instructors of any intended absences for religious observances in advance and that prior notification is especially important in connection with final examinations, since failure to reschedule a final examination before the conclusion of the final examination period may result in loss of credits during the semester. Every feasible effort will be made to accommodate students' requests based on attendance of religious observances. For excused absences lecture materials are available on the ELMS course site. Quizzes, homework and laboratory work can be rescheduled upon consultation with the instructors.

Arrangement for Students with Disabilities

The University is legally obligated to provide appropriate accommodations for students with disabilities. The campus's Disability Support Service (DSS) works with students and faculty to address a variety of issues ranging from learning disabilities and attention deficit hyperactivity disorders to physical and psychological disabilities. DSS will be consulted (4-7682 or dissup@umd.edu) for students with disabilities. Note that to receive accommodations, students must first register with the DSS and have their disabilities documented by DSS. The DSS office then prepares an Accommodation Letter for course instructors regarding needed accommodations. Students are responsible for presenting this letter to their instructors by the end of the drop/add period.

Copyright Protection for Class Materials

Lectures and course materials, including power point presentations, tests, outlines, and similar materials, are protected by copyright. The instructors are the exclusive owners of copyright in those materials created. Students may take notes and make copies of course materials for their own use. Students may not and may not allow others to reproduce or distribute lecture notes and course materials publicly whether or not a fee is charged without the express written consent of the instructors. Similarly, students own copyright in their original papers and exam essays. If the instructors are interested in posting student answers or papers on the course web site, they will
ask for written permission. Persons who publicly distribute or display or help others publicly distribute or display copies or modified copies of an instructor's Course Materials may be considered in violation of the University Code of Student Conduct, Part 9(k).

LECTURE TOPICS

1. Radiation Safety
2. Basic Instrumentation
3. Nuclear Radiation, Counting Statistics
4. Interaction of Radiation with Matter
5. Gas Ionization Detectors
6. Gamma Ray Spectroscopy
7. Radiation Sensors, Basic Principles
8. Detector Efficiency and Resolution
9. Shielding
10. Dosimetry
11. Nuclear Decay and Half-Life
12. Neutron Activation

LIST OF EXPERIMENTS (TENTATIVE)

1. Radiation Safety
2. Introduction to GM Detectors, Counting Statistics
3. Gamma Spectroscopy – NaI/SCA/MCA
4. High Resolution Gamma Spectroscopy – HPGe/MCA
5. Alpha Spectroscopy
6. Radiation Shielding
7. Dosimetry
8. Half-Life Measurements
9. Neutron Activation
10. MUTR