ME 765 Neutron Detection and Production
UNLV Department of Mechanical Engineering

Course Description
Passive and active detection of neutrons. Ionization/proportional tubes, He3 r BF3, liquid and plastic scintillators, fission chambers, activation foils, with laboratory exercises. Count statistics, uncertainty, coincidence measurements, energy unfolding, Monte Carlo modeling. Pulsed and continuous sources including fission reactors, accelerator production through fusion, spallation, photonuclear effects and [alpha, n] reactions.

Course Learning Outcomes
By the end of this course, students will be able to:
- Describe the principles of neutron detection and production.
- Use neutron activation foils and He3 detectors.
- Understand count statistics.
- Apply uncertainty principles.
- Use Monte Carlo software to model sources and detectors.

Prerequisites
ME 455, ME 655 or consent of instructor.

Required Text

Assignments and Evaluation Procedures
1. Academic Requirements: The course is based on lectures and laboratory exercises. Extensive use of the computer is expected using SMATH and Excel. Some programming will be required for Monte Carlo problems using GEANT, MCNP, MCNPX, KENO, FLUKA or similar software.
2. This course will require the completion of several labs in the UNLV Neutron Production Laboratory. Appropriate radiation source training, completion of tests administered by the UNLV RSO (radiation safety officer) and badging will be required.
Grading
Two Midterm Exams (250 points), Homework (200 points), Laboratory Exercises (200 points) and Final Exam (250 points).

Final Grades:

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<th>Score</th>
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<tr>
<td>95%</td>
<td>A</td>
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## Course Schedule

Important: This schedule is subject to change. The instructor will inform you whenever this is the case.

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
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| 1 - 2 | Introduction  
|      | 1. Review of atomic physics, neutron mass and relativistic mass, neutron decay  
|      | 2. Thermal neutron distribution through Maxwell-Boltzmann distribution  
|      | 3. Neutron moderation  
|      | 4. Absorption, scattering, and fission interactions  
|      | 5. Fission and fusion as sources of neutrons |
| 3 - 4 | Neutron interactions with matter  
|      | 1. Probability of interaction – neutron cross sections  
|      | 2. Energy dependency of cross sections  
|      | 3. Cross section databases: ENDF/B, JENDL, plotting cross sections from KAERI and NNDC.  
|      | 4. Monte Carlo modeling of detectors and sources |
|      | Laboratory #1 – Gold Foil Activation (week 3)  
|      | Midterm #1 – (week 4) |
| 5 - 7 | Neutron Detection  
|      | 1. Review of PMT technology, ionization and proportional tubes  
|      | 2. Review of count statistics, multi-channel analysis, uncertainty  
|      | 3. Active and passive detection  
|      | 4. Complication due to neutron plus gamma spectrum – gamma ray sensitivity  
|      | 5. Neutron activation and activation foils  
|      | 6. Fission chambers  
|      | 7. He3 and Boron (BF3) detectors  
|      | 8. Plastic scintillators  
|      | 9. Liquid scintillators  
|      | 10. Neutron coincidence measurements  
|      | 11. Energy unfolding  
|      | 12. Software considerations  
|      | 1. Pile-up  
|      | 2. Discrimination of neutrons from gamma |
|      | Laboratory #2 – Silver Foil Activation (week 5)  
|      | Laboratory #3 – Gold Foil Activation with Cadmium Covers (week 6) |
| 8 - 15 | Production of Neutrons  
|      | 1. Radioactive decay  
|      | 2. Cosmic radiation  
|      | 3. Spontaneous fission and energy spectrum  
|      | 4. Photoneutron production  
|      | 5. Fused versus continuous sources  
|      | 6. Accelerator technology for production of neutrons  
|      | 1. Electron accelerators  
|      | 2. Spallation neutron source  
|      | 3. Nuclear fusion – Deuterium Plasma Focus, string tubes  
|      | 4. Inertial electrostatic confinement (fusor technology)  
|      | 7. Fission reactors (fast and thermal)  
|      | 8. [α, n] sources  
|      | 1. UNILV Pu/Be source  
|      | 2. Am/Be sources |

|      | Laboratory #4 - Neutron Spectrum Analysis through Multiple Activation Foils (week 8)  
|      | Midterm #2 (week 10)  
|      | Laboratory #5 – He-3 Bonner Sphere Detector (week 10)  
|      | Laboratory #6 – Liquid Scintillator and Time Discrimination (week 12) |
Policies and Resources

Library Resources
- Students may consult with a librarian on research needs. For this class, the subject librarian is Sue Wainscott. (https://www.library.unlv.edu/contact/librarians_by_subject). UNLV Libraries provides resources to support students’ access to information. Discovery, access, and use of information are vital skills for academic work and for successful post-college life. Access library resources and ask questions at https://www.library.unlv.edu.

Policies:

Academic Misconduct—Academic integrity is a legitimate concern for every member of the campus community; all share in upholding the fundamental values of honesty, trust, respect, fairness, responsibility and professionalism. By choosing to join the UNLV community, students accept the expectations of the Student Academic Misconduct Policy and are encouraged when faced with choices to always take the ethical path. Students enrolling in UNLV assume the obligation to conduct themselves in a manner compatible with UNLV’s function as an educational institution.

An example of academic misconduct is plagiarism. Plagiarism is using the words or ideas of another, from the Internet or any source, without proper citation of the sources. See the Student Academic Misconduct Policy (approved December 9, 2005) located at: https://www.unlv.edu/studentconduct/student-conduct.

Copyright—The University requires all members of the University Community to familiarize themselves with and to follow copyright and fair use requirements. **You are individually and solely responsible for violations of copyright and fair use laws. The university will neither protect nor defend you nor assume any responsibility for employee or student violations of fair use laws.** Violations of copyright laws could subject you to federal and state civil penalties and criminal liability, as well as disciplinary action under University policies. Additional information can be found at: http://www.unlv.edu/provost/copyright.

Disability Resource Center (DRC)—The UNLV Disability Resource Center (SSC-A 143, http://drc.unlv.edu/, 702-895-0866) provides resources for students with disabilities. If you feel that you have a disability, please make an appointment with a Disabilities Specialist at the DRC to discuss what options may be available to you. If you are registered with the UNLV Disability Resource Center, bring your Academic Accommodation Plan from the DRC to the instructor during office hours so that you may work together to develop strategies for implementing the accommodations to meet both your needs and the requirements of the course. Any information you provide is private and will be treated as such. To maintain the confidentiality of your request, please do not approach the instructor in front of others to discuss your accommodation needs.

Religious Holidays Policy—Any student missing class quizzes, examinations, or any other class or lab work because of observance of religious holidays shall be given an opportunity during that semester to make up missed work. The make-up will apply to the religious holiday absence only. It shall be the responsibility of the student to notify the instructor within the first 14 calendar days of the course for fall and spring courses (excepting modular courses), or within the first 7 calendar days of the course for summer and modular courses, of his or her intention to participate in religious holidays which do not fall on state holidays or periods of class recess. For additional information, please visit:
Transparency in Learning and Teaching—The University encourages application of the transparency method of constructing assignments for student success. Please see these two links for further information:

https://www.unlv.edu/provost/teachingandlearning
https://www.unlv.edu/provost/transparency

Incomplete Grades—The grade of I—Incomplete—can be granted when a student has satisfactorily completed three-fourths of course work for that semester/session but for reason(s) beyond the student’s control, and acceptable to the instructor, cannot complete the last part of the course, and the instructor believes that the student can finish the course without repeating it. The incomplete work must be made up before the end of the following regular semester for undergraduate courses. Graduate students receiving “I” grades in 500-, 600-, or 700-level courses have up to one calendar year to complete the work, at the discretion of the instructor. If course requirements are not completed within the time indicated, a grade of F will be recorded and the GPA will be adjusted accordingly. Students who are fulfilling an Incomplete do not register for the course but make individual arrangements with the instructor who assigned the I grade.

Tutoring and Coaching—The Academic Success Center (ASC) provides tutoring, academic success coaching and other academic assistance for all UNLV undergraduate students. For information regarding tutoring subjects, tutoring times, and other ASC programs and services, visit http://www.unlv.edu/asc or call 702-895-3177. The ASC building is located across from the Student Services Complex (SSC). Academic success coaching is located on the second floor of the SSC (ASC Coaching Spot). Drop-in tutoring is located on the second floor of the Lied Library and College of Engineering TEB second floor.

UNLV Writing Center—One-on-one or small group assistance with writing is available free of charge to UNLV students at the Writing Center, located in CDC-3-301. Although walk-in consultations are sometimes available, students with appointments will receive priority assistance. Appointments may be made in person or by calling 702-895-3908. The student’s Rebel ID Card, a copy of the assignment (if possible), and two copies of any writing to be reviewed are requested for the consultation. More information can be found at: http://writingcenter.unlv.edu/.

Rebelmail—By policy, faculty and staff should e-mail students’ Rebelmail accounts only. Rebelmail is UNLV’s official e-mail system for students. It is one of the primary ways students receive official university communication such as information about deadlines, major campus events, and announcements. All UNLV students receive a Rebelmail account after they have been admitted to the university. Students’ e-mail prefix are listed on class rosters. The suffix is always @unlv.nevada.edu.

Emailing within WebCampus is acceptable.

Final Examinations—The University requires that final exams given at the end of a course occur at the time and on the day specified in the final exam schedule. See the schedule at: http://www.unlv.edu/registrar/calendars.