Texas A&M University
Departmental Request for a New Course
Undergraduate • Graduate • Professional

Submit original form and 2 copies. Attach a course syllabus to each.

1. This request is submitted by the Department of Nuclear Engineering.

2. Course prefix, number and complete title NUEN 605 Radiation Detection and Nuclear Materials Measurement.

3. Course description (not more than 50 words) This is a laboratory-based course studying the fundamentals of nuclear materials measurements. The course covers advanced radiation detection instrumentation with a specific focus on measuring nuclear materials (uranium, plutonium, and other actinides). Nuclear material measurements include detection, identification, and quantification of the materials in a fuel cycle facility and in the field.

4. Prerequisite(s) Graduate standing. Cross-listed with

5. Is this a variable credit course? ☐ Yes ☑ No If yes, from _______ to _______.

6. Is this a repeatable course? ☐ Yes ☑ No If yes, this course may be taken ______ times. Will the course be repeated within the same semester/term? ☑ Yes ☐ No

7. Has this course been taught as a 489/689? ☑ Yes ☐ No If yes, how many times? ______. Indicate the number of students enrolled for each academic period it was taught. _______.

8. This course will be:
   a. required for students enrolled in the following degree program(s) (e.g., B.A. in history)
      M.S. in Nuclear Engineering (nuclear nonproliferation track)
   b. an elective for students enrolled in the following degree program(s) (e.g., M.S., Ph.D. in geography)
      M.S. in Nuclear Engineering (nuclear power and materials tracks), M.S. in Health Physics

9. If other departments are teaching or are responsible for related subject matter, the course must be coordinated with these departments. Attach approval letters.

10. Prefix Course # Title (exclude punctuation) NuEn 605 Radiation Detection & Nuclear Materials Measurement

<table>
<thead>
<tr>
<th>Lect</th>
<th>Lab</th>
<th>SCH</th>
<th>Subject Matter</th>
<th>Content Code</th>
<th>Admin. Unit</th>
<th>Acad. Year</th>
<th>FICE Code</th>
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<tbody>
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Do not complete shaded area.

Approval Recommended by:

Head of Department: [Signature] 5/14/08

Chair, College Review Committee: [Signature] 5/14/08

Dean of College: [Signature] 4/13/08

Submitted to Coordinating Board by:

Director of Academic Support Services: Date

Dean of College: [Signature] 4/13/08

Effective Date:

To have this form reviewed, please send to Linda F. Lacey, Mail Stop 1265 or fax to 847-8737.

OAR/AS-5/04

1 of 7 C11
NUEN 605 – Radiation Detection and Nuclear Materials Measurement
Fall 2008
Course Syllabus

Course Description
This is a laboratory-based course which will study the fundamentals of radiation detection and nuclear materials measurements. The course will cover basic radiation detection instrumentation with a hands-on approach and with a specific focus on measuring nuclear materials (uranium and plutonium). Nuclear material measurements include detection, identification, and quantification of the materials in a fuel cycle facility and in the field. As the student will discover there is a significant increase in difficulty when attempting to quantify nuclear materials compared to simple radiological materials.

The course is designed to provide:
1. An overview of basic radiation detection instruments common to nuclear engineering for students with little to no background in radiation detection. (This portion of the course should be review for any student with a nuclear engineering or physics background.)
2. Instruction in more advanced nuclear material measurement topics (for example uranium and plutonium detection and quantification via coincident neutron counting). (This portion of the course would likely be new topics to even those with significant nuclear engineering or physics backgrounds.)

Detection instruments used will include gas-filled detectors, scintillation detectors, semiconductor detectors, neutron detectors, and calorimetry instruments. Topics in this course will include gamma-ray interactions with matter; gamma-ray detectors, gamma-ray spectroscopy, and passive gamma-ray detection; measurement of uranium enrichment; measurement of plutonium isotopic compositions; neutron interactions with matter; neutron detectors; total neutron counting; neutron coincidence counting; active neutron interrogation; irradiated fuel measurements; perimeter radiation monitors; and holdup measurements. Some application of this detector technology to detecting, identifying, and quantifying nuclear materials will also be explored.

Prerequisites: Graduate Standing

Course Objectives
The primary goal of this course is to educate the students on basic and advanced techniques for detecting radiation and measuring nuclear materials.

It is expected that the student will develop a deep understanding of radiation detection instrumentation and measurement techniques with a specific focus on nuclear materials. The student should develop a working knowledge of instruments for the detection of gamma ray and
neutron radiation (as well as alpha- and beta-particle radiation, to a lesser extent).

After completing this course, the student will be able to:

1. Describe the difference between gas-filled, scintillation, and semiconductor detectors.
2. Determine the appropriate instrument for the measurement of sources of neutron or gamma-ray radiation.
3. Assemble a laboratory setup for a radiation detector (from detector, NIM components, and cables).
4. Describe the instrumentation used in a nuclear reactor.
5. Explain how nuclear materials can be measured for isotopes and fissile material mass.
6. Using instruments studied in class, be able to detect radiological and nuclear materials in a field setting.
7. Using instruments studied in class, identify the isotopic composition of radiological and nuclear materials both in a field and facility setting.
8. Using instruments studied in class, determine the quantity of radiological or nuclear material present in an object or process in a nuclear facility.

Textbooks
The following textbook will be provided in electronic (PDF) form for the students:


The students will also use the instructor’s notes as a principle source of information for this course. These notes will be provided to the student in MS PowerPoint form. No textbook purchase is required for the class.

Class Time and Location
This course will meet two days per week. The course consists of a two hour lecture session and a three hour laboratory session according to the following schedule:

Lecture: T 12:45 P.M. - 2:00 P.M.
TBD

Laboratory: R 12:45 P.M. – 3:35 P.M.
ZACH 133C

The student will also have an opportunity to attend a one-week practical instruction session at Oak Ridge National Laboratory (ORNL). During this training, the students will have an opportunity to have hands-on experience with modern safeguards instrumentation and using special nuclear material available at ORNL. Expenses for travel costs to and from Oak Ridge, TN (including hotel costs in Oak Ridge) will be covered by the instructor. Attendance to this 1-week session is optional and will not impact the student’s grade. The 1-week session will be scheduled as shown in the course schedule below.
Instructor
The primary instructor for the course is:
William S. Charlton, Ph.D.
Associate Professor
Nuclear Security Science and Policy Institute
3473 TAMU, College Station, TX 77843-3473
Office Address: TRC 322A
Phone: (979) 845-7092, Fax: (979) 845-7497
Email: wcharlton@tamu.edu
Office Hours: by appointment only

Also, a laboratory assistant will be available to aid the students with questions specific to the laboratory equipment or the experimental procedures.

Method of Evaluation
The student’s grade will be determined based on attendance and on their performance in the laboratory. Attendance is required for all lecture and laboratory sessions (with the exception of the 1-week practical at ORNL which is optional and does not factor in the student’s grade). The performance in the laboratory will be assessed through laboratory worksheets and laboratory reports. The laboratory worksheets are intended to be completed during the lab session and turned in to the instructor at the beginning of the next class period. The laboratory reports will be due according to the schedule below (generally one week after the completion of the laboratory). Laboratory reports should be between 10-20 pages in length and should follow the format provided by the instructor. There will not be a final examination in this course.

The student’s grade will be determined based on the following percentages:
25% - Homework
50% - Laboratory Worksheets
25% - Laboratory Reports

The grades will be determined on the following scale:
A - 90.00-100.00
B - 80.00-89.99
C - 70.00-79.99
D - 60.00-69.99
F - 0.00-59.99

Online Course Material
All of the material for this course will be maintained on Texas A&M University’s WebCT Vista system. This includes an electronic copy of this syllabus, the course schedule, all lecture notes, laboratory procedures, lab worksheets, supplemental readings, and assignments. The instructor will use the WebCT Vista email system and discussion board to communicate important
messages to the students. Students should check their email often to keep updated on current messages. Also, the student’s grades will be posted on the WebCT Vista system, and the students can use this system to check their grades at any time. The WebCT system can be accessed through elearning.tamu.edu. If you are unfamiliar with this system, instruction will be provided.

**ADA statement**

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact the Department of Student Life, Services for Students with Disabilities in Room B118 of Cain Hall. The phone number is 845-1637.

**Copyrights**

The handouts used in this course are copyrighted. By "handouts" we mean all materials generated for this class, which include but are not limited to syllabi, lab problems, in-class materials, review sheets, and additional problem sets. Because these materials are copyrighted, you do not have the right to copy the handouts, unless the author expressly grants permission.

**Scholastic Dishonesty**

As commonly defined, plagiarism consists of passing off as one’s own the ideas, work, writings, etc., that belong to another. In accordance with this definition, you are committing plagiarism if you copy the work of another person and turn it in as your own, even if you have the permission of that person. Plagiarism is one of the worst academic sins, for the plagiarist destroys the trust among colleagues without which research cannot be safely communicated. If you have questions regarding plagiarism, please consult the latest issue of the Texas A&M University Student Rules [http://student-rules.tamu.edu/], under the section "Scholastic Dishonesty."
## Lecture and Laboratory Schedule

<table>
<thead>
<tr>
<th>Module</th>
<th>Subject</th>
<th>Assessment Due</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overview</td>
<td>Lecture 01: Introduction, Counting Statistics and Error Propagation</td>
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<td></td>
<td>Laboratory 01: Fundamental Nuclear Electronics</td>
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<tr>
<td>Gas Filled Detectors</td>
<td>Lecture 02: Gas-Filled Detectors and Detector Properties</td>
<td>Worksheet 01</td>
<td>Tues, Sept. 4</td>
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<td></td>
<td>Laboratory 02: Gas Flow Proportional Counters, Counting Statistics, and Dead Time</td>
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<td></td>
<td>Lecture 03: Geiger-Mueller Counters</td>
<td>Worksheet 02</td>
<td>Thurs, Sept. 6</td>
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<td></td>
<td>Laboratory 03: Geiger-Mueller Counters and Half-life Measurement</td>
<td></td>
<td>Thurs, Sept. 11</td>
</tr>
<tr>
<td>Neutron Detection</td>
<td>Lecture 04: Neutron Detection</td>
<td>Worksheet 03</td>
<td>Tues, Sept. 18</td>
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<td>Laboratory 04: He-3, BF3, and Fission Chambers</td>
<td></td>
<td>Thurs, Sept. 20</td>
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<td>Lecture 05: Fast Neutron Detection and Neutron Spectroscopy</td>
<td>Worksheet 04</td>
<td>Tues, Sept. 25</td>
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<td></td>
<td>Laboratory 05: Proton Recoil Detectors and Cd-covered He-3 Proportional Counters</td>
<td></td>
<td>Thurs, Sept. 27</td>
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<tr>
<td>Nuclear Material Measurements</td>
<td>Lecture 06: Principles of Total Neutron Counting</td>
<td>Worksheet 05</td>
<td>Tues, Oct. 2</td>
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<tr>
<td>Using Neutrons</td>
<td>Laboratory 06: Total Neutron Counting of Bulk U</td>
<td></td>
<td>Thurs, Oct. 4</td>
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<td>Lecture 07: Principles of Neutron Coincidence Counting</td>
<td>Worksheet 06</td>
<td>Tues, Oct. 9</td>
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<td>Laboratory 07: Doubles Counting for Effective Pu</td>
<td></td>
<td>Thurs, Oct. 11</td>
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<tr>
<td>Nuclear Material Measurements</td>
<td>Lecture 08: Gamma-Ray Spectroscopy and Scintillation Detectors</td>
<td></td>
<td>Tues, Oct. 16</td>
</tr>
<tr>
<td>Using Gamma-Rays</td>
<td>Laboratory 08: Sodium Iodide Detectors, Peak Ratio Method for Determining Source Activity</td>
<td>Report 07</td>
<td>Thurs, Oct. 18</td>
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<td>Lecture 09: Semiconductor Gamma-ray Detectors and Energy Resolution</td>
<td>Worksheet 08</td>
<td>Tues, Oct. 23</td>
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<td>Laboratory 09: High Purity Germanium Detectors, U and Pu Gamma Spectroscopy</td>
<td></td>
<td>Thurs, Oct. 25</td>
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<tr>
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<td>Laboratory 10: Measurements of Scrap and Waste Materials</td>
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<tr>
<td>Nuclear Material Safeguards</td>
<td>Isotope Identifiers and Uranium Enrichment Measurements</td>
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<tr>
<td>Instrumentation at ORNL</td>
<td>Uranium Holdup Measurements</td>
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<td>Mon, Nov. 5</td>
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<td>Active Well Coincidence Counter</td>
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<td>Tues, Nov. 6</td>
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<td>Mass Spectroscopy for U and Pu</td>
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<td>Wed, Nov. 7</td>
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<td>Portal Monitors and Field Measurements</td>
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<td>Thurs, Nov. 8</td>
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<td>Laboratory 11: Spent Fuel Measurements at the NSC</td>
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<td>Thurs, Nov. 15</td>
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<td></td>
<td>Lecture 12: Detector Development Needs for the Future</td>
<td></td>
<td>Tues, Nov. 20</td>
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<tr>
<td>Calorimetry</td>
<td>No Class (Happy Thanksgiving!)</td>
<td></td>
<td>Thurs, Nov. 22</td>
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<tr>
<td></td>
<td>Lecture 13: Principles of Calorimetry</td>
<td>Report 11</td>
<td>Tues, Nov. 27</td>
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<td>Laboratory 12: Calorimetric Assay of Spent Fuel</td>
<td>Thurs, Nov. 29</td>
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<tr>
<td>Conclusions</td>
<td>Student Evaluations (Redefined Day, Students Attend Thursday Classes)</td>
<td>Worksheet 12</td>
<td>Tues, Dec. 4</td>
</tr>
</tbody>
</table>