Course Inventory Change Request

In Workflow

1. 14NE GR Director of Curriculum (murty@ncsu.edu)
2. COE CC Coordinator GR (rfillin@ncsu.edu)
3. COE CC Chair GR (reeves@csc.ncsu.edu; rfillin@ncsu.edu; mdevets@ncsu.edu)
4. COE Final Review GR (rfillin@ncsu.edu)
5. COE Dean GR (reeves@csc.ncsu.edu)
6. ABGS Coordinator (george_hodge@ncsu.edu; lian_lynch@ncsu.edu; mlnosbis@ncsu.edu)
7. ABGS Meeting (george_hodge@ncsu.edu; lian_lynch@ncsu.edu; mlnosbis@ncsu.edu)
8. ABGS Chair (george_hodge@ncsu.edu; lian_lynch@ncsu.edu; mlnosbis@ncsu.edu)
9. Grad Final Review (george_hodge@ncsu.edu; lian_lynch@ncsu.edu; mlnosbis@ncsu.edu)
10. PeopleSoft (lamarcus@ncsu.edu; blpearso@ncsu.edu; Charles_Cliff@ncsu.edu; ldmihalo@ncsu.edu; jmharr19@ncsu.edu; Tracey_Ennis@ncsu.edu)

Approval Path

   Korukonda Murty (murty): Approved for 14NE GR Director of Curriculum
   Robyn Fillinger (rfillin): Approved for COE CC Coordinator GR
   Douglas Reeves (reeves): Approved for COE CC Chair GR
   Robyn Fillinger (rfillin): Approved for COE Final Review GR
5. Wed, 23 Sep 2015 16:12:05 GMT
   Douglas Reeves (reeves): Approved for COE Dean GR
6. Thu, 24 Sep 2015 14:55:01 GMT
   George Hodge (ghodge): Approved for ABGS Coordinator
7. Thu, 01 Oct 2015 15:24:01 GMT
   Melissa Nosbisch (mlnosbis): Approved for ABGS Meeting

Date Submitted: Tue, 22 Sep 2015 22:23:33 GMT

Viewing: NE 521 : Principles of Radiation Measurement

Changes proposed by: jkmattin

Course Prefix

NE (Nuclear Engineering)

Course Number

521

Course ID

016213

Dual-Level Course

No

Cross-listed Course

No
Title
Principles of Radiation Measurement

Abbreviated Title
Principles of Rad Measurement

College
College of Engineering

Academic Org Code
Nuclear Engineering (14NE)

CIP Discipline Specialty Number
14.2301

CIP Discipline Specialty Title
Nuclear Engineering.

Term Offering
Fall Only

Year Offering
Offered Every Year

Effective Date
Fall 2014

Previously taught as Special Topics?
No

Course Delivery
Face-to-Face (On Campus)

Grading Method
Graded/Audit

Credit Hours
3

Course Length
16

weeks

Contact Hours (Per Week)

<table>
<thead>
<tr>
<th>Component Type</th>
<th>Contact Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>2.0</td>
</tr>
<tr>
<td>Laboratory</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Course Is Repeatable for Credit
No
Instructor Name
John Mattingly

Instructor Title
Associate Professor of Nuclear Engineering

Grad Faculty Status
Full

Anticipated On-Campus Enrollment
Open when course_delivery = campus OR course_delivery = blended OR course_delivery = flip

<table>
<thead>
<tr>
<th>Enrollment Component</th>
<th>Per Semester</th>
<th>Per Section</th>
<th>Multiple Sections?</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>24</td>
<td>24</td>
<td>No</td>
<td>One lecture section is offered; all students attend the lectures together.</td>
</tr>
<tr>
<td>Laboratory</td>
<td>24</td>
<td>8</td>
<td>Yes</td>
<td>Multiple lab sections are offered; nominally there are 8 students per lab section.</td>
</tr>
</tbody>
</table>

Course Prerequisites, Corequisites, and Restrictive Statement
Prerequisites: Graduate standing in Nuclear Engineering or instructor permission

Is the course required or an elective for a Curriculum?
No

Catalog Description
Radiation detection measurement methods employed in nuclear engineering. Topics include: physics of nuclear decay and nuclear reactions, interaction of charged particles, photons, and neutrons with matter, fundamental properties of radiation measurement systems, statistical analysis of radiation measurements, common radiation detectors (gas-filled detectors, scintillators, and semiconductor detectors), data acquisition and processing methods, and radiation measurement applications.

Justification for each revision:
The catalog description has not been revised. It is the same as the current catalog description.

Does this course have a fee?
No

Consultation

Instructional Resources Statement
No new resources are required. The course is taught by Dr. John Mattingly, who was hired to the Nuclear Engineering (NE) faculty in June 2011 to teach this course (and other existing NE courses). The NE teaching laboratory is sufficiently equipped for the course lab sessions.

Course Objectives/Goals

Student Learning Outcomes
- Quantitatively describe the properties of radiation emitted by nuclear decay and reactions.
- Quantitatively describe how different types of radiation interact with matter.
- Identify the properties and describe the functioning of radiation measurement system components.
- Describe the layout of nuclear pulse processing systems.
• Construct and operate nuclear pulse processing systems.
• Perform statistical analysis of radiation measurements.
• Demonstrate how to use the most common types of radiation detectors.
• Apply data acquisition and processing methods used in radiation measurements.

Student Evaluation Methods

<table>
<thead>
<tr>
<th>Evaluation Method</th>
<th>Weighting/Points for Each</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>25</td>
<td>Students submit solutions to 10 homework assignments.</td>
</tr>
<tr>
<td>Lab Report</td>
<td>15</td>
<td>Students submit full reports on 4 laboratory experiments.</td>
</tr>
<tr>
<td>Other</td>
<td>10</td>
<td>Students take a laboratory exam at the end of the semester to demonstrate proficiency with the lab equipment.</td>
</tr>
<tr>
<td>Midterm</td>
<td>25</td>
<td>Students take 2 closed-book midterm exams covering subjects discussed in lecture prior to each midterm.</td>
</tr>
<tr>
<td>Final Exam</td>
<td>25</td>
<td>Students take a closed-book, comprehensive final exam.</td>
</tr>
</tbody>
</table>

Topical Outline/Course Schedule

<table>
<thead>
<tr>
<th>Topic</th>
<th>Time Devoted to Each Topic</th>
<th>Activity</th>
</tr>
</thead>
</table>
| Introduction     | 1 lecture                   | • Ionizing radiation  
|                  |                             | • Principles of radiation measurement  
|                  |                             | • Nuclear instrumentation  
|                  |                             | • Factors affecting radiation measurements  
|                  |                             | • Course agenda  
| Radiation sources| 3 lectures                  | • Terminology, nomenclature, and units  
|                  |                             | o Nuclides  
|                  |                             | o Nuclide groups  
|                  |                             | # Isotopes  
|                  |                             | # Isotones  
|                  |                             | # Isobars  
|                  |                             | o Mass and energy units  
|                  |                             | • Nuclear decay  
|                  |                             | o Nuclear instability and the chart of the nuclides  
|                  |                             | o Beta decay  
|                  |                             | # Beta-minus emission  
|                  |                             | # Beta-plus emission / electron capture  
|                  |                             | o Alpha decay  
|                  |                             | o Nuclear energy levels  
|                  |                             | # Excited states  
|                  |                             | # Gamma emission  
|                  |                             | # Isomers  
|                  |                             | o Spontaneous fission  
|                  |                             | o Other decay modes  
|                  |                             | o Nuclear binding energy and Q-values  
|                  |                             | o Kinematics of nuclear decay and reactions  
|                  |                             | o Decay schemes and decay series  
|                  |                             | o Radioactive half-life  
|                  |                             | o Radioactive decay series  
<p>|                  |                             | • Nuclear reactions |</p>
<table>
<thead>
<tr>
<th>Topic</th>
<th>Lectures</th>
<th>Content</th>
</tr>
</thead>
</table>
| Interaction of radiation with matter                                  | 3 lectures | • Charged particle energy loss and range  
• Photon interactions  
o Photoelectric absorption  
o Compton scatter  
o Pair production  
• Neutron interactions  
o Types of neutron reactions  
o Neutron reaction cross-sections |
| Basic properties of radiation measurement systems                     | 3 lectures | • Detection mechanisms  
• Modes of operation  
o Current mode  
o Pulse mode  
• Detection efficiency  
o Geometric effects (solid angle)  
o Intrinsic efficiency  
• Pulse height spectra  
o Linearity vs. energy  
o Energy resolution  
• Timing resolution  
• Dead-time effects  
o Non-paralyzable  
o Paralyzable |
| Statistical properties of radiation measurements                       | 3 lectures | • Accuracy vs. precision  
• Probabilistic nature of nuclear decay  
• Random variables and probability distributions  
• Location statistics: mode, mean, and median  
• Dispersion statistics: variance and standard deviation  
• Covariance and correlation  
• Probability distributions important in radiation measurements  
o Binomial distribution  
o Poisson distribution  
o Normal (a.k.a., Gaussian) distribution  
o Standard deviation, full-width half-max, and confidence intervals  
• Propagation of uncertainty  
o Combining different random variables  
# Uncorrelated variables  
# Correlated variables  
o Uncertainty in mean values  
# Arithmetic mean  
# Inverse-variance-weighted mean |
Scintillators 2 lectures
- Inorganic scintillators
  - Scintillation process
  - Photon emission time dependence
  - Important properties
  - Gamma spectroscopy
- Organic scintillators
  - Scintillation process
  - Types of organic scintillators
    - Crystalline
    - Amorphous plastic
    - Liquid
  - Pulse-shape discrimination
  - Neutron and gamma detection
  - Pulse height vs. energy (nonlinearity)
- Inorganic scintillators
- Organic scintillators
  - Photomultiplier tube (PMT)
  - Operating principle
  - Electron multiplication
  - Optical coupling

Gas-filled detectors 2 lectures
- Operating principles
- Charge collected vs. high voltage
- Types of gas-filled detectors
  - Ionization chambers
  - Proportional counters
  - Geiger-Mueller counters

Semiconductor detectors 2 lectures
- Insulators vs. conductors vs. semiconductors
- Intrinsic vs. extrinsic semiconductors
- The p-n junction
  - Formation
  - Operation as a radiation detector
  - Different types of semiconductor detectors
    - Surface barrier
    - Lithium-drifted silicon - Si(Li)
    - Lithium-drifted germanium - Ge(Li)
    - High purity germanium - HPGe
    - CdTe and CdZnTe
  - Medium- and high-resolution gamma spectroscopy

Signal processing 2 lectures
- Linear vs. logic pulses and pulse processing components
- Coaxial signal cable properties
- Pulse shaping
  - Ballistic deficit
  - Pileup, baseline shift, and energy resolution
- Discriminator timing
  - Leading-edge discriminator
  - Zero-crossing discriminator
  - Constant-fraction discriminator
  - Coincidence and anticoincidence
  - Pulse-shape discrimination
- Coincidence and anticoincidence
- Pulse-shape discrimination

Gamma spectroscopy 2 lectures
- Low- vs. high-resolution gamma spectroscopy
  - Gamma spectral features
    - Photopeaks
    - Compton continua
    - Positron annihilation peak
    - Escape peaks
    - Backscatter peak
    - Sum peaks
  - Radionuclide identification
Neutron measurements

2 lectures

- Detection by (n, charged particle) reactions
  - BF3
  - Boron-lined
  - 6Li
  - 3He
- Fission chambers
- Organic scintillators
- Neutron spectrum measurements
  - Using proton recoil
  - Using time-of-flight
- Neutron time-correlation measurements

Nuclear pulse processing systems

1 lab

- Radiation detection pulses
- Preamplifiers
- Amplifiers
- Discriminators
  - Single-channel analyzers
  - Multichannel analyzers
- Counter/timers
- Oscilloscope

Statistical properties of pulse counting systems

1 lab

- Propagation of uncertainty
- Mean count rate
- Variance and standard deviation
- Confidence intervals
- Absolute measurements and propagation of uncertainty

High-resolution gamma spectroscopy

1 lab

- Gamma spectroscopy system construction
- Energy calibration
- Energy resolution
- Detection efficiency
- Radionuclide identification

Coincidence counting

1 lab

- Cobalt-60 decay scheme
- Absolute measurement of source activity
- Absolute measurement of detection efficiency

Syllabus

Syllabus.pdf

Additional Documentation

Additional Comments

The only change I am requesting is to change the prerequisite from NE202 to ‘Graduate standing in Nuclear Engineering or instructor permission’.

NE202 is the Nuclear Engineering department’s undergraduate radiation detection course. Students graduating with a BS in NE from NCSU will meet this prerequisite. However, this course, NE521, is an entry-level course taken by most new NE graduate students. Students admitted to the NE graduate program from other schools will not have taken NE202, but they are qualified to take the course. So graduate standing in Nuclear Engineering is a sufficient prerequisite.

Furthermore, students in other disciplines (e.g., Physics) occasionally request to take this course, NE521. I would like to retain the ability to admit them to NE521 at my discretion.

So, I would like to change the prerequisite to ‘Graduate standing in Nuclear Engineering or instructor permission’.

CIM forced me to populate all the other required fields associated with this course, NE521. There really needs to be a mechanism in CIM to submit requests for minor course changes, like a change in the prerequisites.

Furthermore, the topical outline in CIM is completely and thoroughly redundant - this information is contained in the syllabus.

minosbis 9/23/2015: Does not appear to conflict with other courses. No consult required.
ghodge 9/23/2015 Ready for ABGS reviewers. This CAF could probably placed on the meeting consent agenda. This is the first edit to the course since moving to CIM, so all items needed to be entered into the form. CIM is the electronic repository for all course actions. Only a few of the data elements can be imported from SIS.

ABGS Reviewer comments:
-This is a minor action. Okay to send to Board.

Course Reviewer Comments

rfillin (Wed, 23 Sep 2015 13:38:02 GMT): The only request here is to change the Prerequisite. However, this minor change still requires the same process as if it were a new course.

Key: 4046

Preview Bridge (http://catalog.ncsu.edu/)