Engineering Faculty Document (EFD) No. 66-13
Date: April 19, 2013

TO: Faculty of College of Engineering

FROM: Faculty of the School of Nuclear Engineering

SUBJECT: New Undergraduate Course, NUCL 42000, Radiation Interaction with Materials and Applications

The Faculty of the School of Nuclear Engineering has approved the new course listed below. This action is now submitted to the Engineering Faculty with a recommendation for approval.

NUCL 42000, Radiation Interaction with Materials and Applications
Sem. 1, Lecture 2, cr. 3

Course Description:
The course covers the fundamentals of radiation interaction with materials and applications. The course introduces students to the types of radiation and radiation sources, physical mechanisms of radiation interaction with solids, radiation damage, ion mixing, applications in nuclear fission and fusion reactors and materials synthesis and modification.

Reason:
As a part of streamlining the nuclear materials part of its curriculum, the School of Nuclear Engineering is redesigning three of its courses, NUCL 32000, NUCL 42000 and NUCL 52000 so as to cover the fundamentals of materials science and survey of nuclear materials, radiation interaction with materials and radiation effects in materials and materials ageing in the nuclear environment in this course series. Only minor adjustments will be made to NUCL 32000. The redeveloped NUCL 42000 will satisfy a graduation requirement for seniors, essentially replacing NUCL 52000 in this regard. It will also serve as a prerequisite or a background filling course for NUCL 52000. The contents of NUCL 52000 will also be modified to concentrate more on radiation effects and materials property changes in nuclear environments. NUCL 42000 has been taught on an experimental basis for four years and the School of Nuclear Engineering wants to make the course permanent.

A. Hassanein

Ahmed Hassanein, Department Head
Paul L. Wattelet Professor
School of Nuclear Engineering

APPROVED FOR THE FACULTY
OF THE SCHOOLS OF ENGINEERING
BY THE ENGINEERING
CURRICULUM COMMITTEE

ECC Minutes 10-4-13

Date 10-4-13

Chairman ECC

EFD 66-13

Office of the Registrar
FORM 40 REV. 12/09

PURDUE UNIVERSITY
REQUEST FOR ADDITION, EXPIRATION,
OR REVISION OF AN UNDERGRADUATE COURSE
(10000-40000 LEVEL)

Print Form

DEPARTMENT Nuclear Engineering

EFFECTIVE SESSION Fall 2013 201420

INSTRUCTIONS: Please check the items below which describe the purpose of this request.

- [X] 1. New course with supporting documents
- [ ] 2. Add existing course offered at another campus
- [ ] 3. Expiration of a course
- [ ] 4. Change in course number
- [ ] 5. Change in course title
- [ ] 6. Change in course credit/type
- [ ] 7. Change in course attributes (department head signature only)
- [ ] 8. Change in instructional hours
- [ ] 9. Change in course description
- [ ] 10. Change in course requisites
- [ ] 11. Change in semesters offered (department head signature only)
- [ ] 12. Transfer from one department to another

PROPOSED:	EXISTING:
Subject Abbreviation: Radiation Interaction with Materials	Subject Abbreviation:
Course Number: NUCL 42001	Course Number:
Long Title: Radiation Interaction with Materials and Applications	
Short Title: Rad Int Mater Apps	

Abbreviated title will be entered by the Office of the Registrar if omitted. (30 CHARACTERS ONLY)

TERMS OFFERED
Check All That Apply:
[X] Fall [ ] Spring [ ] Summer

CAMPUS(ES) INVOLVED
[ ] Calumet [ ] N. Central
[ ] Cont Ed [ ] Tech Statewide
[ ] Ft. Wayne [X] W. Lafayette
[ ] Indianapolis

CREDIT TYPE
1. Fixed Credit: Cr. Hrs. 3
2. Variable Credit Range: Minimum Cr. Hrs ____ (Check One) To [ ] Or [ ] Maximum Cr. Hrs. ____
3. Equivalent Credit: Yes [ ] No [X]

COURSE ATTRIBUTES: Check All That Apply
1. Pass/Not Pass Only [ ]
2. Satisfactory/Unsatisfactory Only [ ]
3. Repeatable [X] L/XM
Maximum Repeatable Credit: [ ]
4. Credit by Examination [ ]
5. Special Fees [ ]
6. Registration Approval Type: Department [ ] Instructor [ ]
7. Variable Title [ ]
8. Honors [ ]
9. Full Time Privilege [ ]
10. Off Campus Experience [ ]

ScheduleType	Minutes Per Mtg	Meetings Per Week	Weeks Offered	% of Credit Allocated
Lecture	75	2	16	
Recitation				
Presentation				
Laboratory				
Lab Prep				
Studio				
Distance				
Clinic				
Experiential				
Research				
Ind. Study				
Pract/Observ				

Cross-Listed Courses

RECEIVED
OCT 15 2013
OFFICE OF THE REGISTRAR

COURSE DESCRIPTION (INCLUDE REQUISITES/RESTRICTIONS):
Fundamental of radiation interaction with materials and applications, types of radiation and radiation sources, physical mechanisms of radiation interaction with solids, radiation damage, ion mixing, applications in nuclear fission and fusion reactors, applications in materials synthesis. Prerequisite: NUCL 32000

*COURSE LEARNING OUTCOMES:
To learn the types and sources of radiation; to understand the physical mechanisms of radiation interaction with materials and model these interactions quantitatively; to understand and model the phenomenon of radiation damage to bulk, surfaces and interfaces; to relate the concepts of radiation damage to neutron interaction with solids in both fission and fusion reactors; to understand radiation effects; to understand the technological applications of radiation interaction with materials.

	Date		Date
Calumet Department Head		Calumet School Dean	
Fort Wayne Department Head		Fort Wayne School Dean	
Indianapolis Department Head		Indianapolis School Dean	
North Central Faculty Senate Chair		Vice Chancellor for Academic Affairs	
West Lafayette Department Head	9/17/2013	West Lafayette College/School Dean	10/16/13
		West Lafayette Registrar	10/21/13

OFFICE OF THE REGISTRAR

10/18/13

SYLLABUS
NUCL 49700 (42000), Radiation Interaction with Materials and Applications
Fall Semester 2012

Course Time: Tuesday and Thursday, 12:00 – 1:15 p.m.
Course Location: Grissom Hall, Room 170
Instructor: Prof. Anter El-Azab
Phone: 765-496-6864
E-mail: aelazab@purdue.edu
Office: NUCL 132D
Office hours: Tuesday and Thursday, 2:00pm -3:00pm and otherwise by appointment

Textbook

Michael Nastasi, James W. Mayer and James K. Hirvonen, Ion-Solid Interactions: Fundamentals and applications, Cambridge University Press, 1996, ISBN 0-521-61606-9.

Reference book

Gary S. Was, Fundamentals of Radiation Materials Science: Metals and Alloys, Springer, 2007, ISBN 978-3-540-49471-3.

Course Objectives: In this course, students will

- learn the types and sources of radiation,
- understand the physical mechanisms of radiation interaction with materials and model these interactions quantitatively,
- understand and model the phenomenon of radiation damage to bulk, surfaces and interfaces,
- relate the concepts of radiation damage to neutron interaction with solids in both fission and fusion reactors,
- understand the technological applications of radiation interaction with materials.

Grading

Grades: A: 85% - 100%; B: 75% - 84%; C: 65% - 74%; D: 50% - 64%; F <49%

Weighting:

25% Homework

25% Project

25% Exam 1

25% Exam 2

Homework

About 6 homework assignments will be given during the semester.

Homework solutions and other assignments should be turned in at the beginning of the hour on the date they are due. Solutions will be graded and handed back to students. The assignments are intended to show the application of lecture material and help students prepare for other tests. As such, individual work is essential. The solution steps and the approach followed must be made clear to the grader. Students are allowed to collaborate on solving homework but that should be limited to discussing the approach only. Unless indicated otherwise, each student is expected to work on the homework assignments independently. Copying solutions of others is considered plagiarism.

The following header should be printed on the top of each solution page:

Last name, First name

NUCL 420 Homework Assignment #

A cover page with the same information should also be used with each assignment.

Project

As part of class work, student teams will be assigned mini-research projects. A list of topics will be provided by the instructor during the second week of classes (following the introductory section of the course). Project grading policy and roles of graduate and undergraduate students will be explained then. The topics of these projects include, but are not limited to, radiation damage and defect production in materials, defect diffusion, segregation processes, and surface and bulk induced effects of radiation.

The project reports will be due Friday 11/30/2012. The team presentations will be given during class in the last week of classes (12/4/2012, 12/6/2012).

Attendance Policy

Regular attendance is mandatory. Students who have an excused absence are responsible for all material covered during class, including assignments and exams. Excused absences include documented illness, deaths in the family and other documented crises, call to active military duty or jury duty, religious holidays, and official University activities. These absences will be

accommodated in a way that does not arbitrarily penalize students who have a valid excuse. Consideration will also be given to students whose dependent children experience serious illness.

Academic Honor Policy

Students are expected to conduct all class related work with the highest level of honesty and integrity. Cheating, plagiarism, and other forms of academic dishonesty will be prosecuted according to the Purdue University policy.

Emergency Provisions:

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances. Here are ways to get information about changes in this course. Blackboard Vista web page, my email address (aelazab@purdue.edu), and my office phone (496-6864).

In case of a fire alarm, students will leave the building and assemble in the east end of the main hall on the first floor of Stewart Center – near the doors you would go through to get to the Union.

In case of tornado, go down the center staircase of Grissom Hall and assemble in the basement hall.

Purdue's home page is the official source of emergency information, www.purdue.edu. Below is the link for evacuation and shelter in place for this class.

https://engineering.purdue.edu/Intranet/Groups/Administration/RPM/Safety/ClassroomEmergencyPlanning/GRIS/GRIS%20170.pdf

ASSIGNMENT SHEET
NUCL 49700 (42000), Radiation Interaction with Materials and Applications
Fall Semester 2012

Course Contents

1. Course Introduction
   - Sources and types of radiation
   - Mechanisms of radiation interaction with materials
   - Relevance to nuclear science and engineering
   - Non-nuclear applications (materials and devices)
   - Basic concepts
   - Scope of the course
2. Interatomic Potentials
   - Interatomic forces, short and long-interaction forces
   - Model interatomic potentials
   - Bonding and properties of solids
   - The role of electrons in interactions in solids
3. Binary Elastic Collisions
   - Kinematics of elastic collisions
   - Two-particle scattering theory; energy and momentum conservation
   - Angular orbital momentum and the impact parameter
   - Classical scattering integral
4. Cross Section
   - Angular differential scattering cross section
   - Energy transfer cross section
5. Stopping and Range of Ions in Solids
   - The energy loss process
   - Nuclear stopping
   - ZBL nuclear stopping cross section; ZBL universal scattering formula
   - Electronic stopping
   - Ion range in solids and related statistical aspects
   - Brief overview of TRIM and SRIM codes
6. Radiation Damage
   - Concept of radiation damage
   - Atomic displacements and displacement energy
   - Damage produced by energetic ions
   - Damage production rates
   - Polyatomic materials
   - Spikes and replacement collision sequences
   - Morphological aspects of damage
   - Irradiation enhanced diffusion
7. Simulation techniques
   - Monte Carlo method
   - Molecular dynamics method

- Computer simulation codes

8. Radiation Damage at Surfaces: Sputtering
   - Basic concepts
   - Sputtering yield
   - Sputtering in single component materials
   - Sputtering in multi-component materials
9. Neutron Damage and Radiation Effects in Reactor Materials
   - Damage cross sections
   - Damage rates for neutron and connection with neutron fluxes
   - Consequences of radiation damage in reactor materials (material property changes)
10. Application of Ion-Solid Interactions
    - An overview of ion-beam processing of materials
    - Radiation modification of materials