

**ENU 4800 Section 06FA**  
**Introduction to Nuclear Reactor Materials**  
**Spring 2019, MWF 12:50-1:40PM, WEIL 279**

**1. Catalog Description**

This course provides a background on the types of materials used in nuclear reactors and their response to reactor environment. Many of the desirable material properties designed for nuclear reactor materials may degrade with exposure to the extreme environments (irradiation, temperature, stress, etc.) that are common to nuclear reactors. The objective of this course is to provide nuclear engineering students with background in materials and to discuss the unique challenges that occur in these materials under irradiation, so students understand the limitations put on reactor operations and design by materials performance.

**2. Pre-requisites and Co-requisites**

EMA 3010 Materials

**3. Course Objectives**

Successful students at the end of the course will have:

- A basic understanding of the relationship between material microstructure and macroscopic behavior of materials.
- An overall view of the materials used in nuclear power reactors, and an understanding of the basic mechanisms of materials degradation induced by neutron irradiation and the reactor environment including processes such as swelling, creep, phase transformations, embrittlement, and radiation induced segregation.
- The overall objective of the course is to enable the students (the majority of which may work directly in the nuclear materials area in the future) to understand the issues associated with materials degradation in nuclear reactors and be able to discuss said issues with others who do not have the appropriate background.

**4. Professional Component (ABET)**

This course provides 3 credits towards Engineering Sciences, and Students are required to apply advanced mathematics, science, and engineering science, including atomic and nuclear physics, and interaction of radiation with matter to understand and solve the issues of the radiation damage induced material degradations including volumetric swelling, radiation hardening and embrittlement, and elemental segregations in nuclear structural and fuel materials.

**5. Relationship of Course to Program Outcomes**

This course supports the following program outcomes:

- a. An ability to apply knowledge of mathematics, science, and engineering
- i. A recognition of the need for, and an ability to engage in life-long learning
- j. A knowledge of contemporary issues

**6. Instructor**

Dr. Assel Aitkaliyeva  
156 Rhines Hall  
352-846-3778  
[aitkaliyeva@mse.ufl.edu](mailto:aitkaliyeva@mse.ufl.edu)

**7. Office Hours:**

Mondays 1:45PM-3:45PM  
156 Rhines Hall

**8. Teaching Assistant**

N/A

**9. Meeting Times**

M, W, F: Period 6 (12:50-1:40 PM)

**10. Meeting Location**

Weil Hall (WEIL), Room 279

**11. Material and Supply Fees**

N/A

**12. Textbooks Required**

None required. Course notes and suggested reading material will be provided through Canvas.

**13. Recommended Reading**

Recommended Materials to Assist with Understanding Course Objectives

- Fundamentals of Radiation Materials Science, G. Was
- Fundamental aspects of nuclear reactor fuel elements, D. R. Olander
- Nuclear Reactor Materials and Applications by B. Ma

Recommended Texts and Support to Assist with Project Report Writing

- The Mayfield Handbook of Technical and Scientific Writing (available at <http://www.mhhe.com/mayfieldpub/tsw/toc.htm>). *Excellent resource and free!*
- The University of Florida Reading and Writing Center is also available to help students become better readers and writers. More information (including operating hours) can be found at <http://www.at.ufl.edu/rwcenter>.

**14. Course Outline**

The following topics will be covered in the course:

**Overview:**

- Course introduction
- Introduction to nuclear materials

**Fundamental materials science:**

- Introduction to materials science

- Crystal structures
- Point defects
- Line defects
- Volume defects
- Diffusion
- Phase diagrams

**Radiation damage:**

- Damage cascades
- Displacement energies, collision theory, energy loss
- Displacement cross-sections
- SRIM, range, damage
- Ion vs. neutron damage
- Microstructure evolution

**Mechanical properties:**

- Creep
- Hardening
- Toughness

**Fuel:**

- Chemistry, fabrication, failure
- Microstructural changes
- Fission products
- Swelling
- Property changes

**Other issues:**

- Hydriding
- Corrosion
- Accident behavior

**Notice:** We **will not have classes** on the following dates: **January 20<sup>th</sup>, March 2-6<sup>th</sup>, March 13<sup>th</sup>, March 22<sup>nd</sup>, and April 24-25<sup>th</sup>** due to scheduled travel, holiday, spring break, and reading days.

**Note:** Course schedule may also change due to unscheduled travel, in which case you will be notified via Canvas and in class. I reserve the right to hold make-up classes if necessary (for example, in case of class cancellations due to weather).

### **15. Attendance and Expectations**

Proper behavior in class is always important and leads to a relaxed and productive educational environment. Thus, eating, drinking, texting, reading of newspapers, working on homework for this or other courses, or other activities that are not part of the class are not allowed. Students who do not comply with these requirements or who behave disorderly or disrespectfully may be asked to leave the classroom. Cell phone use during class is discouraged as you should be paying attention to the course content. Students **MUST** participate during classes, and especially during the student presentations at the end of the course in order to successfully complete the course. Attendance is a

requirement worth 5% of the final grade, and participation is worth another 5% of the grade.

**16. Grading**

Homework	10%
Quizzes	20%
Project Final Report	30%
Project Oral Presentation	20%
Final Exam	10%
Attendance and participation	10%

**Homework**

Homework will be assigned some Fridays and due the next Friday (by 5 PM). Homeworks submitted after 5 PM on the due day will be considered as submitted the next day. Late homeworks will receive a penalty of 10% per day late. Homeworks submitted after one week after the due date will not be accepted.

**Quizzes**

Quizzes will be given during the semester and will be assigned during the normal class time or given on Canvas depending on the time constraints. Policies for each quiz will be detailed the class period before the exam. Pop-up in-class quizzes will be held periodically and will not be announced ahead of the time.

**Final Exam**

A 2-hour final exam will take place on **Monday, April 29<sup>th</sup>** from **10:00 AM** till **12:00 PM**. The final exam will be cumulative. The exam may consist of multiple choice, calculations, diagram interpretation, and/or short answer questions.

**Project Report**

Students are asked to form research groups of 2-3 investigators each, depending on the size of the class. More information on the team projects will be provided during team assignments. The report shall be written up in the format of a peer-reviewed journal article. Student teams will submit one manuscript with the division of labor documented in acknowledgement section. The course instructor will verify independently the division of effort on both the project and the manuscript – targeted to be split evenly. As part of this, you will perform team self-assessments.

Project teams will be formed by the instructor on **Monday, January 28<sup>th</sup>** and the topics should be selected by the team members before **Friday, February 8<sup>th</sup>**.

Substantial penalties will result from plagiarism and data falsification including automatic course failure and possible expulsion. Grades for the final design manuscripts will be based upon (1) technical content, and (2) writing style. Students are asked to prepare their papers according to the author instructions for

the Journal of Nuclear Materials (but others mentioned in the recommended reading are acceptable too).

Students are asked to follow the instructions to the letter, except for the following:

- Limit your total number of pages of text (Abstract to Conclusions) to no more than 15 pages and no fewer than 10 pages. (single spaced)
- Submit only one copy of the Manuscript per group (including all tables and figures) in pdf format. MS word is also acceptable, but you are held responsible for any formatting changes between computers that can happen with Word.
- Each paper must have at least four tables and figures (combined).
- Each paper must have at least 5 peer-reviewed journal article citations (beyond textbooks or conference proceedings).

Each manuscript will be submitted with a cover letter to the appropriate Editor-in-Chief noting why you think your work is worthy of publication. Final manuscripts from all groups are due on **Monday, April 15<sup>th</sup> by 5:00 PM.**

Late submissions will receive a penalty of 10% per day late. Manuscripts submitted after 5:00 PM on the due day will be considered as submitted the next day.

### **Project Presentation**

On **Friday, April 19<sup>th</sup>** (teams 1-3), **Monday, April 22<sup>nd</sup>** (teams 4-6), and **Wednesday, April 24<sup>th</sup>** (teams 7-10) we will meet during our normal class schedule to hold oral presentations on your assigned projects. Each project 2-3 member team will prepare a PowerPoint Presentation for viewing to the class. Each presentation will be limited to 12 minutes with 1-3 minutes for questions. Typically, one partner will address the introduction of the problem, and give the materials and methods. Then, the other partner will discuss results and conclusions.

Presentations need to be sent to the instructor at least one day before your presentation date so they can be uploaded (not the night or the morning of).  
***Presentations sent on the day of the presentation will receive a penalty of 10%.***

## **17. Grading Scale**

The grading scale is generally as follows:

Percent	Grade
93-100	A
90-92	A-
87-89	B+
83-86	B
80-82	B-
77-79	C+
73-76	C

70-72	C-
67-69	D+
63-66	D
60-62	D-
0-59	E

For more information on grades and grading policies, please visit:  
<http://www.registrar.ufl.edu/catalog/policies/regulationgrades.html>”

### **18. Make-up Exam Policy**

Make-up Exams and Laboratory Experiments are only allowed through prior requests or DOCUMENTED medical reasons. In cases where students will be out of town, a reasonable attempt to take the exam before the scheduled exam date will be performed.

### **19. Students Requiring Accommodations**

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, <https://www.dso.ufl.edu/drc>) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

### **20. Course Evaluation**

Students are expected to provide feedback on the quality of instruction in this course by completing online evaluations at <https://evaluations.ufl.edu/evals>. Evaluations are typically open during the last two or three weeks of the semester, but students will be given specific times when they are open. Summary results of these assessments are available to students at <https://evaluations.ufl.edu/results/>.

### **21. University Honesty Policy**

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Honor Code (<https://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor.

### **22. Software Use**

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as

appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

### 23. Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <http://registrar.ufl.edu/catalog0910/policies/regulationferpa.html>

### 24. Campus Resources:

#### Health and Wellness

**U Matter, We Care:**

If you or a friend is in distress, please contact [umatter@ufl.edu](mailto:umatter@ufl.edu) or 352 392-1575 so that a team member can reach out to the student.

**Counseling and Wellness Center:** <http://www.counseling.ufl.edu/cwc>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

**Sexual Assault Recovery Services (SARS)**

Student Health Care Center, 392-1161.

**University Police Department** at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

#### Academic Resources

**E-learning technical support**, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. <https://lss.at.ufl.edu/help.shtml>.

**Career Resource Center**, Reitz Union, 392-1601. Career assistance and counseling. <https://www.crc.ufl.edu/>.

**Library Support**, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

**Teaching Center**, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. <https://teachingcenter.ufl.edu/>.

**Writing Studio**, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers. <https://writing.ufl.edu/writing-studio/>.

**Student Complaints Campus:**

[https://www.dso.ufl.edu/documents/UF\\_Complaints\\_policy.pdf](https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf).

**On-Line Students Complaints:** <http://www.distance.ufl.edu/student-complaint-process>.