# Introduction to Nuclear Reactor Materials

ENU 4800-06FA (12473)
Spring 2022, T 8:30-10:25AM and R 8:30-9:20AM
Location: TUR 2349

## 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. Instructor

Dr. Assel Aitkaliyeva
176 Rhines Hall
352-846-3778
aitkaliyeva@mse.ufl.edu

## 6. Office Hours:

Mondays: 1:00PM-2:00PM
Thursdays: 2:00PM-3:00PM
176 Rhines Hall

## 7. Textbooks Required

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

## 8. Recommended Reading

*Recommended Materials to Assist with Understanding Course Objectives*

- Fundamentals of Radiation Materials Science: Metals and Alloys, G. Was, Springer Berlin 2007, ISBN 978-3-540-49472-0.
- Light Water Reactor Materials, Volume I: Fundamentals, A.T. Motta, D.R. Olander, ANS 2017, ISBN: 978-0-89448-461-2
- Light Water Reactor Materials, Volume II: Applications, A.T. Motta, D.R. Olander, ANS 2021, ISBN: 978-0-89448-467-4

*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.

## 9. Course Schedule

Week 1: Introduction, point defects/Homework 1 assigned
Week 2: Diffusion and phase diagrams/Homework 1 due/Homework 2 assigned
Week 3: Line defects and mechanical properties of materials/Homework 2 due/Homework 3 assigned
Week 4: Volume defects and radiation damage/Homework 3 due
Week 5: Damage rate theory/Exam 1/Homework 4 assigned
Week 6: Damage rate theory/Homework 4 due
Week 7: Dimensional instability/Homework 5 assigned
Week 8: Irradiation hardening/Homework 5 due
Week 9: Corrosion, stress corrosion cracking, and irradiation assisted stress corrosion cracking/Exam 2
Week 10: Oxide fuels/Term project written report due
Week 11: Metal fuels/Quiz 1
Week 12: Fuel properties/Exam 3
Week 13: Design base accidents/Quiz 2
Week 14: Short- and long-term solutions to material problems/Quiz 3
Week 15: Term project oral presentations
Week 16: Recap and preparation for final exam

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

## 10. Attendance and Expectations

Students MUST participate during classes, and especially during the student presentations at the end of the course to successfully complete the course. 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/zoom room. Cell phone use during class is prohibited.

## 11. Grading

| Assignment | Total Points | Percentage of Final Grade |
|---|---|---|
| Homework Sets (5) | 100 each | 20% |
| In-class exams:<br>1. Exam 1<br>2. Exam 2<br>3. Exam 3<br>4. Exam 4 (final) | 100 each | 20% |
| Project Report:<br>1. Outline<br>2. Second draft<br>3. Final draft | 100 each | 20% |
| Project Presentation | 100 | 20% |
| Nuclear made simple video series | 100 each | 10% |
| In class quizzes | 100 | 5% |
| Attendance and participation | 100 | 5% |

### Homework

Late homeworks will receive a penalty of 10% per day late. Homeworks submitted after one week after the due date will not be accepted.

### Exams

Four exams will be given during the semester. Policies for each exam 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. A 2-hour final exam will take place on **April 25th** from **10:00AM** till **12:00PM**. All exams 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. Student teams will submit one report 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 **Tuesday, January 18th** and the topics should be selected by the team members before **Tuesday, January 25th.**

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 will be provided with guidance and examples on how to structure a report. Also note that:

- 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 a copy of the report per group (including all tables and figures) in pdf and in MS word formats.
- Each paper must have at least 4 tables and figures (combined).
- Each paper must have at least 10 peer-reviewed journal article citations (beyond textbooks or conference proceedings).

Late submissions will receive a penalty of 10% per day late. Manuscripts submitted after the time indicated on Canvas will be considered as submitted the next day.

**Project Presentation**
On **Tuesday, April 12th** (teams 1-5) and **Thursday, April 14th** (teams 6-7) 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%.***

## 12. Grading Scale

The grading scale is as follows:

| Percent | Grade | Grade Points |
|---|---|---|
| 93.4 - 100 | A | 4.00 |
| 90.0 - 93.3 | A- | 3.67 |
| 86.7 - 89.9 | B+ | 3.33 |
| 83.4 - 86.6 | B | 3.00 |
| 80.0 - 83.3 | B- | 2.67 |
| 76.7 - 79.9 | C+ | 2.33 |
| 73.4 - 76.6 | C | 2.00 |
| 70.0 - 73.3 | C- | 1.67 |
| 66.7 - 69.9 | D+ | 1.33 |
| 63.4 - 66.6 | D | 1.00 |
| 60.0 - 63.3 | D- | 0.67 |
| 0 - 59.9 | E | 0.00 |

More information on UF grading policy may be found at:
https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

## 13. 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.

## 14. Students Requiring Accommodations

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting https://disability.ufl.edu/students/get-started/. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

## 15. Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

**16. In-Class Recording**

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third-party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

***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 Conduct Code (https://sccr.dso.ufl.edu/process/student-conduct-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. If you have any questions or concerns, please consult with the instructor or TAs in this class.

***Commitment to a Safe and Inclusive Learning Environment***

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:
• Your academic advisor or Graduate Program Coordinator
• Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@ufl.edu
• Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
• Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

***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.

***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: https://registrar.ufl.edu/ferpa.html

***Campus Resources:***
*Health and Wellness*

**U Matter, We Care:**
Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

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

**Sexual Discrimination, Harassment, Assault, or Violence**
If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

**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/.

**COVID-19**

- You are expected to wear approved face coverings at all times during class and within buildings even if you are vaccinated.
- If you are sick, stay home and self-quarantine. Please visit the UF Health Screen, Test & Protect website about next steps, retake the questionnaire and schedule your test for no sooner than 24 hours after your symptoms began. Please call your primary care provider if you are ill and need immediate care or the UF Student Health Care Center at 352-392-1161 (or email covid@shcc.ufl.edu) to be evaluated for testing and to receive further instructions about returning to campus.
- If you are withheld from campus by the Department of Health through Screen, Test & Protect, you are not permitted to use any on campus facilities. Students attempting to attend campus activities when withheld from campus will be referred to the Dean of Students Office.
- UF Health Screen, Test & Protect offers guidance when you are sick, have been exposed to someone who has tested positive or have tested positive yourself. Visit the UF Health Screen, Test & Protect website for more information.
- Please continue to follow healthy habits, including best practices like frequent hand washing. Following these practices is our responsibility as Gators.

*Academic Resources*

**E-learning technical suppor***t*, 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://career.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://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/;https://care.dso.ufl.edu.

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