

Reactor Analysis and Computation I

ENU 4103 Section 2B30

Class Periods: M,W, Period 3-4, 9:35 am – 11:30 am

Location: M – TUR 2349, W – TUR 2342

Academic Term: Spring 2025

Instructor:

Justin Watson

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(352) 237-0241

Office Hours: 178 Rhines Hall, Wednesday 1:00 pm – 3:00 pm, or by appointment

Teaching Assistant/Peer Mentor/Supervised Teaching Student:

None

Course Description

Four one-hour lectures discussing neutron reactions, fission chain and criticality and neutron transport/diffusion for nuclear reactors. Neutron thermalization and thermal scattering kernels. Dynamic analysis of reactors including point and space-time models. Feedback and reactor dynamics and control. Short-term transient analysis and long-term time-dependence.

Course Pre-Requisites / Co-Requisites

ENU 4003 and ENU 4605 with minimum grades of C

Course Objectives

1. Students will develop a familiarity with basic topics in atomic and nuclear physics, interactions of radiation with matter, and neutron energy distributions. classical reactor physics and their application to simplified reactor geometries (HW 1-2, Exam 1, Final Exam).
2. Students will develop a familiarity with basic neutronics characteristics of both traditional light water reactors and non-light water reactors (HW 3, Exam 2, Final Exam).
3. Students will develop a familiarity with basic topics in classical reactor physics and their application to simplified reactor geometries, including time dependent behavior (HW 4-7, Exam 2, Final Exam).
4. Students will learn modern computer programming techniques for solving classical reactor physics problems, including Monte Carlo methods (Project).
5. Students will demonstrate proficiency in solving reactor physics problems using modern computer programming techniques (HW 6).
6. Students will demonstrate an ability to document computer model development and numerical analysis, including any assumptions or approximations necessary to address the problem statement (Project).

Materials and Supply Fees

None

Relation to Program Outcomes (ABET):

Outcome	Coverage*
1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	High
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare,	Medium

as well as global, cultural, social, environmental, and economic factors	
3. An ability to communicate effectively with a range of audiences	Low
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	Low
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies	

*Coverage is given as high, medium, or low. An empty box indicates that this outcome is not covered or assessed in the course.

Required Textbooks and Software

- Introduction to Nuclear Engineering, Fourth Edition
- John R. Lamarsh and Anthony J. Baratta
- 2018, Fourth Edition
- 0134570057

Recommended Materials

- Nuclear Reactor Physics
- Weston M. Stacey
- 2018 Third Edition
- 978-527-41366-9

Required Computer

UF student computing requirement: <https://news.it.ufl.edu/education/student-computing-requirements-for-uf/>

Course Schedule

Week 1:	Introduction Atomic and Nuclear Physics (L&B Chapter 2): Atomic structure; nuclear forces; binding energy and mass defect; nuclear stability; excited states; magic numbers; nuclear decay.
Week 2:	1/20/2025 Martin Luther King , Jr. Day (No Class) Atomic and Nuclear Physics (L&B Chapter 2) : Atomic structure; nuclear forces; binding energy and mass defect; nuclear stability; excited states; magic numbers; nuclear decay.
Week 3:	Interactions of Neutrons with Matter (L&B Chapter 3): Neutron interactions, neutron cross-sections, neutron attenuation, neutron flux, energy loss in scattering collisions, fission, gamma-ray interactions with matter, charged particles.
Week 4:	Interactions of Neutrons with Matter (L&B Chapter 3): Neutron interactions, neutron cross-sections, neutron attenuation, neutron flux, energy loss in scattering collisions, fission, gamma-ray interactions with matter, charged particles.

Week 5:	<i>Nuclear Reactors and Nuclear Power (L&B Chapter 4):</i> The fission chain reaction, nuclear reactor fuels, non-nuclear components of nuclear power plants, components of nuclear reactors, power reactors and nuclear steam supply system, nuclear cycles, isotope separation, fuel reprocessing, radioactive waste disposal.
Week 6:	<i>Exam 1 Review</i> <i>Nuclear Reactors and Nuclear Power (L&B Chapter 4):</i> The fission chain reaction, nuclear reactor fuels, non-nuclear components of nuclear power plants, components of nuclear reactors, power reactors and nuclear steam supply system, nuclear cycles, isotope separation, fuel reprocessing, radioactive waste disposal. <i>2/19/2025 Exam 1</i>
Week 7:	<i>Nuclear Reactors and Nuclear Power (L&B Chapter 4):</i> The fission chain reaction, nuclear reactor fuels, non-nuclear components of nuclear power plants, components of nuclear reactors, power reactors and nuclear steam supply system, nuclear cycles, isotope separation, fuel reprocessing, radioactive waste disposal.
Week 8:	<i>Neutron Diffusion and Moderation (L&B Chapter 5):</i> Neutron flux, Fick's Law, the equation of continuity, the diffusion equation, boundary conditions, solutions of the diffusion equation, the diffusion length, the group-diffusion method, thermal neutron diffusion, two-group calculation of neutron moderation,
Week 9:	<i>Neutron Diffusion and Moderation (L&B Chapter 5):</i> Neutron flux, Fick's Law, the equation of continuity, the diffusion equation, boundary conditions, solutions of the diffusion equation, the diffusion length, the group-diffusion method, thermal neutron diffusion, two-group calculation of neutron moderation.
Week 10:	<i>Spring Break (No Class)</i>
Week 11:	<i>Exam 2 Review</i> <i>Introduction to Numerical Methods:</i> Numerical Methods for Solving Neutron Diffusion Eq., Monte Carlo Methods, OpenMC. <i>3/26/2025 Exam 2</i>
Week 12:	<i>Nuclear Reactor Theory (L&B Chapter 6):</i> One-group reactor equation, the slab reactor, other reactor shapes, the one-group critical equation, thermal reactors, reflected reactors, multigroup calculations, heterogeneous reactors.
Week 13:	<i>Nuclear Reactor Theory (L&B Chapter 6):</i> One-group reactor equation, the slab reactor, other reactor shapes, the one-group critical equation, thermal reactors, reflected reactors, multigroup calculations, heterogeneous reactors.
Week 14:	<i>Nuclear Reactor Theory (L&B Chapter 6):</i> One-group reactor equation, the slab reactor, other reactor shapes, the one-group critical equation, thermal reactors, reflected reactors, multigroup calculations, heterogeneous reactors. <i>The Time-Dependent Reactor (L&B Chapter 7):</i> Classification of time problems, reactor kinetics, control rods and chemical shim, temperature effects on reactivity, fission product poisoning, core properties during lifetime. <i>4/16/2025 Project Report Due</i>

Week 15:	<i>The Time-Dependent Reactor (L&B Chapter 7):</i> Classification of time problems, reactor kinetics, control rods and chemical shim, temperature effects on reactivity, fission product poisoning, core properties during lifetime.
Week 16:	<i>5/2/2025 Final Exam @ 10:00 am – 12:00 pm</i>

HW Topic Listing

1. Atomic and Nuclear Physics
2. Interaction of Radiation with Matter, Neutron Energy Distributions
3. Nuclear Reactors and Nuclear Power
4. Neutron Diffusion and Moderation
5. Nuclear Reactor Theory (1/2)
6. Nuclear Reactor Theory (2/2)
7. The Time Dependent Reactor

Project: Monte Carlo Simulation of a simplified nuclear reactor.

Exams:

1. Atomic and Nuclear Physics, Interactions, Neutron Energy Distributions
2. Nuclear Power, Neutron Diffusion and Moderation, Nuclear Reactor Theory
3. Final exam is comprehensive but will focus on Nuclear Reactor Theory and Reactor Kinetics

Attendance Policy, Class Expectations, and Make-Up Policy

Students are expected to attend all class lectures, barring meritorious professional or University-sanctioned personal reasons. Particularly meritorious reasons are expected for any absence from exams. Whether or not your justification for your absence is acceptable (other than those that are sanctioned by the University) is at the sole discretion of the instructor. Notify the Instructor and check to see if it is acceptable as soon as you know you will be absent. Attendance will be taken at the beginning of each class and will be included as part of the course grading. In addition, material will be covered during the lectures not covered in the text, it is the responsibility of the student to take notes during lecture.

Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies. Click here to read the university attendance policies:

<https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/>

Class distractions such as cell phones are unacceptable, and the use of such devices are prohibited during the lectures. Students will ensure that any such device into the classroom will be turned off or put on silent mode. Such disruptions (including texting) will lead to the student being told to leave the room for the duration of the class period, including during examinations periods. NOTE: if a pop quiz is given after the student is asked to leave, they will receive a zero as a grade for that pop quiz. Laptops, tablets, iPads, etc. are only allowed for note taking purposes. All other use is prohibited. If a student arrives late or leaves early, they are expected to do so with minimum level of disruption to the class in progress. If a pop quiz is given before or after the student is in the classroom, they will receive a zero for that pop quiz (no make-up).

All exams are cumulative, i.e. every topic that is covered prior to the exam day (including the latest class period) may be on the test. Your lowest exam grade will be dropped. If you are satisfied with your grade at the end of the semester, you may elect to not take the final exam.

Evaluation of Grades

Assignment	Total Points	Percentage of Final Grade
Homework Sets (7)	15 each	25%

Midterm Exam (2)	100 each	30%
Final Exam	100	15%
Project	100	30%
		100%

Grading Policy

Percent	Grade	Grade Points
92 - 100	A	4.00
88 - 91.9	A-	3.67
84 - 87.9	B+	3.33
81 - 83.9	B	3.00
78 - 80.9	B-	2.67
76 - 79.9	C+	2.33
73 - 75.9	C	2.00
70 - 72.9	C-	1.67
66 - 69.9	D+	1.33
63 - 65.9	D	1.00
60 - 62.9	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>

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.

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.bluer.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.aa.ufl.edu/public-results/>.

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 Honor 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. 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 or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values varied perspectives and lived experiences within our community and is committed to supporting the University’s core values, including the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of race, creed, color, religion, age, disability, sex, sexual orientation, gender identity and expression, marital status, national origin, political opinions or affiliations, genetic information, and veteran status.

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 Undergraduate Coordinator
- HWCoe Human Resources, 352-392-0904, student-support-hr@eng.ufl.edu
- Pam Dickrell, Associate Dean of Student Affairs, 352-392-2177, pld@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/>.

Academic Resources

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

Career Connections 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: <https://distance.ufl.edu/getting-help/>; <https://distance.ufl.edu/state-authorization-status/#student-complaint>.