Reactor Analysis and Computation 2

ENU 4104   Section 4104

Class Periods: T, Period 8-9, 3:00 pm – 4:55 pm, R, Period 9, 4:05 pm – 4:55 pm

Location: T,R FLG 0265

Academic Term: Fall 2025

Instructor:
Justin Watson
Justin.watson@ufl.edu
(352) 237-0241
Office Hours: 135A Rhines Hall, Mondays 3:00 pm – 5:00 pm

No Teaching Assistant
None

Course Description
A continuation of ENU 4103. Three one-hour lectures discussing physical principles and computational methods for reactor analysis and design. Multigroup diffusion theory; determination of fast and thermal group constants; cell calculations for heterogeneous core lattices. Dynamic analysis of reactors including point model and space-time models. Feedback and reactor dynamics and control.

Course Pre-Requisites / Co-Requisites
ENU 4103

Course Objectives

1. Students will develop a familiarity with basic methods and assumptions for reduction of the neutron transport equation to the diffusion approximation including multigroup diffusion (HW 1-2, HW 4-5, Exam 1 & 2, Final Exam).
2. Students will develop a familiarity with basic topics in nuclear reactor kinetics and dynamics (HW 3-4, Exam 2, Final Exam).
3. Students will develop a familiarity with fast and thermal spectrum calculations and cell calculations for heterogeneous core latices (HW 6-7, Exam 2, Final Exam).
4. Students will learn modern computer programming techniques for solving eigenvalue problems for Monte Carlo and finite difference methods (Project, Final Exam).
5. Students will demonstrate proficiency in solving reactor physics problems using modern computer programming techniques (Project).
6. Students will demonstrate an ability to document computer code 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, as well as global, cultural, social, environmental, and economic factors	Medium

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

- Nuclear Reactor Analysis
- James J. Duderstadt and Louis J. Hamilton
- 1976
- 0-471-22363-8

- OpenMC (openmc.org)

Recommended Materials

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

Course Schedule

Week 1:	***Introduction*** ***Review of Basic Concepts /Chapter 2 & 3 Duderstadt and Hamilton :*** Nuclear Reactions, Nuclear Fission, Multiplication Factor and Nuclear Criticality, Nuclear Power Reactors, Nuclear Reactor Design
Week 2:	***Neutron Transport/Chapter 4 Duderstadt and Hamilton:*** The Neutron Transport Equation, Direct Numerical Solution of the Transport Equation, The Diffusion Approximation Homework 1 Due 9/2/2025
Week 3:	***Neutron Transport/Chapter 4 Duderstadt and Hamilton:*** The Neutron Transport Equation, Direct Numerical Solution of the Transport Equation, The Diffusion Approximation
Week 4:	***The One-Speed Diffusion Theory Model/Chapter 5 Duderstadt and Hamilton:*** The One-Speed Diffusion Equation, Neutron Diffusion in NonMultiplying Equation, The One-Speed Diffusion Model of a Nuclear Reactor, Reactor Criticality Calculations, Perturbation Theory Homework 2 Due 9/14/2025

Week 5:	***The One-Speed Diffusion Theory Model/Chapter 5 Duderstadt and Hamilton:*** The One-Speed Diffusion Equation, Neutron Diffusion in NonMultiplying Equation, The One-Speed Diffusion Model of a Nuclear Reactor, Reactor Criticality Calculations, Perturbation Theory
Week 6:	***Exam 1 Review*** ***Nuclear Reactor Kinetics/Chapter 6 Duderstadt and Hamilton:*** The point Reactor Kinetics Model, Solution of the Point Reactor Kinetics Equations, Reactivity Feedback and Reactor Dynamics, Experiential Determination of Reactor Kinetics Parameters, Spatial Effects in Reactor Kinetics 9/2**3**/2025 Exam 1
Week 7:	***Nuclear Reactor Kinetics/Chapter 6 Duderstadt and Hamilton:*** The point Reactor Kinetics Model, Solution of the Point Reactor Kinetics Equations, Reactivity Feedback and Reactor Dynamics, Experiential Determination of Reactor Kinetics Parameters, Spatial Effects in Reactor Kinetics Homework 3 Due 9/29/2025
Week 8:	***Nuclear Reactor Kinetics/Chapter 6 Duderstadt and Hamilton:*** The point Reactor Kinetics Model, Solution of the Point Reactor Kinetics Equations, Reactivity Feedback and Reactor Dynamics, Experiential Determination of Reactor Kinetics Parameters, Spatial Effects in Reactor Kinetics
Week 9:	***Project Overview*** ***Multigroup Diffusion Theory/Chapter 7 Duderstadt and Hamilton:*** Heuristic Derivation of the Multigroup Diffusion Equations, Derivation of the Multigroup Equations from Energy-Dependent Diffusion Theory, Applications of the Multigroup Diffusion Model, Numerical Solution of the Multigroup Diffusion Equation, Multigroup Perturbation Theory Homework 4 Due 10/13/2025
Week 10:	***Multigroup Diffusion Theory/Chapter 7 Duderstadt and Hamilton:*** Heuristic Derivation of the Multigroup Diffusion Equations, Derivation of the Multigroup Equations from Energy-Dependent Diffusion Theory, Applications of the Multigroup Diffusion Model, Numerical Solution of the Multigroup Diffusion Equation, Multigroup Perturbation Theory
Week 11:	***Cell Calculations for Heterogeneous Core Lattices/Chapter 10 Duderstadt and Hamilton:*** Lattice Effects in Nuclear Reactor Analysis, Heterogeneous Effects in Thermal Neutron Physics, Heterogeneous Effects in Fast Neutron Physics Homework 5 Due 10/27/2025
Week 12:	***Fast Spectrum Calculations and Fast Group Constants/Chapter 8 Duderstadt and Hamilton:*** Neutron Slowing Down in an Infinite Medium, Resonance absorption (Infinite Medium), Neutron Slowing Down in Finite Media, Fast Spectrum Calculations and Fast Group Constants. 11/4/2025 Exam 2
Week 13:	**Project Work** Homework 6 Due 11/18/2025

Week 14	***Thermal Spectrum Calculations and Thermal Group Constants/Chapter 9 Duderstadt and Hamilton:*** General Features of Thermal Neutron Spectra, Approximate Models of Neutron Thermalization, General Calculations of Thermal Neutron Spectra 11/21/2025 Project Report Due
Week 15:	**No Class: Thanksgiving**
Week 16 (half-week, reading days):	***General Aspects of Nuclear Reactor Core Design/Chapter 11 Duderstadt and Hamilton:*** Nuclear Core Analysis, Reactor Calculation Models Homework 7 Due 12/1/2025
	12/9/2025 Final Exam 3:00 pm – 5:00 pm

HW Topic Listing (15 points each)

1. Basic Concepts, Neutron Transport (1/2)
2. Neutron Transport (2/2), One-Speed Diffusion Theory Model
3. Nuclear Reactor Kinetics (1/2)
4. Nuclear Reactor Kinetics (2/2), Multigroup Diffusion Theory
5. Multigroup Diffusion Theory
6. Fast and Thermal Spectrum Calculations
7. Cell Calculations for Heterogeneous Core Latices

Project: Numerical solution of pin wise eigenvalue problem for varying assembly compositions. (Groups of 2 will be used.)

Exams:

1. Neutron Transport, Once Speed Diffusion Theory
2. Nuclear Reactor Kinetics, Multigroup Diffusion Theory
3. Final exam is comprehensive but will focus on fast and thermal spectrum and cell calculations.

Attendance Policy, Class Expectations, and Make-Up Policy

Students are expected to attend all class lectures, barring meritorious professional or University-sanctioned personal reasons. 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. 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 lectures.

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/

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

The following is given as an example only.

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

Academic Policies & Resources

To support consistent and accessible communication of university-wide student resources, instructors must include this link to academic policies and campus resources: https://go.ufl.edu/syllabuspolicies. Instructor-specific guidelines for courses must accommodate these policies.

Commitment to a Positive 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.

If you feel like your performance in class is being impacted, 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