

Course Syllabus

Reactor Analysis I

ENU 6106

Class #: 12963, 24422, 24424, 24423

Sections: 17DB, 1FE2, OVER, 2FED

Class Periods: M,W,F|Period 5 (11:45 AM - 12:35 PM)

Location : NPB 1200 : Fall 2021

Welcome to the Course

(Official catalog version) Neutron reactions, fission and criticality for nuclear reactors. Analytical and numerical calculations for reactor design and analysis.

Key Course Elements

Course Objective

The focus of this course is an understanding of the modern practice of reactor physics. This entails both an understanding of classic deterministic reactor theory and concepts and governing equations that goes into computational Monte Carlo techniques, and how they are applied to the analysis of real reactors.

This course will require some facility with programming in a high level language (C++, FORTRAN, Matlab, Python, etc) to solve problems related to radiation transport and to apply concepts learned into applied problems and evaluations (often as self-study or homework, the benefit of such exercises is thus highly dependent on the effort exerted by each student). You are responsible for familiarizing yourself with these topics.

Classical Reactor Physics

- Overview of Reactor Physics
- Basic Neutronics
- Transport Theory Derivation
- Diffusion Theory and Thermal Diffusion Length
- Reactor Eq. as Diffusion w/Fission Source & Time Coupled Modes
- Solutions of Reactor Eq. in different Geometries & 1.5 Group Theory
- Reflected Reactors, Self-Shielding, Homogenization

- Perturbation Theory and Intro to Adjoint
- Adjoint Operators and Derivation of Adjoint Transport Eq.
- Feedback and Reactivity Coefficients
- Reactor Kinetics Crash Course
- Further Reactor Kinetics

Advanced Topics

- Multi-Group Theory
- Core Design
- Fuel Cycle
- Transport Theory
- Core Power Distributions/Peaking
- Reactivity Control

Course Structure

Instructor:

Dr. Justin Watson
178 Rhines Hall
Phone: 352-273-0241
Email: justin.watson@ufl.edu
Office Hours: By Appointment

Course Teaching Assistant (TA):

None

Course Pre-Requisites/Co-Requisites:

None

Materials and Supply Fees:

None

Required Textbook and Software:

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

Recommended Materials:

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

Lecture Materials:

Lectures will be given synchronously at during the assigned class time. On occasion, asynchronous lectures, example problem solutions, or other course material may be provided. Students are expected to attend all lectures.

Course Schedule:

| | |
|---------|---|
| Week 1: | <i>Introduction and Syllabus</i> <i>Basic Reactor Physics and Nuclear Reactions</i> <i>Neutron-Nucleus Interactions</i> |
| Week 2: | <i>Differential Scattering Cross Sections</i> <i>Kinematics of Neutron Scattering</i> |
| Week 3: | 9/6/2021 Labor Day (No Class) <i>Nuclear Motion</i> <i>Fission Chain Reaction and Criticality</i> Homework 1 |
| Week 4: | <i>Neutron Transport Equation</i> <i>The Diffusion Approximation</i> |
| Week 5: | 9/20/2021 Exam 1 <i>Project Overview</i> <i>Monte Carlo Solution Methodology</i> |
| Week 6: | <i>One-Speed Diffusion Equation</i> <i>Initial and Boundary Conditions</i> <i>Diffusion Equation Solution and Criticality</i> Homework 2 |

| | |
|----------|---|
| Week 7: | <p><i>Diffusion Equation Solution (Examples)</i></p> <p><i>Finite Difference Equations</i></p> <p><i>10/8/2021 Homecoming (No Class)</i></p> |
| Week 8: | <p><i>Numerical Methods</i></p> <p><i>Reflected, Criticality, and Multigroup Diffusion</i></p> <p>Project Part 1</p> |
| Week 9: | <p><i>Multigroup Neutron Diffusion Theory</i></p> <p><i>Multigroup Finite Difference</i></p> <p><i>Two-Group Diffusion Equation</i></p> |
| Week 10: | <p><i>Two-Group Diffusion Equation</i></p> <p><i>Two-Region Problem</i></p> <p><i>Nuclear Power and Nuclear Reactors</i></p> <p>Homework 3</p> |
| Week 11: | <p><i>Nuclear Power and Nuclear Reactors</i></p> <p>10/25/2021 Exam 2</p> |
| Week 12: | <p><i>Nuclear Power and Nuclear Reactors</i></p> <p><i>Homogenization</i></p> <p>Project Part 2</p> |
| Week 13: | <p><i>Neutron Slowing Down Theory</i></p> <p><i>Point Reactor Kinetics Equations</i></p> |
| Week 14: | <p><i>Point Reactor Kinetics Equations</i></p> <p>Homework 4</p> <p><i>Thanksgiving Break</i></p> |
| Week 15: | <p><i>Point Reactor Kinetics Equations</i></p> <p><i>Kinetics Parameter Determination</i></p> |
| Week 16: | <p><i>Reactivity Feedback</i></p> |

See [Modules](#) page for additional information.

Expectations and Evaluation

Attendance:

Students are expected to attend all class lectures. Attendance will not be included in the grade however, material will be covered during the lectures not covered in the text. The use of cell phones is prohibited during the lectures. Laptops/tablets can be used for taking notes.

Excused absences must be in compliance with university policies in the Graduate Catalog (<http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#attendance> (Links to an external site.)) and require appropriate documentation.

Grading Policy:

Grades will be given for all homework, semester project, and exams (except where explicitly stated) using the following weights:

Homeworks = 30%

Project = 40%

Exams = 30%

Grades will be assigned according to the following scale and will be curved at the discretion of the instructor:

| Grade | Percent | Grade Points |
|-------|----------|--------------|
| A | 92 - 100 | 4.00 |
| A- | 88 - 91 | 3.67 |
| B+ | 84 - 87 | 3.33 |
| B | 81 - 83 | 3.00 |
| B- | 78 - 80 | 2.67 |
| C+ | 76 - 79 | 2.33 |
| C | 73 - 75 | 2.00 |
| C- | 70 - 72 | 1.67 |
| D+ | 66 - 69 | 1.33 |
| D | 63 - 65 | 1.00 |
| D- | 60 - 62 | 0.67 |
| E | 0 - 59 | 0.00 |

Homework handed in up to 12 hours late will receive 30% off, homework handed in up to 24 hours late will receive 50% off. No homework will be accepted after 24 hours. [Links to an external site.](#)

Requests for re-grading of any course document should be submitted as a written request within one week of the graded document being returned. After one week, re-grading requests will no longer be considered.

In order to graduate, graduate students must have an overall GPA and an upper-division GPA of 3.0 or better (B or better). Note: A B- average is equivalent to a GPA of 2.67, and therefore, it does not satisfy this graduation requirement. More information on UF grading policy may be found at: <http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades> (Links to an external site.)

Final Exam:

Final Exam: 12/15/2021 @ 3:00 PM - 5:00 PM

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.bluera.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.

Online Course Recording

Our class sessions may be audio visually recorded for students in the class to refer back and for enrolled students who are unable to attend live. Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image. Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the "chat" feature, which allows students to type questions and comments live. The chat will not be recorded or shared. As in all courses, unauthorized recording and unauthorized sharing of recorded materials is prohibited.

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>

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 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://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>.

About Your Instructor



JUSTIN C. KYLE WATSON, PHD, ASSOCIATE PROFESSOR, received his B.S., M.S. and Ph.D. degrees in Nuclear Engineering from the Pennsylvania State University. He worked for the Applied Research Laboratory and had dual title with the Nuclear Engineering Department at the Pennsylvania State University before joining the faculty in the Department of Materials Science and Engineering, Nuclear Engineering Program at the University of Florida in September of 2018.

Research Group: [FAMMoS](#)