

ENU 6106 – Reactor Analysis 1
3 credits, Graduate Level, Fall 2018

1. Course Description

(Official catalog version) Credits: 3; three 1-hour lectures. Neutron reactions, fission and criticality for nuclear reactors. Analytical and numerical calculations for reactor design and analysis.

2. Prerequisites

None.

3. Instructors and Course Meetings

Andreas Enqvist, Director UFTR, Florida Power and Light Assistant Professor of Nuclear Engineering,
174 Rhines Hall
352-294-2177
enqvist@mse.ufl.edu

Lecture: CBD0234, MW 6-7 (1250-1445), an average of 3 hours/lectures will be used per week.

Office hours: TBD / by appointment.

4. Texts

Required Text: *Nuclear Reactor Analysis*, Duderstadt and Hamilton.

The following references will be useful for students needing additional background to the material presented in this class:

1. *Nuclear Reactor Physics*, Stacey, (ISBN:3527406794), more modern exhaustive application as relevant to various fuel cycles and applications. However, less detailed on basic concepts before application. More recommended if a student has already taken a reactor analysis/theory class before this one.
2. *Fundamentals of Nuclear Reactor Physics*, (ISBN-10: 0123706319), This new streamlined text offers a one-semester treatment of the essentials of how the fission nuclear reactor works, the various approaches to the design of reactors, and their safe and efficient operation. A good alternative/complement to D&H due to alternative modernized/simplified text and the appended practice problems.
3. *Introductory Nuclear Physics*, Krane, 1987 (3th edition). (ISBN: 047180553X). What it says on the tin: a book on nuclear physics.
4. *Introduction to Nuclear Engineering*, J. Lamarsh and T. Baretta, 3rd Edition, 2001 (ISBN number: 978-0201824988)
5. *Nuclear Reactor Theory*, Bell & Glasstone, 1970, (ISBN-13: 978-0442206840)
6. *Advanced Engineering Mathematics*, Kreyszig, 2011 (10th edition). (ISBN: 0470458364). Reactor physics and radiation transport are heavily mathematical subjects, this book gives a good

engineer's guide to using the math, without overemphasizing the theory; a solid reference for6 when you don't remember what a Bessel function is.

Additionally, I will place course notes on the Canvas electronic course web-site, as we progress through the lectures (mostly helpful in case of a missed class, no significant).

5. Course Outline

The focus of this course is an understanding of the modern *practice* of reactor physics. This entails an 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 (Matlab, Python etc), and the use of MCNP for radiation transport calculations to apply the 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.

Unit 1 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 Gp 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

HW-problem sections, multiple questions with hand-ins

Unit 2 Advanced Topics

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

- Reactor Noise

Project TBD (collection of problems, numerical solving or Monte Carlo coding/simulation) and possible 1 HW-problem section also

Class Projects/Homework

Homework/Projects turned in between the due date and the release of solutions will be worth 50% of their score had they been on time. Submissions will not be accepted after solutions are released. Solutions are typically released a week after the class period following the due date. There may be assignments for which no “late homework, half-credit” period will exist.

6. Attendance and Class Conduct

You’re a graduate student: attendance is not considered in the grade. However, many materials in the course will not be covered in the textbook or in the notes – only in class. Some example problems and complex figures fall into this category. Students are responsible for these materials.

7. Grading

There will be project/homework assignments and a final exam. Weights towards the final grade are as follows:

20% Project, 40% HW-sections, 40% Final Exam

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

- 93.0%+: A
- 90.0-92.9%: A-
- 87.0-89.9%: B+
- 83.0-86.9%: B
- 80.0-82.9%: B-
- 77.0-79.9%: C+
- 73.0-76.9%: C
- 70.0-72.0%: C-
- 67.0-69.9%: D+
- 63.0-66.9%: D
- 60.0-62.9%: D-
- 59.9% and lower: E

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. For more information on grades and grading policies, please visit: <http://gradschool.ufl.edu/catalog/current-catalog/catalog-general-regulations.html>

Final Exam

Final exam schedule is: 13D

Thurs. Dec 13th: 3:00 p.m. - 5:00 p.m, Exam Group D

8. 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 (<http://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 or TAs in this class.

Note that failure to comply with this commitment will result in disciplinary action compliant with the UF Student Honor Code Procedures. See <http://www.dso.ufl.edu/sccr/procedures/honorcode.php>

Addendum: Any academic dishonesty, including unauthorized collaborations on projects or copying of homework, and/or cheating on exams will be reported through appropriate official channels. If this is your first documented offense at UF, you should expect to receive, at minimum, a failing grade in this course. If you have prior offenses, I will recommend suspension or expulsion from UF, as appropriate.

9. UF Counseling Services

Resources are available on-campus for students having personal problems or lacking clear career and academic goals. The resources include:

- U Matter, We Care resources: <http://www.umatter.ufl.edu/>
- SafeZone+ Faculty.
- UF Counseling & Wellness Center, 3190 Radio Rd, 392-1575, <http://www.counseling.ufl.edu/cwc/Default.aspx>, counseling services and mental health services.
- **GatorWell:** GatorWell offers health promotion services on alcohol and other drugs (AOD), body image and eating concerns, sleep, stress, tobacco, sexual health, time management, healthy eating and active living, and interpersonal violence prevention.
- **Therapist Assisted Online (TAO):** TAO is a seven-week, interactive, web-based program that provides assistant to help overcome anxiety. Each of the seven weeks, participants will watch videos, complete exercises, and meet with a counselor via video conferencing for a 10-15 minute consultation. This is a great option if you are apprehensive about in-person counseling sessions.
- Also, within our College we have Deborah Mayhew (dmayh@eng.ufl.edu; 352-392-0944), who is a nationally certified counselor, and serves as Director of Engineering Student Development & First Year Advising for our students.
- University Police Department 392-1111

10. UF Counseling Services

Students are expected to provide feedback on the quality of instruction in this course based on 10 criteria. These evaluations are conducted online at <https://evaluations.ufl.edu>. 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>. 9

11. Accommodation for Students with Disabilities

Students requesting classroom accommodation must first register with the Dean of Students Office. That office will provide the student with documentation that he/she must provide to the course instructor when requesting accommodation.

12. Software Use:

All faculty, staff and student 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.