Nuclear Engineering 250

Nuclear Reactor Theory

Fall 2015

M W 10:00 - 12:00 PM

205 Wheeler

Course Objectives

The objectives of this course are to provide graduate students in Nuclear Engineering with a deep understanding of physical principles of reactor design and analysis.

Instructor

Rachel Slaybaugh
slaybaugh@berkeley.edu
4173 Etcheverry Hall
Office hours by appointment

Reader

Kelly Rowland
krowland@berkeley.edu
3115 Etcheverry Hall
Office hours TBD

Textbook

J.J. Duderstadt and L.J. Hamilton. *Nuclear Reactor Analysis.* John Wiley & Sons (1976), ISBN 0-471-22363-8

Additional Resources

- Class GitHub: https://github.com/rachelslaybaugh/NE250
- Bcourses: https://bcourses.berkeley.edu

- Free Python ebooks: http://www.leettips.org/2013/02/top-10-free-python-pdf-ebooks-download.html
- The Hacker Within: http://thehackerwithin.github.io/berkeley/
- Software Carpentry: http://software-carpentry.org/lessons.html
- Library: http://www.lib.berkeley.edu/node
- KAERI: http://atom.kaeri.re.kr/
- U.S. Nuclear Datahttp://www.nndc.bnl.gov/
- Serpent official website: http://montecarlo.vtt.fi/
- DECF (1171 and 1111 Etcheverry): http://www.decf.berkeley.edu/

Prerequisites

Students are expected to be familiar with the following topics:

- basic nuclear physics (i.e. interactions of radiation with matter, cross-sections, reaction rates, fission chain reaction, multiplication factor, four- and six-factor formula);
- solution of linear, first, and second order differential equations;
- vector calculus and special functions (Bessel functions, exponential integrals); and
- basic programming and unix knowledge.

Course Policies

Attendance is mandatory. Request approval for absence for extenuating circumstances prior to absence.

Take-home tests (homework) will be posted on bCourses biweekly. Assignments will require a considerable amount of time (don’t start working on it the night before!) and no extension will be granted. The lowest grade will be dropped (play it well!).

On an irregular schedule, but with a two weeks notice, a research paper will be assigned for reading. A student will be selected every week to prepare a critique of the paper based on an extensive literature review. The student will present their critique and a class discussion will follow. More details to be provided.
Grade proportion:

- Take-home tests (6): 60% (lowest grade is dropped)
- Paper critique: 30%
- In class participation: 10%

Grading scale (tentative): A+ $>$ 95%, A $>$ 91%, A- $>$ 87%, B+ $>$ 83%, B $>$ 79%, B- $>$ 75%, C+ $>$ 71%, C $>$ 67%, C- $>$ 63%, D+ $>$ 59%, D $>$ 55%, D- $>$ 50%, F $\leq$ 50%.

Classroom Decorum

This class leverages and thrives on the active participation of the students; therefore, it is preferable (meaning mandatory) that students turn off all electronic devices (laptop, tablets, cellphones, etc.) during class. Exceptions may be granted for note taking.

Academic Integrity

The student community at UC Berkeley has adopted the following Honor Code: "As a member of the UC Berkeley community, I act with honesty, integrity, and respect for others." The hope and expectation is that you will adhere to this code.

Collaboration and Independence: Reviewing lecture and reading materials and studying for exams can be enjoyable and enriching things to do with fellow students. This is recommended. However, unless otherwise instructed, homework assignments are to be completed independently and materials submitted as homework should be the result of one's own independent work.

Cheating: A good lifetime strategy is always to act in such a way that no one would ever imagine that you would even consider cheating. Anyone caught cheating on a quiz or exam in this course will receive a failing grade in the course and will also be reported to the University Center for Student Conduct. To guarantee that you are not suspected of cheating, please keep your eyes on your own materials and do not converse with others during the quizzes and exams.

Plagiarism: To copy text or ideas from another source without appropriate reference is plagiarism and will result in a failing grade for your assignment and usually further disciplinary action. For additional information on plagiarism and how to avoid it, see, for example:

http://www.lib.berkeley.edu/instruct/guides/citations.html#Plagiarism
http://gsi.berkeley.edu/teachingguide/misconduct/prevent-plag.html

Academic Integrity and Ethics: Cheating on exams and plagiarism are two common examples of dishonest, unethical behavior. Honesty and integrity are of great importance in all facets of life. They help to build a sense of self-confidence and are key to building trust within relationships, whether personal or professional. There is no tolerance for dishonesty in the academic world, for it undermines what we are dedicated to doing–furthering knowledge for the benefit of humanity. Your experience as a student at UC Berkeley is hopefully fueled by passion for learning and replete with fulfilling activities. We do appreciate that being a student can be stressful. There may be times when there is temptation to engage in some kind of cheating in order to improve a grade or otherwise advance your career. This could be as blatant as having someone else sit for you in an exam, or submitting a written assignment that has been copied from another source. It could be as subtle as glancing at a fellow student's exam when you are unsure of an answer to a question and are looking for some confirmation. One might do any of these things and potentially not get caught. However, if you cheat, no matter how much you may have learned in this class, you have failed to learn perhaps the most important lesson of all.

Accessibility

Please see me as soon as possible if you need particular accommodations, and we will work out the necessary arrangements.

Contents

We will cover these topics (subject to change):

- Fundamental neutron physics concepts
  - nuclear reactions
  - cross-sections
  - reaction rates
  - fission and chain reaction
  - multiplication factor
  - four- and six-factor formula
- The neutron transport equation as static balance
- The diffusion equation and separation of space and energy dependence
- The space-dependent neutron flux
  - flux shape in homogeneous regions
  - flux shape in slab, sphere, and cylindrical bare core
  - flux shape in multi-region cores
- The energy dependent neutron flux; multi-group diffusion
- Neutron slowing-down (fast spectrum calculations)
  - slowing down in hydrogen
  - slowing down in non-hydrogenous materials
  - slowing down with resonance absorption
- Thermal spectrum calculations
- Space and energy dependence in cell calculations
- Solving the neutron transport problem
  - the discretization approach: S_n theory
  - the spherical harmonic approach: P_n theory
- Perturbation theory and sensitivity analysis
- The adjoint transport equation
- Neutronics modeling tools: Serpent