

NPRE555: Reactor Theory I

University of Illinois, Urbana-Champaign

Fall 2025

Instructor: Prof. Kathryn Huff

Time: MW 1:00pm– 2:50pm

Email: kdhuff@illinois.edu

Place: 106B3 Engineering Hall

Course Pages:

1. <https://canvas.illinois.edu/courses/57908>
2. <https://github.com/katyhuff/NPRE555>
3. https://mediaspace.illinois.edu/playlist/dedicated/1_fetbf4t5/

Office Hours: Prof. Huff will hold office hours by appointment only and prefers to meet in her office, 111B Talbot Laboratory. Please make an appointment at <https://katyhuff.youcanbook.me>. If your colleagues might be helpful, please discuss your questions with them directly before scheduling office hours.

Main References: A few essential references for this course will be assigned as readings and will be the source of homework problems. The required texts for this course are [1] and [2]. I also recommend [3] for conceptual review and [4] for computational methods details. Electronic copies of these books can be found online if they are not available in the UIUC library.

- [1] Weston M. Stacey. *Nuclear reactor physics*. Wiley. com, 2007.
- [2] George I. Bell and Samuel Glasstone. *Nuclear Reactor Theory*. Van Nostrand Reinhold Company, New York, 1970.
- [3] James J. Duderstadt and William R. Martin. *Transport Theory*. Wiley, New York, 1979.
- [4] Elmer E. Lewis and Warren F. Miller Jr. *Computational Methods of Neutron Transport*. Amer Nuclear Society, La Grange Park, Ill, 2nd edition edition, January 1993.

Objectives:

- Advanced development of neutron transport theory
- neutron slowing-down,
- resonance absorption,
- approximations to the transport equation,

- direct numerical methods and other techniques of approximation theory applied to the neutron transport equation,
- and advanced topics.

Prerequisites:

- NPRE455 (waived for Physics Majors)

Grading Policy: Grades will be assigned as a weighted sum of the following work.

| Work | Weight |
|---------------|--------|
| Homework | (25%) |
| Journal Club | (25%) |
| Project 1 | (15%) |
| Project 2 | (15%) |
| Final Project | (20%) |
| Total | (100%) |

Homework: There will be a small number of homework assignments throughout the semester, approximately one every two weeks. If you use AI when completing your homework, please include a section of the homework describing its use in detail. I may spot check understanding with individual students through oral assessments. Insufficiently reported AI use may result a reduction of your homework grade.

Computational Projects: The computational projects will be submitted via GitHub Classroom and will be spaced evenly through the semester. The final project will be presented during the time reserved for this course's final exam.

Journal Club: A small library of original research papers will be provided for students to engage with. All students will be asked to submit short reviews of the papers. Individual students will each be assigned to present a review and summary of at least one of these papers to the class (15 minutes) over the course of the semester. Participation in class discussion during this activity by the student audience will constitute a fraction of the awarded grade for this activity.

Important Dates:

Project #1 1:00pm, Monday October 6, 2025
Project #2 1:00pm, Monday November 3, 2025
Final Project 5:00pm, Wednesday Dec. 17, 2025
Presentation 7:00pm–10:00pm, Wednesday Dec. 17, 2025

Class Policies:

Integrity: This is an institution of higher learning. Do not undermine its integrity. Academic dishonesty may result in a failing grade. Every student is expected to review and abide by the Academic Integrity Policy. Ignorance is not an excuse for any academic dishonesty. It is your responsibility to read this policy to avoid any misunderstanding. Note the [Student's Quick Reference Guide to Academic Integrity](#) and the [Academic Integrity Policy and Procedure](#).

Attendance: Regular class attendance is expected of all students at the university. Request approval for absence for extenuating circumstances prior to absence. If you are or become ill, please communicate with me and the Dean of Students regarding your expected need for accommodation in this class. I am willing, able, and ready to make necessary accommodations.

Electronics: Active participation is essential and expected. Accordingly, students should only use electronic devices (laptop, tablets, etc.) during class if engaging in computational exercises or taking notes.

Collaboration: Collaboratively reviewing course materials and working through homework problems with fellow students can be enriching. This is recommended. However, unless otherwise instructed, homework assignments are to be completed with individual attainment in mind and materials submitted as homework or computational assignments should be the result of one's own independent work.

Late Work: Late work has a half-life of 1 hour. That is, adjusted for lateness, your grade $G(t)$ is a decaying percentage of the raw grade G_0 . An assignment turned in t hours late will receive a grade according to the following relation:

$$G(t) = G_0 e^{-\lambda t}$$

where

$G(t)$ = grade adjusted for lateness

G_0 = raw grade

$$\lambda = \frac{\ln(2)}{t_{1/2}} = \text{decay constant}$$

t = time elapsed since due [hours]

$t_{1/2} = 1$ = half-life [hours]

Make-up Work: There will be no negotiation about late work except in the case of absence documented by an [Absence Letter](#) from the Dean of Students. Please note that such a letter is appropriate for many types of conflicts, but that religious conflicts require special early handling. In accordance with university policy, students seeking an excused absence for religious reasons should complete the Request for Accommodation for Religious Observances Form, which can be found on the Office of the Dean of Students website. The deadline for submitting this form is fairly early in the semester.

Emergency response recommendations can be found at [this website](#). I encourage you to review this website and the campus building [floor plans website](#) within the first 10 days of class. If you want to better prepare yourself for any of these situations, visit police.illinois.edu/safe. Remember you can sign up for emergency text messages at emergency.illinois.edu.

Grade Disputes: It is important that you understand and agree with the grade you receive on assignments. If you would like to dispute your score, you must send an explanation by email to Prof. Huff within one week of receiving the grade. **Do not expect me to regrade anything while in conversation with you** as that would not be fair to the other students in the class, whose homeworks were graded without them present. If you request a regrade, be aware that the entire assignment will be regraded and is subject to double-jeopardy: it is possible that your score will go down. Regrade requests should be based on an error on my part (e.g., adding up the points incorrectly) or what you suspect is a misunderstanding of your work (e.g., arriving at the correct answer using an unexpected technique). Regrade requests that argue with the rubric (e.g., “this is wrong, but you took too many points off”) will be returned without consideration. **Your work should stand alone.** If an assignment is disorganized or ambiguous, and requires an extensive explanation to the grader, you will likely still lose points. The homeworks not only evaluate your understanding of the material - they also evaluate your ability to communicate that understanding clearly and concisely.

Anti-Racism and Inclusivity Statement The Grainger College of Engineering is committed to the creation of an anti-racist, inclusive community that welcomes diversity along a number of dimensions, including, but not limited to, race, ethnicity and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs. The College recognizes that we are learning together in the midst of the Black Lives Matter movement, that Black, Hispanic, and Indigenous voices and contributions have largely either been excluded from, or not recognized in, science and engineering, and that both overt racism and micro-aggressions threaten the well-being of our students and our university community. The effectiveness of this course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us. Everyone is expected to help establish and maintain an environment where students, staff, and faculty can contribute without fear of personal ridicule, or intolerant or offensive language. If you witness or experience racism, discrimination, micro-aggressions, or other offensive behavior, you are encouraged to bring this to the attention of the course director if you feel comfortable. You can also report these behaviors to the [Campus Belonging portal](#). Based on your report, Campus Belonging will follow up and reach out to students to make sure they have the support they need to be healthy and safe. If the reported behavior also violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.

Disability-Related Accommodations: The University of Illinois Champaign-Urbana, is committed to ensuring that all students, including students with disabilities, do not experience barriers to learning and participating fully in class. Students who have a letter of accommodation from DRES are advised to share that with instructors as soon as possible to ensure accommodation needs can be discussed and met.

To obtain disability-related academic accommodations, disabled students must contact Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES, please visit 1207 S. Oak Street, Champaign, call 217.333.1970, email disability@illinois.edu, or visit the DRES website: disability.illinois.edu.

Family Educational Rights and Privacy Act (FERPA): Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See [this link](#) for more information on FERPA.

Religious Observances It is the policy of the University of Illinois Urbana-Champaign

to reasonably accommodate its students' religious beliefs, observances, and practices that conflict with a student's class attendance or participation in a scheduled examination or work requirement, consistent with state and federal law. Students must make requests for accommodation in advance of the conflict to allow time for both consideration of the request and alternate procedures to be prepared. Requests should be directed to the instructor. The Office of the Dean of Students provides an optional resource on its website to assist students in making such requests. [this link](#) to request appropriate accommodations.

Land Acknowledgement: As a land-grant institution, the University of Illinois Urbana-Champaign has a responsibility to acknowledge the historical context in which it exists. In order to remind ourselves and our community, we begin this course with the following statement. We are currently on the lands of the Peoria, Kaskaskia, Piankashaw, Wea, Miami, Mascoutin, Odawa, Sauk, Mesquaki, Kickapoo, Potawatomi, Ojibwe, and Chickasaw Nations. It is necessary for us to acknowledge these Native Nations and for us to work with them as we move forward as an institution. Over the next 150 years, we will be a vibrant community inclusive of all our differences, with Native peoples at the core of our efforts. [Office of the Chancellor Land Acknowledgement Statement](#).

Sexual Misconduct Reporting Obligation: The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University's Title IX Office. In turn, an individual with the Title IX Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options.

A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found [here](#). Other information about resources and reporting is available here: wecare.illinois.edu.

Other Resources: University students typically experience a wide range of stressors during their time on campus. Accordingly, campus resources exist to help students manage stress levels, mental health, physical health, and emergencies while navigating this environment. I hope you will take advantage of these campus resources as soon as they can be of help.

- [The Campus Recreational Centers](#)
- [The Counseling Center](#)
- [The McKinley Mental Health Clinic](#)
- [The Emergency Dean](#)

Course Schedule: *Note that this schedule is subject to change*

| Date | Week | Day | Unit | Chap. Stacey | Chap. B&G | HW Given | HW Due |
|-------|------|-----|---------------------------|-----------------|--------------|-------------|-----------|
| 08-25 | 1 | M | Transport Eqn. | 9 | 1 | HW1 | |
| 08-27 | 1 | W | Transport Eqn. | 9 | 1 | CP1 | |
| 09-01 | 2 | M | Boundary Conds. | 9 | 1 | HW2 | HW1 |
| 09-03 | 2 | W | Boundary Conds. | 9 | 1 | | |
| 09-08 | 3 | M | Angle & Energy | 9 | 1 | | |
| 09-10 | 3 | W | Angle & Energy | 9 | 1 | | |
| 09-15 | 4 | M | Monte Carlo | 9.12 | 1&2 | HW3 | HW2 |
| 09-17 | 4 | W | Monte Carlo | 9.12 | 1&2 | | |
| 09-22 | 5 | M | Monte Carlo | 9.12 | 1&2 | | |
| 09-24 | 5 | W | Monte Carlo | 9.12 | 1&2 | | |
| 09-29 | 6 | M | P_N | 9 | 3 | HW4 | HW3 |
| 10-01 | 6 | W | P_N | 9 | 3 | | |
| 10-06 | 7 | M | Multi-group P_N | 9 | 4 | CP2 | CP1 |
| 10-08 | 7 | W | Multi-group P_N | 9 | 4 | | |
| 10-13 | 8 | M | P_N Eigenvalue Calcs. | 9 | 4 | HW5 | HW4 |
| 10-15 | 8 | W | P_N Eigenvalue Calcs. | 9 | 4 | | |
| 10-20 | 9 | M | S_N | 9 | 5 | | |
| 10-22 | 9 | W | S_N | 9 | 5 | | |
| 10-27 | 10 | M | S_N | 9 | 5 | HW6 | HW5 |
| 10-29 | 10 | W | S_N | 9 | 5 | | |
| 11-03 | 11 | M | Adjoint Eqn. | 13 | 6 | CP3 | CP2 |
| 11-05 | 11 | W | Adjoint Eqn. | 13 | 6 | | |
| 11-10 | 12 | M | Perturbation Theory | 13 | 6 | HW7 | HW6 |
| 11-12 | 12 | W | Variational Methods | 15 | 6 | | |
| 11-17 | 13 | M | Neutron Slowing Down | 10 | 7 | | |
| 11-19 | 13 | W | Neutron Slowing Down | 10 | 7 | | |
| 11-24 | 14 | M | Fall Break | | | | |
| 11-26 | 14 | W | Fall Break | | | | |
| 12-01 | 15 | M | Neutron Thermalization | 11 | 7 | HW8 | HW7 |
| 12-03 | 15 | W | Neutron Thermalization | 11 | 7 | | |
| 12-08 | 16 | M | Resonance Absorption | 12 | 11 | | HW8 |
| 12-10 | 16 | W | Resonance Absorption | 12 | 11 | | |
| 12-17 | 17 | W | Final Presentation | | | CP3 | |