Summer 2026
NRE 7203: Advanced Reactor Physics
Course Syllabus

Instructor: Dr. Dan Kotlyar

Office Location: Boggs 3-73

Office Hours: TR 12:00–13:00, by appointment

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Course Description:

This course covers the advanced and modern topics in reactor physics and transport theory for practical calculation route of fission systems.

Credit Hours: 3

Textbook:

Transport Theory, **Authors** James J. Duderstadt and William R. Martin; John Wiley (1979)
Reference: *Methods of Steady-State Reactor Physics in Nuclear Design*, **Authors**Stamm'ler and Abbate;
Reference: *Computational Methods in Neutron Transport*, **Authors**E. E. Lewis and W. F. Miller;

Course Objectives:

At the completion of this course, students will be able to:

1. Understand the practical multilevel approach for reactor analysis.
2. Understand various approaches to generate few-group macroscopic cross sections.
3. Understand the role of equivalence correction factors.
4. Understand and apply 3D core diffusion-based solutions.
5. Understand the standard branch-off technique and the corresponding tabulation approach.
6. Understand the burnup dependence and multi-cycle simulation.
7. Understand the complete computational sequence and apply to perform core design.

Grade Distribution:

Assignments ×(6-8)	75%
Final Project ×(1)	25%

List of planned assignments:

There are 6-8 planned assignments (mini-projects) during the semester. Reports must be all typed and submitted in either word or pdf formats. All the assignments will be a direct continuation of the workshops conducted in class. The submitted reports must be concise and clear. As this is a pilot class, the number of assignments may slightly alter, but these will accumulate to 75%.

1. Neutron transport using MC
2. Cross sections generation using MC
3. Analytic transport correction
4. Review of transport cross sections
5. Nodal solution (fixed source) with equivalence factors
6. Nodal solution with burnup
7. Complete nodal solution with branch-off tabulation
8. Investigation of numerical instabilities

Final project:

The final project must be typed and submitted in either word or pdf format. The final project will also be followed by a mandatory presentation. The project is currently planned as an individual project but depending on the class size this requirement may change. The project must cover the following aspects:

1. A specific core and fuel cycle.
2. Cross-section generation using branch-off analysis (the lecturer may provide help).
3. Fuel cycle analysis with a specific objective (defined by the lecturer, e.g., extended burnup).
4. Proposed optimization of the fuel cycle.

Course Policies:

- **General**
  - In-person attendance is strongly encouraged if possible. A virtual section will be available for every lecture.
  - Lecture (incomplete) notes are provided before each class. These notes will assist you to follow the lecture while completing the missing equations.
  - Interactive workshops will be provided in advance.
  - Office hours will be conducted virtually unless scheduled in advance as in-person.
- **Assignments**
  - Students are expected to work independently. Offering and accepting solutions from others is an act of plagiarism, and all involved parties will be penalized according to the Academic Honesty Policy. Discussion among students is encouraged, but when in doubt, direct your questions to the professor.
  - No late assignments will be accepted.
  - You must make sure the assignments are properly submitted via Canvas.
  - All assignment and project reports must be submitted in a single pdf file. The file name must include the home-work number and your name (e.g. NRE7203_SOL4_FirstLast.pdf).
  - The software and documentation must be provided with the submission. Clear expectations will be provided by the lecturer.

- Grading of each project will be done based on the report and the software package submitted. Among others, the grading will also examine the accuracy, execution time, and aesthetics of the code.
- After every assignment various champions will be announced (e.g., Best executor, best writer, and so on).
- Champions will receive symbolic awards throughout the semester.

- **Attendance and Absences**
  - Students are responsible for all missed work, regardless of the reason for absence. It is also the absentee's responsibility to get all missing notes or materials.
  - The office hours is a great opportunity to explain any material that was not well understood or missed.

Honer Code:

Scholastic Dishonesty is any act designed to give an unfair academic advantage to a student, or the attempt to commit such an act. This includes copying from another student's exam; possessing or using unauthorized materials during an exam; using, buying, stealing, transporting or soliciting a test or the answer key; collaborating with another student during a test; copying someone else's homework or assignment; and permitting someone to take a test for you. The falsification of academic records is also an act of scholastic dishonesty. Students who participate in scholastic dishonesty will be reported and dealt with in accordance with Institute regulations. Specific instructions will be provided on projects. Specific instructions will be given when the project(s) is assigned as to what is acceptable interaction between student teams. The complete Georgia Tech Honor Code is found at http://www.policylibrary.gatech.edu/student-affairs/academic-honor-code.

Mental Health & Wellness:

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, depression, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student's ability to participate in daily activities. GT offers services to assist you with addressing these and other concerns you may be experiencing. If you or someone you know is experiencing any of the issues noted above, consider utilizing the confidential mental health services available on campus. I encourage you to reach out to GT CARE (www.care.gatech.edu, 404-894-3498) or the Counseling Center (www.counseling.gatech.edu, 404-894-2575) for support. An on-campus counselor or after-hours services are available to assist you.

Acceptable Student Conduct

Students are expected to comply with the Student–Faculty Expectations Agreement and to maintain professional, respectful conduct in all course-related activities, including lectures, office hours, email communication, and instructional platforms.

Disability Services Statement

Georgia Tech provides reasonable accommodations for students with documented disabilities through the Office of Disability Services. Students requiring accommodations are encouraged to contact the Office of Disability Services and inform the instructor as early as possible.

Course Outline:
The weekly coverage might change as it depends on the progress of the class. Every lecture will include a theoretical part provided in the lecture notes and a hands-on workshop. Lecture notes and workshops will be uploaded to canvas before the lectures.

1. **Introduction and background**
   (a) Multilevel approach for core analysis
   (b) Multi-group cross-section generation with Monte Carlo codes
2. **Fundamentals and overview**
   (a) Anisotropy in neutron scattering
   (b) Condensation of cross sections
3. **The P_L approximation and diffusion theory**
   (a) General P_L equations
   (b) P_1 equations
   (c) The diffusion equation
   (d) The transport correction
   (e) Analytic transport correction ratio
4. **Review of Multi-group transport cross sections**
   (a) In-scatter
   (b) Out-scatter
   (c) Flux limited
   (d) The transport correction
   (e) Modern methods
5. **Spatial homogenization methodology**
   (a) Critical spectrum correction
   (b) The B_1 method for the asymptotic spectrum
6. **Equivalence Theory**
   (a) Assembly discontinuity factors (ADFs)
   (b) Reference discontinuity factors (RDFs)
   (c) Superhomogenization (SPH) factors
7. **Nodal Equations for 3D Reactor Calculations**
   (a) Two group analytic nodal method
   (b) Nodal expansion method
8. **Pin power reconstruction**

(a) If time permits

9. **Fuel cycle analysis**
   (a) Fuel depletion
   (b) Poisoning
   (c) Multi-cycle analysis
10. **Depletion**
    (a) Micro-depletion model
    (b) Time integration schemes (e.g., predictor-corrector method)
    (c) Stability of time integration schemes
11. **Coupled Thermal Analysis**
    (a) Thermal feedback
    (b) Doppler effect
12. **Multi-dimensional tabulations**
    (a) Cross sections
    (b) History effects
13. **Full core analysis**
    (a) Light Water Reactors (PWRs and BWRs)
    (b) Gas cooled Reactors