



NUCL 497, Simulation of Nuclear Reactor Physics using Nuclear Codes

CRN: 25926

1. 3 Credit Hours.

Class Time: Tuesdays/Thursdays

2. Instructor: Yunlin Xu, yunlin@purdue.edu, ph: 69033

Lecture time: Tuesdays/Thursdays 9:00 am - 10:15 am

Stanley Coulter Hall 179

Office hours: TBD, Room 5282, LMBS Hall

3. Textbook(s): None required.

Reference(s):

J. LEPPANEN, "PSG2/Serpent—A Continuous-Energy Monte Carlo Reactor Physics Burnup Calculation Code," VTT Technical Research Centre of Finland; Nov. 2008.

Y. Xu, T. Downar, GenPMAXS Code for Generating the PARCS Cross Section Interface File PMAXS, PU/NE-00-20 (Rev. 8) 2006

T. Downar, Y. Xu, V. Seker, N. Hudson, PARCS v3.0 U.S. NRC Core Neutronics Simulator UM-NERS-09-0001, March, 2010

<https://www.nrc.gov/docs/ML1200/ML120060239.pdf> TRACE V5.0 USER'S MANUAL

4. Course Description:

This course is a computer laboratory course. Students will use modern neutronics codes for nuclear reactor core simulation. 4 codes will be in this course.

1. MCNP/Serpent: Monte Carlo Neutron Transport Codes
2. GenPMAXS: a code to process Polaris or Serpent results and generate cross section libraries for PARCS
3. PARCS: a Nuclear reactor core physics simulator
4. TRACE: a Thermal hydraulic code for simulate Nuclear reactor system, TRACE can coupled with PARCS to perform coupled nuclear reactor physics and thermal hydraulic simulation for safety analysis

The physics and solution methods which are used in those codes will be briefly introduced.

There will be instructions provided to student about how to prepare input for those codes, how to run those codes and how to understand and use the output of those codes. This course will prepare students for their senior design.

These codes will be used to simulate TMI power plant unit 1 first cycle simulation including depletion, reactivity coefficient and control rod worth calculation as well as transient analysis. Serpent code will be used to generate assembly cross sections at all different history and thermal hydraulic conditions. GenPMAXS will be used to convert Serpent output to PARCS cross section library. And PARCS will be used for core simulation, TRACE/PARCS will be used for transient analysis. MCNP/Serpent codes will be used to simulated the reactor core and provide reference solution for comparisons.

There will be 5 labs

1. Nuclear reactor fuel Pin, and assembly with Serpent
2. Generate PARCS cross section library from Serpent output
3. Nuclear reactor cycle analysis with PARCS
4. Control rod worth and reactivity evaluation with PARCS
5. Nuclear reactor transient simulation with TRACE/PARCS

5. Prerequisites: NUCL 310, or any equivalent introductory course in reactor physics. If you don't meet prerequisites. The course material is presented at an intermediate level, not suitable for students with no background on reactor physics.

6. Classification: Selected

7. Learning Objectives:

- a. To learn the codes which are used in nuclear reactor physics simulation.
- b. To know how to setup numerical model for nuclear reactor core simulation.
- c. To understand the simulation results.
- d. To have skill set for nuclear reactor core design
- e. To have skill set for nuclear reactor safety analysis

Student Outcomes

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. An ability to communicate effectively with a range of audiences.
5. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.
6. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
7. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.

Grading: Projects: There will be 5 labs, 60% of total score

Presentation: 20% of total score

Attendance and Participation: 20% of total score

Guaranteed floors for letter grade

F	D-	D	D+	C-	C	C+	B-	B	B+	A-	A	A+
60	63.33	66.67	70	73.33	76.67	80	83.33	86.67	90	93.33	96.67	

Possible Adjustments:

Whole class adjustment if there are unreasonable requirements in labs

Minor adjustment (≤ 5 points) for students who made significant effort and improvement for the course

Project reports are due at midnight of due day, can be submitted earlier. Late submissions will have 5% per day reduction in score, and not accepted after a week from due day.

Regrade requests must be submitted with a written justification within a week after grade released to students.

Tentative Schedule

Weeks	Topic	Remark
1	Course introduction Tutorial on Unix/Linux commands	
2	Introduction of Monte-Carlo method for reactor physics simulation Overview on Nuclear Reactor Core Design and safety analysis tasks.	
3	Tutorial on prepare Serpent Input Hand on training on running Serpent TMI-1 cycle 1 introduction	Lab 1
4	Introduction of cross section homogenization Tallies for homogenous cross sections	
5	Students present Lab1 report Prepare cross sections with all possible conditions	Lab 2
6	Training on GenPAMXS input Hand on training on running GenPAMXS	
7	Tutorial on prepare GenPAMXS Input Introduce PARCS cross section model	
8	Students present Lab2 report Hand on training on running PARCS	Lab 3
9	Training on PARCS input Introduction of methods for core simulator PARCS	
10	Students present Lab3 report Hand on training on running TRACE Hand on training on running coupled TRACE/PARCS	Lab 4
11	Tutorial on prepare TRACE input	

	Introduction of method for system thermal hydraulics simulation	
12	Students present Lab4 report Coupled Neutronic and Thermal hydraulic simulation Prepare data for safety analysis	Lab 5
13	Introduction of generalized equivalence theory	
14	Methods for generate equivalent parameters from reference lattice solution	
15	Introduction of Generate cross section and generalized equivalence factors from Monte-Carlo results. Generate cross section and equivalent parameters from Monte-carlo whole core solution.	
16	Students present Lab5 report	