NUCL 497: Simulation of Nuclear Reactor Physics using Nuclear Codes
Syllabus for Fall 2021

Course Overview

This course is a computer laboratory course. Students will use modern neutronics codes for nuclear reactor core simulation. 5 codes will be used in this course.

1. Polaris: a Deterministic Neutron Transport code
2. Serpent: a Monte Carlo Neutron Transport Code
3. GenPMAXS: a code to process Polaris or Serpent results and generate cross section libraries for PARCS
4. PARCS: a Nuclear reactor core physics simulator
5. 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 method 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.

There will be 10 labs

1. Pin cell simulation with Polaris
2. Assembly simulation with Polaris
3. Generate PARCS cross section library from Polaris output
4. Pin Cell Simulation with Serpent
5. Assembly simulation with Serpent
6. Nuclear reactor core simulation with Serpent
7. Generate PARCS cross section library from Serpent output
8. Nuclear reactor core cycle analysis with PARCS
9. Control rod worth and reactivity evaluation with PARCS
10. Nuclear reactor transient simulation with TRACE/PARCS

3 Credit Hours

Prerequisites: NUCL 310

Instructor(s): Yunlin Xu
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Textbook(s): None required.

Reference(s):

B. T. Rearden and M.A. Jessee, Eds., SCALE Code System, ORNL/TM-2005/39, Version 6.2.3, Oak Ridge National Laboratory, Oak Ridge, Tennessee (2018).

J. LEPPA¨ NEN, "PSG2/Serpent—A Continuous-Energy Monte Carlo Reactor Physics Burnup Calculation Code," VTT Technical Research Centre of Finland; Nov. 2008.
T. Downar, Y. Xu, V. Seker, N. Hudson, PARCS v3.0 U.S. NRC Core Neutronics Simulator UM-NERS-09-0001, March, 2010

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

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 10 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	

There will be no curve with percentage.

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

Tentative Schedule

Weeks	Topic	Remark
1	Course introduction Introduction for solution methods used in Polaris which is part of Scale package. Training on how to prepare Polaris input	
2	Hand on training for running Polaris Explain output of Polaris, Discussing Nuclear Data library for Polaris	Lab1
3	Students present Lab1 report Discussing advantage and approximations and possible improvement of Polaris	Lab 2
4	Students present Lab2 report Training on GenPAMXS input Hand on training on running GenPMAXS	Lab3
5	Students present Lab3 report Introduction of Monti-carlo method for reactor physics simulation Training on Serpent input Hand on training on running Serpent	Lab 4
6	Students present Lab4 report Introduction of cross section homogenization Tallies for homogenous cross sections	Lab 5
7	Students present Lab5 report Introduction of Generate cross section and generalized equivalence factors from Serpent.	Lab 6
8	Students present Lab6 report Training on PARCS input Hand on training on running PARCS	Lab 7
9	Training on TRACE input Hand on training on running TRACE	
10	Students present Lab7 report Coupled Neutronic and Thermal hydraulic simulation Hand on training on running coupled TRACE/PARCS	Lab 8
11	Introduction of methods for core simulator PARCS Introduction of method for system thermal hydraulics simulation	
12	Students present Lab8 report	Lab 9

	PARCS cross section model Prepare cross sections with all possible conditions	
13	Method for cycle analysis Prepare data for real reactor cycle simulation	
14	Students present Lab9 report Prepare data for safety analysis Introduction of generalized equivalence theory	Lab 10
15	Methods for generate equivalent parameters from reference lattice solution	
16	Students present Lab10 report Generate cross section and equivalent parameters from Monte-carlo whole core solution	