UNIVERSITY OF ILLINOIS
DEPARTMENT OF NUCLEAR, PLASMA AND RADIOLOGICAL ENGINEERING
NPRE 449: Nuclear Systems Engineering and Design (3 credit hours)
Fall 2026

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Engineering principles underling nuclear power plant components and systems will be covered. Specifically, the focus of this course will be on energy generation, heat conduction, single- and two-phase flows, and on energy removal in single- and two-phase flows. Equal emphasis will be placed on component and system level treatment, as well as on both the underlying theory and its applications to practical design and maintenance problems encountered in the field of nuclear engineering.

Prerequisite: NPRE 349, and NPRE 455.

Course Grading Policy:

Quiz	10%
Homework	35%
Computer Project	15%
Exam I	20%
Final Exam	20%

All assignments (quiz, homework, CP) will be submitted through Gradescope. Quizzes are done at the beginning of lecture and cover a fundamental concept from the previous lecture or assigned reading material (with some exceptions). **You must pass 70% of the quizzes to pass the course, lowest four quizzes are dropped, no makeup quizzes will be offered.** At least one week from day assigned is given for completing Homework and they are due by 11:59 pm. 5% will be deducted for late submission (and additional 5% every 24hrs) unless extenuating circumstances have been discussed with the instructor and an extension has been approved prior to the due date.

Recommended References (all required reading material will be provided):
Todreas and Kazimi, Nuclear Systems, Vol. I, CRC Press.
El-Wakil, Nuclear Heat Transport, American Nuclear Society.
Incorpera et al., Fundamentals of Heat and Mass Transfer, Wiley.
Munson et al., Fundamentals of Fluid Mechanics, Wiley.
Duderstadt and Hamilton, Nuclear Reactor Analysis, Wiley.

Office hours:
Prof. Brooks, csbrooks@illinois.edu
Directly following class
Or by appointment

Sohaib Malik, msmalik2@illinois.edu
Seth Stines, cstines2@illinois.edu
Location: NPRE student lounge
Office hours: Wednesdays 4-6pm or by appointment

Learning outcomes/objectives:
- Proficiency in design nuclear power systems
- Understanding critical thermal-hydraulic phenomena
- Understanding principles of nuclear operation and reactor safety

Use of AI: Generative AI tools, such as ChatGPT, Co-pilot, and Gemini, are not permitted for any stage or phase of work in this class. Use of these tools in this course will be considered academic dishonesty and a violation of the University of Illinois Student Code. Any work written, developed, created, or inspired by artificial intelligence (AI) is considered plagiarism and will not be tolerated. While these tools will find their place in our workforces and personal lives, for this class their use hinders the learning process and therefore is not allowed.

Tentative Schedule

Week	Class	Topic	Reference Material	Assignment
1	Tues	PWR/BWR System & Components	T&K Ch 1 & NRC docs	HW1
	Thurs	PWR/BWR System & Components	T&K Ch 1 & NRC docs	
2	Tues	PWR/BWR System & Components	T&K Ch 1 & NRC docs	HW2
	Thurs	HTGR Systems & Components	T&K Ch 1 & INL doc	
3	Tues	Reactor Simulator		HW3
	Thurs	Thermal design margin of nuclear systems / Heat generation	T&K Ch 2, 3	
4	Tues	Heat generation / Review of Control Volume analysis	T&K Ch 3 & Notes	HW4
	Thurs	Thermodynamics of Nuclear Systems	T&K Ch 6 & Notes	
5	Tues	Thermodynamics of Nuclear Systems	T&K Ch 6 & Notes	HW5
	Thurs	Thermodynamics of Nuclear Systems	T&K Ch 6 & Notes	
6	Tues	Control Volume Analysis and Reactor response	Notes	
	Thurs	Review for Exam 1		
7	Tues	EXAM 1		
	Thurs	Exam -1 postmortem / Conduction Heat Transfer review	Notes	
8	Tues	Multi-region fuel pin HT analysis	Notes	HW6
	Thurs	Shielding HT analysis	Notes	
9	Tues	Convection Heat Transfer Review	Notes	HW7
	Thurs	Single-phase flow governing equations		
10	Tues	Single-phase reactor channel	Notes	HW8
	Thurs	Single-phase reactor channel	Notes	
11	Tues	Pool boiling / Flow boiling review	Notes	mini CP
	Thurs	Two-phase flow equations (HEM)	Notes	
12	Tues	Two-phase flow equations (HEM)	Notes	HW9
	Thurs	Two-phase flow equations (HEM)	Notes	
13	Tues	Two-phase flow equations (HEM)	Notes	
	Thurs	Thermal analysis of BWR / CP overview	Notes	Comp Project
14	*Tues*	*Fall break – No class*		
	Thurs	*Fall break – No class*		
15	Tues	Critical heat flux in reactor channels	Notes	
	Thurs	Design/challenges of Next-Gen reactor Concepts	Notes	
16	Tues	Review for final exam	Notes	
	Thurs	*Reading day – No class*		
17		Final Exam		