**UNIVERSITY OF ILLINOIS**

**DEPARTMENT OF NUCLEAR, PLASMA AND RADIOLOGICAL ENGINEERING**

**NPRE 449: Nuclear Systems Engineering and Design (3 credit hours)**

Fall 2024

Prof. Caleb Brooks

111C Talbot Laboratory

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Engineering principles underling nuclear power plant components and systems will be covered. Specifically, focus in 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 25%

Computer Project 15%

Midterm Exam 25%

Final Exam 25%

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 75% of the quizzes to pass the course, no makeup quizzes will be offered.** One week from day assigned is given for completing Homework and they are due by 11:59 pm. 10% will be deducted for late submission (and additional 10% 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](mailto:csbrooks@illinois.edu)

111C Talbot

Directly following class

Or by appointment

Sohaib Malik, [msmalik2@illinois.edu](mailto:msmalik2@illinois.edu)

Location: NPRE student lounge

Office hours: M: 11-12; Tu: 5-7

**Learning outcomes/objectives:**

* Proficiency in design nuclear power systems
* Understanding critical thermal-hydraulic phenomena
* Understanding principles of nuclear operation and reactor safety

**Tentative Schedule**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Week** | **Class** | **Topic** | **Reference Material** | **Assignment Due** |
| 1 | Tues | PWR/BWR System Components | T&K Ch 1 & NRC docs |  |
|  | Thurs | PWR/BWR System Components | T&K Ch 1 & NRC docs |  |
| 2 | Tues | PWR/BWR System Components | T&K Ch 1 & NRC docs | HW1 |
|  | Thurs | Thermal design margin of nuclear systems | T&K Ch 2 |  |
| 3 | Tues | Heat generation | T&K Ch 3 | HW2 |
|  | Thurs | Heat generation / Review of Control Volume analysis | T&K Ch 3 & Notes |  |
| 4 | Tues | Thermodynamics of Nuclear Systems | T&K Ch 6 & Notes | HW3 |
|  | Thurs | Thermodynamics of Nuclear Systems | T&K Ch 6 & Notes |  |
| 5 | Tues | Thermodynamics of Nuclear Systems | T&K Ch 6 & Notes | HW4 |
|  | Thurs | Control Volume Analysis and Reactor response | Notes |  |
| 6 | Tues | Conduction Heat Transfer review | Notes | HW5 |
|  | Thurs | Multi-region fuel pin HT analysis | Notes |  |
| 7 | Tues | Shielding HT analysis/ Time dependent HT | Notes |  |
|  | Thurs | Review for Exam 1 | Notes | HW6 |
| 8 | Tues | EXAM 1 |  |  |
|  | Thurs | Exam -1 postmortem / Nusselt Number Correlations | Notes |  |
| 9 | Tues | Convection Het Transfer Review | Notes |  |
|  | Thurs | Convection Het Transfer example problems | Notes |  |
| 10 | Tues | Single-phase reactor channel | Notes | HW7 |
|  | Thurs | Single-phase reactor channel | Notes |  |
| 11 | Tues | Introduction to Two-phase flow | Notes | HW8 |
|  | Thurs | Pool boiling review | Notes |  |
| 12 | Tues | Flow boiling | Notes | HW9 |
|  | Thurs | Homogeneous Equilibrium model | Notes |  |
| 13 | Tues | Homogeneous Equilibrium model | Notes | HW 10 |
|  | Thurs | Thermal analysis of BWR/ CP overview | Notes |  |
| 14 | Tues | Critical heat flux | Notes | HW 11 (mini CP) |
|  | Thurs | Design/challenges of Next-Gen reactor Concepts | Notes |  |
| 15 | Tues | Review for final exam | Notes |  |
|  | Thurs | Reading day |  | Comp Project |
| 16 |  | Final Exam |  |  |