Welcome to NE 591(491)-602:
Special Topics in Nuclear Engineering I - Multi-Physics of Nuclear Reactors

North Carolina State University
Dr. Maria Avramova
COURSE OBJECTIVES

This graduate and senior undergraduate level course is focused on reactor multi-physics methods and techniques for multi-dimensional reactor analysis.
**TIME-DEPENDENT REACTOR**

\[ k = k^* + \alpha_f \Delta T_f + \alpha_m \Delta T_m + \alpha_x \Delta x + \cdots \]

**BWR Instabilities**

**Ringhals-1**

Stability tests at BOC14, BOC15, BOC16, MOC16, BOC17

All recirculation pumps lost their torques simultaneously
Feed water temperature coast down to 350 Kelvin in 60 seconds
Core flow and power response
TIME-DEPENDENT REACTOR

PWR Control Rod Ejection Accident

- Radial Power Distribution
- Overall Power Evolution With Time
- Control Rod Position (Red)
- Axial Power Distribution
COURSE OBJECTIVES

It consists of six major topics:

1. Fundamentals of Reactor Multi-Physics;
2. Short-Time Multi-Physics Phenomena in a Reactor Core;
3. Simplified Multi-Physics Modeling;
4. Traditional Multi-Physics Modeling;
5. Novel Multi-Physics Modeling;

The course computer project will provide students with knowledge about state-of-the-art multi-physics methods used to model reactor steady-states, cycle depletion, and transients for design and safety evaluations.
COURSE TIME & LOCATION
327 Daniels Hall       Tuesday / Thursday 4:30pm – 5:45pm

TEXTBOOKS
M. Avramova, “Multi-Physics of Nuclear Reactors” - Class Notes, NCSU

REFERENCES

WEBSITE
Homework problems/solutions and other course materials will be posted on the course Moodle Space.

COURSE INSTRUCTOR
Dr. Maria Avramova
Burlington Laboratory 2107
(919) 513-6354
mnavramo@ncsu.edu
Office Hours: appointment

COURSE TEACHING ASSISTANT
N/A

COURSE SCHEDULE
Lectures & assignments schedule and due dates are available via course Moodle Calendar (minor changes are possible).
The grading distributions are approximately as follows:

- Course Project - 30 %;
- Mid-term Exam 1 (open book/notes; no proctor) - 20 %;
- Mid-term Exam 2 (open book/notes; no proctor) - 20 %;
- Homework & Quizzes (closed book) - 30% of the average.
- Grading scale:

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<td>A+</td>
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A grade of C- satisfies all "grade of C or better" prerequisites and other "C-wall" requirements. A+ grades will contribute to the Grade Point Average up to a maximum of 4.000.

A grade higher than 100% will be given for an excellent job (more than what is required) or when an innovative treatment of the problem is presented.
Course Topics

Part I: Fundamentals of Reactor Multi-Physics
- Introduction
- Basic Topics and Nomenclature
- Basic Time-Dependent Phenomena in Nuclear Reactors
- Multi-Physics Interactions in Reactor Core
- Classification of Multi-Physics Modeling and Simulation Tools

Part II: Short-Time Multi-Physics Phenomena in Reactor Cores
- Prompt and Delayed Neutron Phenomena
- Prompt Reactivity Feedback Phenomena
- Delayed Reactivity Feedback Phenomena
- General Reactor Stability
**Course Topics**

**Part III: Simplified Multi-Physics Modeling**
- Pre-Traditional Multi-Physics Coupling Schemes
- Point Kinetics Theory
- Thermal-Hydraulics Codes with Point Kinetics Models
- Neutronics Core Simulators with 1-D Thermal-Hydraulics Models
- Neutronics and Thermal-Hydraulics Models in Fuel Performance Codes

**Part IV: Traditional Multi-Physics Modeling**
- 3D Nodal Kinetics Models in Thermal Hydraulic Analysis
- Space-Energy Dependent Dynamics
- Coupled Thermal-Hydraulics and Neutronics Simulations
  - Ways of coupling
  - Coupling approaches
  - Spatial mapping overlays
  - Temporal coupling
  - Cross-section modeling
Course Topics

Part V: Novel Multi-Physics Modeling

- High-Fidelity Neutronics, Thermal-Hydraulics and Fuel Performance Models
- Feedback Parameters
- Spatial Coupling Schemes
- Temporal Coupling Schemes
- Simulation Multi-Physics Platforms

Part VI: Multi-Physics Validation & Uncertainty Quantification, and Applications

- Verification and Validation of Multi-Physics Simulations
- Uncertainty Quantification in Multi-Physics Modeling
- Applications of Multi-Physics Calculations
Let’s try to have fun &
we always can learn more!