NE 522 **Principles of Nuclear Reactor Engineering** **Fall 2024**

Course Description

Graduate level course designed as an intensive course introducing engineering principles of nuclear reactors to graduate students with non-nuclear engineering background or returning students.

3 credit hours

Instructors

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Teaching Assistant

TBD

Class Location and Meeting Time

331 111 Lampe Drive

TuTh 10:15AM - 11:30AM

Prerequisites

Graduate standing.

Course Objectives

The objectives are to introduce graduate students with non-nuclear engineering background or returning students to the principles of nuclear reactor and power engineering. After successfully completing the course, students will be able to effectively follow the regular nuclear engineering graduate level curriculum.

Student Learning Outcomes

By the end of this course, the student should be able to understand and apply the concepts and principles of:

- Nuclear reactions and interactions relevant to nuclear engineering including fission, cross-sections, reaction rate calculations, energy depositions rates, and radioactive decay.
- Nuclear reactor design including static and dynamic reactor theory applied to reactor design problems and thermal-hydraulic considerations in reactor design.

Course Requirements and Evaluation Methods

- Homework: Five assignments each valued at 6%. Homework assignments to be submitted via Moodle.
- Quizzes: Two quizzes each valued at 10%.
- Exams: Two exams each valued at 25%.
- Grading Scale: A+ (>100); A (92÷100); A- (90÷91); B+ (88÷89); B (82÷87); B- (80÷81); C+ (78÷79) C (72÷77); C- (70÷71); D+ (68÷69); D (62÷67); D- (60÷61); F (<60)

- Late Assignments: Unless stated otherwise, assignments are due at the beginning of class on the designated due date. Assignments turned in within 24 hours of this time are considered LATE and will be assessed 25% penalty. Assignments turned in after 24 hours will be marked and returned to the student, but no credit will be assigned. To allow for unforeseen circumstances, students are granted a onetime exemption if an assignment is turned in by 5:00 PM on the designated due date. Exceptions to this policy may be granted for documented medical or family emergencies.

Attendance and Absence policy

- Face-to-face attendance is highly recommended.
- Active class participation is strongly encouraged. University policy on definition of excused absences: http://policies.ncsu.edu/regulation/reg-02-20-03

Required Textbook

- Lamarsh and Baratta, Introduction to Nuclear Engineering, 3rd edition, Prentice Hall, 2001

Additional (optional) References

- J. K. Shults and R. E. Faw, Fundamentals of Nuclear Science and Engineering, Taylor & Francis Group, 2007
- J. J. Duderstadt and L. J. Hamilton, Nuclear Reactor Analysis, John Wiley & Sons, 1976

Computer and Internet Requirements

Please review minimum computer specifications recommended by NC State University and Engineering Online.

Course Delivery

- Face-to-Face: On Campus
- Distance Education: DELTA.
- Captured Lectures: This on campus course will be captured and distributed via the Internet and/or electronic media as part of the Engineering Online (EOL) program for distance students. These video recordings may contain an image of you entering the classroom, asking questions or being a part of the studio class. Please notify EOL if you DO NOT want your image to be included in the lecture presentation. If we do not hear from you after the first week of the class, we will assume that you are in agreement with this procedure.

Academic Integrity

- University policy on academic integrity: Code of Student Conduct Policy (POL11.35.01) (http://policies.ncsu.edu/policy/pol-11-35-01). Violations of academic integrity will be handled in accordance with the Student Discipline Procedures (NCSU REG11.35.02). The unauthorized posting of any lecture notes, homework answers, exams, or any other course materials on third-party websites constitutes a violation of copyright as described in section 8.2 (f) of the Code of Student Conduct. Students posting such materials will be immediately referred to the Office of Student Conduct.

Supporting Fellow Students in Distress

As members of the NC State Wolfpack community, we each share a personal responsibility to express concern for one another and to ensure that this classroom and the campus as a whole remains a safe environment for learning. Occasionally, you may come across a fellow classmate whose personal behavior concerns or worries you. When this is the case, you are encouraged to report this behavior to NC State CARES: https://prevention.dasa.ncsu.edu/nc-state-cares/about/

Students with Disabilities

Reasonable accommodation will be made for students with verifiable disabilities. In order to take advantage of available accommodation, students must register with Disability Services for Students at 1900 Student Health Center, Campus Box 7509, 515-7653. For more information on NC State's policy on working with students with disabilities, please see REG 02.20.01 – Academic Accommodations for Students with Disabilities – Policies, Regulations & Rules (ncsu.edu)

Additional NC State Rules and Regulations

Students are responsible for reviewing the NC State University Policies, Rules, and Regulations (PRRs) which pertain to their course rights and responsibilities, including those referenced both below and above in this syllabus:

- Equal Opportunity and Non-Discrimination Policy Statement https://policies.ncsu.edu/policy/pol-04-25-05 with additional references at https://oied.ncsu.edu/divweb/policies/
- Code of Student Conduct https://policies.ncsu.edu/policy/pol-11-35-01.

Course Fall 2024 Schedule

Unit # 1 - Scope of Nuclear Engineering & Atomic and Nuclear Physics		*Assignments*
Week 1 / Lecture 1 08-20-24	Welcome to NE 522: Principles of Nuclear Reactor Engineering Scope of Nuclear Reactor Engineering	
W1 / L2 08-22-24	Atomic and Nuclear Physics (1) – fundamental particles – atomic and nuclear structure – atomic and molecular weight – mass and energy – particle wavelength	
W2 / L3 08-27-24	Atomic and Nuclear Physics (2) – excited states and radiation – nuclear stability and radioactive decay – radioactive calculations	
W2 / L4 08-29-24	Atomic and Nuclear Physics (3) – nuclear reactions – binding energy	Homework 1: Atomic and Nuclear Physics

	– nuclear models – atom density	
Unit # 2 - Interaction of Radiation with Matter		
W3 / L5 09-03-24	Interaction of Radiation with Matter (1) – neutron interactions – cross-section – neutron attenuation – neutron flux	
W3 / L6 09-05-24	Interaction of Radiation with Matter (2) – energy lost in scattering reactions – fission	
W4 / L7 09-10-24	Interaction of Radiation with Matter (3) – gamma-ray interactions with matter – charged particles	Homework 1 DUE **Homework 2:** Interaction of Radiation with Matter
Unit # 3 – Nuclear Power Reactors		
W4 / L8 09-12-24	Nuclear Power Reactors: – fission chain reactions and its utilization for electricity generation	
W5 / L9 09-19-24	New generation nuclear power reactors	Homework 2 DUE
W6 / E1 09-24-24	Exam 1: Atomic and Nuclear Physics & Interaction of Radiation with Matter	
Unit # 4 – Neutron Diffusion and Moderation		
W6 / L10 09-26-24	Diffusion and Moderation (1) – neutron flux; Fick's law – equation of continuity; diffusion equation – boundary conditions	
W7 / L11 10-01-24	Diffusion and Moderation (2) – solutions of diffusion equation – diffusion length	
W7 / L12 10-03-24	Diffusion and Moderation (3) – group-diffusion method – thermal neutron diffusion – two-group calculation of neutron moderation	**Homework 3:** Neutron Diffusion and Moderation
W8 / Q1 10-08-24	Quiz 1: Nuclear Power Reactors	
Unit # 5 – Nuclear Reactor Theory		
W8 / L13 10-10-24	Nuclear Reactor Theory (1) – one-group reactor equation – fuel utilization and production factors – geometrical and material bucklings	

	– critical reactor and eigenvalue problem	
W9 / L14 10-17	Nuclear Reactor Theory (2) – one-group criticality equation – 3-, 4-, and 6-factor formulas – migration area and modified one group critical equation	Homework 3 DUE
W10/ L15 10-22-24	Nuclear Reactor Theory (3) – flux distribution in reflected thermal reactor – reflector savings – multi-group diffusion equation	
W10 / L16 10-24-24	Nuclear Reactor Theory (4) – heterogeneous reactors	**Homework 4:** Nuclear Reactor Theory
Unit # 6 – The Time Dependent Reactor		
W11 / L17 10-29-24	Time Dependent Reactor (1) – classification of time problems – reactor kinetics	
W11 / L18 10-31-24	Time Dependent Reactor (2) – control rods & chemical shim	Homework 4 DUE
W12 / L19 11-05-24	Time Dependent Reactor (3) – temperature effects on reactivity	
W12 / L20 11-07-24	Time Dependent Reactor (4) – fission product poisoning – core properties during lifetime	**Homework 5:** The Time Dependent Reactor
W13 / E2 11-12-24	Exam 2: Neutron Diffusion and Moderation & Nuclear Reactor Theory	
Unit # 7 – Thermal-Hydraulic Considerations in Reactor Design		
W13 / L21 11-14-24	Thermal-Hydraulic Considerations in Reactor Design (1) – heat generation and removal in nuclear reactors	
W14 / L22 11-19-24	Thermal-Hydraulic Considerations in Reactor Design (2) – boiling heat transfer	Homework 5 DUE
W14 / L23 11-21-24	Thermal-Hydraulic Considerations in Reactor Design (3) – reactor thermal design	
W15/ Q2 11-26-24	Quiz 2: Thermal-Hydraulic Considerations in Reactor Design	
W16 / L24 12-03-24	COURSE WARP-UP	
FINALS PERIOD 12-05÷11-24	MAKE-UP EXAM (*PER REQUEST*) & MAKE-UP QUIZ (*PER REQUEST*)	