School of Nuclear Engineering
Purdue University
West Lafayette, IN 47907

NUCL 50200 Nuclear Engineering Systems

Course Description: Engineering aspects of nuclear power. Materials of construction; fuel and fuel cycles; heat removal; radiation shielding; economics; and nuclear power systems.

Offered : Spring Fall and Summer semester as needed
Pre-requisite: NUCL 501 or equivalent
Co-requisite: None
Classification: Required

Credit: 3

Instructor: S.T. Revankar,

Textbook: Because the material is very broad, in addition to the main references additional references are used. Class notes will be provided time to time on various topics.

References:

1. N. E. Todreas and M. S. Kazimi, "Nuclear Systems I - Thermal Hydraulic Fundamentals," 2nd Edition, CRC Press, Taylor & Francis Group, 2012, ISBN 978-1-4398-0887-0
2. J. R. Lamarsh, and A. J. Baratta "Introduction to Nuclear Engineering,"4th Edition, (January 19, 2017) Pearson Publication, ; 4 edition, ISBN-10: 0134570057, ISBN-13: 978-0134570051
3. S. Glasstone and A. Sesonske, "Nuclear Reactor Engineering," Chapman and Hall, 1994.
4. A. Sesonske, " Nuclear Power Plant Design Analysis," Technical Information Center, Office of Information Services, U.S. Atomic Energy Commission, 1973.

Specific Goals:

a. To acquire knowledge on nuclear power plant components and systems, designs, principle of operation, control and safety. Develop understanding of the engineering and physical principles of a reactor including neutron transport, kinetics, thermodynamics, thermalhydraulics, materials, fuels, radiation, shielding and safety. To overview nuclear fuel cycle and waste management.
b. To apply knowledge of mathematics and physics to the design of nuclear power plant engineering systems. To understand the design principles of nuclear power reactors and related systems. To develop a quantitative and qualitative foundation of nuclear reactor control, fuel cycles, radiation protection, shielding, and safety. To perform groups based term project in the area of nuclear systems

Course Information

The graduate courses in nuclear engineering at Purdue University do not have a nuclear system course that cover all aspects of the nuclear power plant. For overall understanding of the nuclear power plants, total system study is required that covers, reactor types, designs, operational and future designs, reactor components, reactor kinetics, control, radiation and shielding, materials, heat removal, safety, and economics, and environmental impact. This course provide this knowledge and prepare graduate students with ability to look holistically the nuclear powers system.

The course cover the basic science and detailed theory behind each topic at graduate level. It reviews state-of the art on each topics to update advances made in this technology. The student mastery of the subject is assessed through homework, closed book tests, and individual student project where each will research new topic other than course topics and writes a report as a

project report. The advanced topics covered will highlight possible challenges in technology and hence exposes graduate level research opportunities.

Learning Outcomes:

1. Student able to apply knowledge of mathematics, science and engineering. Demonstrate an ability to solve typical nuclear reactor calculations: Develop a quantitative foundation of nuclear reactor safety, radiation protection and shielding. Apply knowledge of mathematics and physics to the design of nuclear power reactor systems
2. Students able to design a reactor system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
3. Student model engineering issues in nuclear reactor safety, radiation protection and shielding quantitatively and draw appropriate inferences:
4. Student able to use the techniques, skills, and modern engineering tools necessary for nuclear reactor systems through a project

Lecture Room: Online course

Instructor details: S.T. Revankar, *Office:* WANG 4085*, Email:* shripad@purdue.edu, *Phone:* 496-1782 *Office Hours:* TBD

Computer Usage: Knowledge of word processing and spreadsheet software will be necessary for laboratory report preparation and some homework assignments. Knowledge of a computer programming language may also be helpful for some assignments.

Assessment Weighting:

Homework	20%
Tests (3)	65%
Project	15%

Course Grading Policy

A	85% - 100%
B	75% - 84%
C	65% - 74%
D	50% - 64%
F	< 49%

Homework:

Homework problems should be turned in before the date due. They will be graded and returned as soon as possible. Problems turned in one day late will be graded on a one-half credit basis. Two days late will get ¼ credit and any later day submission will get zero credit. Since these problems are intended to show the application of lecture material and provide preparation for tests, individual work is essential. Solutions should make the approach followed clear to the grader. Collaboration on homework is limited to general discussion of the problems and approaches. Each student must independently complete their own written solution to each homework problem. Each homework problem must contain the following header printed in the upper right corner of each page:

Last name, First name NUCL 502, Hwk Assignment #

You can scan the homework and submit at the Blackboard Learn site or email to: shripad@purdue.edu.

Examinations:

All exams will be closed notes and closed book. Depending on exam if required formula sheets/figures will be provided with the exams. No materials other than the formula sheets provided are to be used during exams. A score of zero will be recorded for a missed exam.

Term Project

Each student will work on a term project.The project can be on any topic in Nuclear Engineering. It should contain at least two key areas covered such as reactor physics, reactor kinetics, reactor control, reactor components, radiation, doses, shielding, thermalhydraulics, fuel and fuel cycle, fuel management, nuclear materials, and reactor safety. Each student complete a project on the topic chosen related reactor systems or component, writes and submits a formal report. Guidelines for the term project will be provided.

Course Syllabus

Nuclear Power Plants: Introduction, Power reactors, LWR : PWR, BWR, HTGR, LMFBR CANDU, SMR, GEN IV Reactors, Micro Reactors, Accelerator Based subcritical reactors

Reactor Operation: Reactor control-Kinetics review, Power Excursion, Temperature, void coefficients, Fission product poisoning

Radiation and Shielding : Radiation protection, Radiation dose rate**,** Radiation dose calculations**,** Reactor shielding **,** Shielding design

Material of Construction and Nuclear Materials: Reactor Vessel, Primary and secondary systems, Containment, Fuels and properties, Fuel Cycle, Spent fuel processing, radioactive waste management

Reactor Heat Removal: Reactor heat generation, Shutdown, decay power, Thermal design and limits Fuel thermal analysis, Temperature distribution, Thermal resistance, Thermodynamics of nuclear plant Simplified PWR system, Power plant PWR system, Reactor thermal analysis, Single & Two phase heat transfer, Two phase pressure drop

Reactor Safety: Safety and Emergency Systems, Reactor Accidents TMI*,* Cherobyl Reactor Accidents Fukushima

Economics of Nuclear Power Plant: Electric utility economics, plant investment costs, fuel costs, operation and maintenance cost, power supply economics

Environmental Impact: Radiation hazard, waste from nuclear plant, environmental issues.