NUCE 403: ADVANCED REACTOR DESIGN

Fall 2011

M W F 12:20P - 01:10P  105 Forum

INSTRUCTOR:          TEACHING ASSISTANT:
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Office Hours: M W 09:30A – 10:30A   Office Hours TBD

COURSE OBJECTIVES: The objectives of this course are to provide students in Nuclear Engineering with sufficient background in physical principles and computational methods for reactor design and analysis including multi-group diffusion theory; determination of fast and thermal group constants; and cell calculations for heterogeneous core lattices.

TEXTBOOKS:

REFERENCES:
1) J. R. Lamarsh and A. J. Baratta, Introduction to Nuclear Engineering
2) W. M. Stacey, Nuclear Reactor Physics, John Wiley&Sons, Inc. (2001)

WEBSITE: Homework problems/solutions and other course materials will be posted on ANGEL

PREREQUISITES: NUC E302

POLICIES:
- Homework is due one week from the day assigned. One of the homeworks will be computer algorithm and code homework. No late homework will be accepted with exception of illness or other proved circumstances. Homework should be typed and submitted by 5:00 pm on the due day via ANGEL. Additional notes on the homework format and requirements are following.
- Attendance is mandatory. 0.5 points will be subtracted from the student’s final grade per each class missed. If there is a valid reason to miss the class a brief explanation should be e-mailed beforehand.
- NucE Seminar (NucE 590): Only applicable to students not taking NUCE 430 this semester in order to prevent double accounting. 0.5 extra points will be earned per each seminar attended. In order to get extra credit, students need to submit the preformatted memo to the Teaching Assistant at the end of the seminar session. No late memo is accepted.
- Exams: There will be three in-class exams. Make-up exams will be given only to the students who, were absent due to a possible valid reasons. For all those reasons an
official excuse note must be provided. During the exam, the students will be allowed to use one double-sided page (letter format) with notes, equations, etc.

- **Course Project:** A team project will be assigned on the Westinghouse reactor core design code ANC Input and Output.

- **Quizzes:** There will be several 10-minutes “surprise” quizzes given during the semester.

**EVALUATION METHODS:**

The grading distributions are approximately as follows:

- Course Project: 15 %;
- Exams: 15 % each;
- Homework: 25 % of the average;
- Quizzes: 15 % of the average.

**Grading scale:**

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<thead>
<tr>
<th>Grade</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>A</td>
<td>93 - 100</td>
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<tr>
<td>A-</td>
<td>90 - 92</td>
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<tr>
<td>B+</td>
<td>87 - 89</td>
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<td>B</td>
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<td>C+</td>
<td>76 - 79</td>
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<tr>
<td>C</td>
<td>69 - 75 – Needed to graduate</td>
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<tr>
<td>D</td>
<td>57 - 68</td>
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<tr>
<td>F</td>
<td>0 - 56</td>
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A grade higher than 100% might be given for an excellent job (greater than what is required) or when an innovative treatment of the problem is presented.

**ACADEMIC INTEGRITY:** The University and the College of Engineering consider academic dishonesty, including cheating and plagiarism, to be a serious offense. The University Policy 49-20 describes the general University policy on academic dishonesty. For Engineering, the academic integrity website is at [http://www.engr.psu.edu/CurrentStudents/acadinteg.asp](http://www.engr.psu.edu/CurrentStudents/acadinteg.asp).

**HOMEWORK FORMAT:**

It is recommended that the homework is prepared in the following format:

**Introduction:** Brief statement of the problem with the purpose and background of the calculation.

**Assumptions:** List and justification of the assumptions used in the calculations.

**Analysis Approach:** Identification of the analytical approach, computer codes, speared sheet, or other methods used for the calculations.
**Calculations and Results:** Presentation of the performed calculations. If calculations were used to develop code input, this should be shown including units and references. Please, high-light or box the final results. The calculations be performed in either British or SI units, but a unit balance must be included.

**Discussion of the Results:** This is the most important section!!! Do the results make sense? If so, why; if not why not. The students should show that they understand what they are doing.

**Conclusions:** Brief summary of the performed work.

**DESIGN PROJECT:**

**For resident students**

The project will start with lectures on UNIX Operation System and Editors, ANC User Manual, and on ANC job creation and execution basics. Two weeks period will be given for team work on the project. The project will be evaluated by a Westinghouse mentor and the course instructor.

The students will use the code as a computational tool for purposes of illustration and understanding of the advanced reactor physics design of LWR cores.

It will be a team work. Each team will consist of 4 students. The students can select their teammates. The teams must be set by the end of October 2011, at the latest. If not the teams will be formed by the course Instructor. Each team has to prepare a project report following the homework format as described above.

**For distance students**

The project is based on the PSU multi-group nodal diffusion code NEM designed to be compiled and executed under Windows OS environment using one of FORTRAN compilers. Each distance student will be assigned a model of two-dimensional BWR mini-cores with provided geometry, and material specifications and cross-sections to be simulated with NEM. Two weeks period will be given to each student on the project. Each student has to prepare a project report following the homework format as described above.
1. Nuclear Reactions
2. Nuclear Fission
3. Multiplication Factor and Nuclear Criticality
4. Nuclear Power Reactors
5. Nuclear Reactor Design
6. Neutron Transport Equation
7. Direct Numerical Solution
8. Diffusion Approximation
9. One Speed Diffusion Equation
10. Neutron Diffusion in Non-multiplying Media
11. Reactor Criticality Calculations
12. Multi-Group Diffusion Equations
13. Energy-Dependent Diffusion Theory
14. Applications of Multi-Group Diffusion Equations
15. Numerical Solution of Multi-Group Diffusion Equations
16. Neutron Slowing Down in Infinite Medium
17. Resonance Absorption
18. Neutron Slowing Down in Finite Media
20. Features of Thermal Neutron Spectrum
21. Models of Thermalization
22. Calculations of Thermal Neutron Spectrum
23. Lattice Effects in Nuclear Reactor Analysis
24. Heterogeneous Effects in Thermal Neutron Physics
25. UNIX OS and Editors/WINDOWS OS and Compilers
27. Computer Project Review