Reactor Theory, Design and Safety
Outline of Instruction

Course Information
Organization: Monroe County Community College, Applied Science and Engineering Technology
Development Date: 4/5/2010
Course Number: NUET 240
Instructional Area: Nuclear Engineering Technology
Potential Hours of Instruction: 60
Total Credits: 3

Description
This course presents the fundamental concepts of nuclear reactor theory with a primary focus on light water cooled boiling water reactors. Concepts presented will include neutron interactions, nuclear fission, and chain reactions in thermal light water cooled reactors; thermal diffusion and neutron thermalization; criticality and reactivity calculations; reactivity kinetics and feedback mechanisms; fission product daughter production and radionuclide transmutation; reactor safety principles including emergency core cooling and engineered safety features; design basis accident and core damage mitigation; case studies.

Major Units:
1. Atomic Physics, Chart of the nuclides
2. Radioactivity and radioactive decay
3. Neutron interactions and fission, interaction of radiation with matter
4. Basic Nuclear Parameters: Neutron sources, flux, cross sections, reaction rates, moderation, prompt and delayed neutrons, six factor formula
5. Advanced Nuclear Parameters: neutron life cycle, reactivity and reactivity coefficients, neutron poisons, control rods
6. Reactor Operations: subcritical multiplication, reactor kinetics, reactor operational variations
7. Reactor Protection and Safety: engineered safety features, defense in depth concept, fission product barriers, limiting conditions for operation
8. Accident analysis and design basis accidents, mitigation of core damage

Types of Instruction

<table>
<thead>
<tr>
<th>Instruction Type</th>
<th>Contact Hours</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>The methods of instruction for this course will include but will not be limited to, discussion, lecture, demonstration, in-class activity, lab experiments, and examination.</td>
<td>60</td>
<td>3</td>
</tr>
</tbody>
</table>

Textbooks
Lamarsh. Introduction to Nuclear Engineering.

Prerequisites
Exit Learning Outcomes

Program Outcomes
A. Describe and apply the culture of safety, continuous improvement, and peer checking.
B. Describe the main systems in a nuclear power plant, and how they are used in power generation.
C. Describe different sources of radiation, their effects on organic matter, methods of detection, and shielding. Describe different sources of radiation, their effects on organic matter, methods of detection, and shielding.
D. Identify and define problems in mathematical and scientific terms
E. Recognize assumptions and limits of analysis to the application of technology, including social and ethical implications.
F. Recognize the need to engage in lifelong learning, and to perform research or conduct investigations to continuously upgrade knowledge and skills.
G. Communicate effectively, and work as part of a team.

General Education Outcomes
A. Apply mathematical approaches to the interpretation of numerical information
B. Apply mathematical approaches to the analysis of numerical information
C. Communicate ideas in writing using the rules of standard American English
D. Demonstrate an understanding of the process of scientific inquiry
E. Use computer technology to retrieve information
F. Use computer technology to communicate information

Course Outcomes
1. Summarize atoms, including components, structure and nomenclature, modes of decay, nuclear interactions, and neutron sources.
2. Explain basic concepts in reactor physics and perform calculations.
3. Explain the production process and effects on fission of prompt and delayed neutrons.
4. Summarize how reactivity varies with the thermodynamic properties of the moderator and the fuel and the use of neutron poisons.
5. Characterize the neutron life cycle, subcritical multiplication, and neutron energy spectrum for various reactor types.
6. Describe how control rods and fission product poisons affect the reactor core.
7. Enumerate how power changes in a reactor that is near criticality and perform related calculations.
8. Explain the concepts concerning reactor startup, operation, and shutdown.
9. Summarize basic concepts related to reactor plant protection, accident analysis, and core damage mitigation.
10. Break down in detail major world nuclear industry operating experience, including TMI, Chernobyl, Salem, Brown's Ferry, SL-1 and Davis Besse.