COURSE SYLLABUS

RP 246 Radiological Aspects of Reactor Designs

Instructor: Credit Hours: 4
Phone: Semester: Spring
E-mail: Room:

Catalog Course Description
A study of the types of radiation and their properties relative to reactor design. (class 3 hours, lab 3 hours).

Prerequisites: RP 154

Corequisites: None

Entry Level Standards

Textbook/Materials
1. DOE Fundamentals Handbook, Thermodynamics, Heat Transfer and Fluid Flow (DOE-HDBK-1019/1,2,3-92)
2. DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory (DOE-HDBK-1012/1,2-93)
4. USNRC Reactor Concepts Manual Boiling Water Reactor (BWR) Systems
5. ACAD 93-008 Standards 1.1.3 Electrical Sciences, 1.1.5 Heat Transfer and Fluid Flow, 1.1.9 Reactor Plant Protection and Safety, 1.2 Basic Systems Knowledge, 1.3 Basic Components Knowledge, 3.1 Plant systems and Components Knowledge: Systems

Institutional Student Learning Outcomes
ISLO2. Competence in a Specialty Area
ISLO5. Information and Technology

Program Student Learning Outcomes
PSLO2. An ability to conduct experiments, collect, analyze, and interpret data.[ISLO5]
PSLO11. The ability to use the techniques, skills, and modern engineering tools necessary to function as a Radiation Protection Technician. [ISLO2]

I. Course Student Learning Outcomes

CSLO1 Employ the principles, procedures, and applications of radiation protection. [PSLO2][PSLO11]

CSLO2 Meet the requirements for formal classroom training for Nuclear Uniform
II. **Topics:**

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Heat transfer, Heat transfer mechanisms, steam/water cycles</td>
</tr>
<tr>
<td>2</td>
<td>Fluid flow, fluid properties</td>
</tr>
<tr>
<td>3</td>
<td>Flow and pressure relationships, flow in open and closed systems</td>
</tr>
<tr>
<td>4</td>
<td>Atomic and nuclear physics, fission process and control</td>
</tr>
<tr>
<td>5</td>
<td>Basic reactors parameters, reactivity and reactivity control, basic reactor types</td>
</tr>
<tr>
<td>6</td>
<td>Reactor plant protection, defense in dept, fission product barriers</td>
</tr>
<tr>
<td>7</td>
<td>Basic plant systems and components</td>
</tr>
<tr>
<td>8</td>
<td>PWR systems and components</td>
</tr>
<tr>
<td>9</td>
<td>BWR systems and components</td>
</tr>
<tr>
<td>10</td>
<td>Design basis events and analysis, core damage mitigation</td>
</tr>
<tr>
<td>11</td>
<td>Major Industry Events</td>
</tr>
<tr>
<td>12</td>
<td>Electrical systems</td>
</tr>
<tr>
<td>13</td>
<td>Review</td>
</tr>
<tr>
<td>14</td>
<td>Final Exam</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CSLO1</th>
<th>CSLO2</th>
<th>CSLO3</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Lab assignments</td>
<td>a) Lab assignments</td>
<td>a) Lab assignments</td>
</tr>
<tr>
<td>b) Quizzes</td>
<td>b) Quizzes</td>
<td>b) Quizzes</td>
</tr>
<tr>
<td>c) Section Tests</td>
<td>c) Section Tests</td>
<td>c) Section Tests</td>
</tr>
<tr>
<td>d) Final Exam</td>
<td>d) Final Exam</td>
<td>d) Final Exam</td>
</tr>
</tbody>
</table>

III. **Course Objectives**

O1 Apply direct current (DC) concepts and laws; and perform calculations and measurements, including the following: [I1—T3]

- Basic electrical circuits, such as series and parallel, series-parallel combinations
- Conductors and insulators
- Direct current (DC) theory and DC sources (such as ideal voltage and current, non-ideal voltage, and current
- Electrical laws (such as Ohm’s law, Kirchhoff’s voltage, and current laws)
- Electron theory
- Units of electrical measurement (such as ohms, volts, amps, watts, coulombs, joules)
- Voltage, current, and resistance (content added: power)

O2  Apply alternating current (AC) concepts and laws; and perform calculations and measurements, including the following: [I1—I3]
- Alternating current (AC) theory and AC sources (such as ideal voltage and current, non-ideal voltage, and current)
- Basic electrical circuits, such as series and parallel
- Units of electrical measurement (such as henries, farads, reactance, impedance)
- (content added: passive components, capacitors, inductors)
- (content added: single-phase versus three-phase)
- Voltage, current, and impedance (content added: real, reactive, apparent power, and power factor relationships)

O3  Explain principles and concepts related to heat, including the following: [I1—I3]
- Heat transfer mechanisms and heat exchanger construction and types
- Temperature, including temperature scales, F, C, and K (such as kinetic theory of gases)

O4  Explain the concepts and principles of steam, including the following: [I1—I3]
- Basic steam-water cycle
- Boiling and saturation
- Pressure-temperature relationship
- Properties of steam and water, including pressure-temperature relationship, basic steam-water cycle, steam tables, boiling, saturation temperature/pressure, and thermal efficiency
- Steam tables

O5  Explain principles of heat transfer, including the following: [I1—I3]
- Heat transfer mechanism, such as conduction, convection, and radiation
- Heat exchangers
- Latent and sensible heat
- Thermal efficiency

O6  Explain principles of fluid flow, including the following: [I1—I3]
- Effects of throttling on flow and pressure
- Filling and venting—understanding the concept of high point vents relating to air binding and water hammer
- Fluid properties and mechanics, including laminar and turbulent flow filling and venting, and the effects of throttling
- Pump theory, including cavitation
- Water hammer types and mechanisms

O7  Explain basic concepts related to reactor plant protection: [I1—I3]
- Administrative controls and procedural concepts
• Automatic reactor plant protection concepts
• Defense in depth
• Fission product barriers
• Limiting conditions for operation
• Safety limits

O8 Explain basic concepts related to accident analysis: [I1—I3]
• Anticipated radiation levels
• Design basis accidents
• Description
• Effect on workplace
• Evacuation criteria
• (content added: Final Safety analysis Report)
• Recovery process mitigation
• Symptoms and indications

O9 Explain basic concepts related to transient prevention and mitigation of core damage and accident management, including the following: [I1—I3]
• Core cooling mechanisms
• Core damage
• Hydrogen hazards during accidents
• Critical parameter monitoring during accident conditions
• Radiation hazards and radiation monitoring response

O10 Summarize basic information about major industry operating experience, including the Three Mile Island Nuclear Station accident, the Chernobyl Nuclear Power Plant accident, the Salem Generating Station turbine blade throw, the Browns Ferry Nuclear Plant fire, the Idaho Falls stuck rod accident, and the Davis-Besse Nuclear Power State event. [I1—I3]

O11 Explain the basic operation of the following subsystems: [I1-I3]
• Chemical and volume control (PWR)
• Circulation water
• Condensate
• Containment
• Containment spray
• Control rod drive mechanism
• Emergency core cooling systems
• Emergency power
• Environmental monitoring
• Feedwater
• Main steam
• Ofgas (BWR)
• Post accident sampling
• Pressurizer (PWR)
• Radiation monitoring
• Reactor coolant
• Reactor water cleanup (BWR)
• Recirculation (BWR)
- Residual heat removal/shutdown cooling
- Suppression pool (BWR)

O12 Describe the theory, construction, and application of the following mechanical components: [I1—I3]
- Air compressors (such as rotary, reciprocating, and centrifugal)
- Heat exchangers (such as cross-flow, counter-flow and parallel flow); steam condensers and steam generators (U-tube and once-through))
  - Include discussion on heat transfer across the heat exchanger and indications of heat exchanger fouling
- Pumps, ejectors, and educators, such as for pumps (centrifugal, positive displacement)-Include centrifugal pump laws, series, and parallel operation; net positive suction head; requirements of minimum flow and effects of dead-heading pump; can causes and indications of cavitation and how to prevent it.
- Strainers, filters, and traps, including demineralizers, screens, and centrifuges for process filtration systems
- Steam traps (such as lever-operated, piston-operated and float-operated)
- Steam turbines (such as impulse and reaction turbines, turbine arrangements and steam flow, high-pressure and low-pressure turbines)
- Valves (such as gate, globe, butterfly, ball, check, needle, diaphragm-operated, plug, pressure relief and safety) and dampers (pneumatic, hydraulic) and limitation of different valve types (for example, gate valve not good for throttling)

O13 Describe the theory, construction and application of diesel engines including the following: accessories/support systems, failure mechanisms and systems, main structural components, main moving components, principles of operations. [I1-I3]

O14 Describe the theory, construction and application of air conditioning, heating and ventilation systems, including refrigeration machines and the basic refrigeration cycle [I1-I3]

O15 Describe the theory, construction, and application of structural and auxiliary equipment, including the following: [I1-I3]
- boilers (such as electric, gas-fired, fuel-oil-fired)
- elevators (such as basic operation of and basic rescue methodology)
- fire barriers (such as purpose and construction of and identification of barrier degradation
- hangers and snubbers for support and restraint (such as discussion of water hammer and different types, including water slug, valve slam, column rejoining, and condensate induced)
- hoists and cranes (such as manual and electric)

O16 Describe the theory, construction, and application of rotating equipment including the following: generators, motors, motor-generators. [I1-I3]

O17 Describe the theory, construction and resistive electrical equipment including the following: heaters, heat tracing (such as reasons for using heat tracing) [I1-I3]
Describe the theory, construction and application of electrical supply components including the following: batteries and chargers, circuit breakers (such as protection), inverters and uninterruptible power supplies, switchgear, load centers, and motor control centers (such as protective relaying and schematics of a basic system from high voltage to lower voltage), transformers (such as step-up transformers and stepdown transformers, winding configurations) [I1-I3]

Describe the theory, construction and application of electrical control components including the following: cables (such as routing for train separation and methods of fire detection/protection for cables/cable trays), control circuits (such as proportional, integral and derivative or a combination thereof), meters (such as voltage and current and how a change in meter indication could indicate circuit degradation of a change in process (pump discharge valve opened for increased flow)), relays (such as schematics to show operation of relays that energize to actuate, deenergize to actuate, time delay energize and time delay deenergize) [I1-I3]

Describe the theory, construction and application of valve actuator types (such as motors, pneumatic, hydraulic) including the following: manual operation (such as methods used for different types of actuators), position indication (such as methods for indication, local and remote indications and observation of process indications to determine valve position), impact of environmental conditions [I1-I3]

Describe the theory and application of electronic equipment including the following: analyzers (such as H₂, O₂ and chemical), signal converters [I1-I3]

Explain the importance of the following systems to plant safety and radioactivity containment and identify any radiological hazards and precautions associated with maintenance tasks for each. [I1-I3]

- Chemical and volume control (PWR)
- Circulation water
- Condensate
- Containment
- Containment spray
- Control rod drive mechanism
- Emergency core cooling systems
- Emergency power
- Environmental monitoring
- Feedwater
- Main steam
- Offgas (BWR)
- Post accident sampling
- Pressurizer (PWR)
- Radiation monitoring
- Reactor coolant
- Reactor water cleanup (BWR)
- Recirculation (BWR)
- Residual heat removal/shutdown cooling
- Suppression pool (BWR)

O23 Draw a basic system block diagram [I1-I3]
O24 Identify conditions that preclude safety work in the vicinity of system components [I1-I3]
O25 Identify the basic interrelationships with other plant systems [I1-I3]
O26 Identify specific isotopes of concern in power reactors during operation and following shutdown (such as H-3, N-16, Ar-41, Cr-51, Mn-54, Fe-55, Co-58, Co-60, Zn-65, Kr-85, Kr-88, Zr-95, Ag-110m, I-131-135, Xe-133-135, Cs-134, Cs-137 and transuranics). [I1-I3]
O27 Describe the processes and characteristics of heavy charged particle (alpha particles, protons) interaction with matter to include range of alpha particles in air, water, and tissue [I1-I3]
O28 Describe recent significant radiological incidents at this plant or at other nuclear power plants. [I1-I3]

IV. Assessment

Grades will be determined in the following manner:

<table>
<thead>
<tr>
<th>Assessment Method</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1. Tests</td>
<td>50% Test</td>
</tr>
<tr>
<td>A2. Assignments/Quizzes</td>
<td>10% Test/Performance</td>
</tr>
<tr>
<td>A3. Lab</td>
<td>20% Performance</td>
</tr>
<tr>
<td>A4. Final Exam</td>
<td>20% Test</td>
</tr>
</tbody>
</table>

Total 100%

A1. Tests: A minimum of three [3] tests and or final exam will be given. Each test and final exam may consist of multiple choice or discussion type questions along with problems. The tests will generally not be comprehensive, but will cover the material since the previous test. The final exam may or may not be comprehensive at the discretion of the instructor. The tests and final exam will count 70% of the overall grade. [CSLO 1,2,3]

A2. Assignments/Quizzes may be made by the instructor. Assignments must be completed in a professional manner and turned in when scheduled. At the discretion of the instructor, late assignments may not be accepted. Quizzes may be given at random times during the semester. The quizzes are designed to encourage keeping up with course material, class attendance, and participation. The assignments and quizzes will count for 10%--20% of the overall grade. [CSLO 1,2,3]
A3. Lab: Lab expectations will include lab attendance, activities, and reports. Lab will count 10% of the final grade. [CSLO 1,2,3]

A4. Final Exam: The final exam will be given during the scheduled final exam period. The final exam will be open book and notes. The final exam will count for 20% of the overall grade. [CSLO 1,2,3]

Certification: Students will be required to make a minimum of an 80 to obtain the Nuclear Uniform Curriculum Certification of completion.

V. Grading Scale

<table>
<thead>
<tr>
<th>Score Range</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>90—100</td>
<td>A</td>
</tr>
<tr>
<td>80—89.9</td>
<td>B</td>
</tr>
<tr>
<td>70—79.9</td>
<td>C</td>
</tr>
<tr>
<td>65—69.9</td>
<td>D</td>
</tr>
<tr>
<td>0—64.9</td>
<td>F</td>
</tr>
</tbody>
</table>

VI. Course Delivery Format

Standard Format

VIII. College Policies

This class is governed by the policies and procedures stated in the current Chattanooga State Student Handbook. Additional or more specific guidelines may apply.

ADA Statement

Students who have educational, psychological, and/or physical disabilities may be eligible for accommodations that provide equal access to educational programs and activities at Chattanooga State. These students should notify the instructor immediately, and should contact Disabilities Support Services within the first two weeks of the semester in order to discuss individual needs. The student must provide documentation of the disability so that reasonable accommodations can be requested in a timely manner. All students are expected to fulfill essential course requirements in order to receive a passing grade in a class, with or without reasonable accommodations.

Disruptive Students

The term “classroom disruption” means – student behavior that a reasonable person would view as substantially or repeatedly interfering with the activities of a class. A student who persists in disrupting a class will be directed by the faculty member to leave the classroom for the remainder of the class period. The student will be told the reason(s) for such action and given an opportunity to discuss the matter with the faculty member as soon as practical. The faculty member will
promptly consult with the division dean and the college judicial officer. If a
disruption is serious, and other reasonable measures have failed, the class may be
adjourned, and the campus police summoned. Unauthorized use of any electronic
device constitutes a disturbance. Also, if a student is concerned about the conduct
of another student, he or she should please see the teacher, department head, or
division dean.

**Affirmative Action**
Students who feel that he or she has not received equal access to educational
programming should contact the college affirmative action officer.

**Academic Integrity/Academic Honesty**
In their academic activities, students are expected to maintain high standards of
honesty and integrity. Academic dishonesty is prohibited. Such conduct includes,
but is not limited to, an attempt by one or more students to use unauthorized
information in the taking of an exam, to submit as one's own work, themes, reports,
drawings, laboratory notes, computer programs, or other products prepared by
another person, or to knowingly assist another student in obtaining or using
unauthorized materials. Plagiarism, cheating, and other forms of academic
dishonesty are prohibited. Students guilty of academic misconduct, either directly
or indirectly through participation or assistance, are immediately responsible to the
instructor of the class. In addition to other possible disciplinary sanctions, which
may be imposed through the regular institutional procedures as a result of
academic misconduct, the instructor has the authority to assign an "F" or zero for an
activity or to assign an "F" for the course.

**SMOKING/TOBACCO USE**
Chattanooga State Technical Community College recognizes the increasing weight
of scientific evidence that smoking is harmful not only to the "active" smoker but
also to the "passive" smoker who is exposed to others' smoke. Smoking is defined
as the lighting or carrying of a lighted cigarette, cigar, pipe, or similar device.

Smoking is prohibited in all college buildings, owned or leased. Additionally,
smoking will not be allowed in any college owned vehicles. All building entrances
are posted as non-smoking areas. Signs stating “No Smoking within 50 ft of
Entrance” are posted at all entrances. Signs are posted at all exits stating “Smoking
Prohibited within 50 ft of Building.

The use of mouth tobacco (to include dipping, chewing, etc.) is prohibited in all
Chattanooga State buildings, facilities, and vehicles.

The policy applies to all campuses and to the entire college community, including
employees, students, and visitors. It is the responsibility of all faculty, staff, and
students to adhere to, enforce, and inform visitors of the College’s smoking policy. If
a student continues to disregard the posting, he/she will be reported to the Dean of
Student Affairs. If an employee continues to disregard the posting, he/she will be
reported to their respective Vice-President
DESIGNATED SMOKING AREAS
The College has designated “Smoking” areas on campuses and at the sites. These areas can be located on the campus map.

CAMPUS AWARENESS PLAN
The policy shall be published in the College catalog, student handbook, and the policies and procedures manual. Periodic notices shall be placed in other college publications.

Flyers will be posted on all bulletin board and e-mail notices will be sent each semester, which will inform college visitors as well as students, staff, and faculty of the College’s position on this issue.

The instructor reserves the right to modify this syllabus in writing during the course of the semester.

Children
It is Tennessee Board of Regents policy that children are not permitted in the classrooms or laboratories. If you have children who must stay home for some reason, you must make other arrangements for their care than bringing them with you to class.

Tigermail is the official means of communication for the College.

The instructor reserves the right to modify this syllabus in writing during the course of the semester.

IX. Instructor Policies

Cell Phones
Activation of these devices represents a distraction and their use during lectures and labs (including instant messaging, games, and etc.) will be considered extremely disruptive to the learning environment. Please turn off (or set to vibrate) all such devices before entering the classroom. Please excuse yourself from the room if an emergency requires you to make or receive a phone call during class. If your cell phone goes off during a testing period, five points will be deducted from your test.

Use of Computers/Printers
The use of a computer is mandatory for all students. Students will have access to the computers in C24, C33, C54, C84, & C87. These computers are connected to the ET server and can be used to access Microsoft Office and other software. There may be times when one of the computer rooms will not be available; these times will be posted with as much advance notice as possible. It is the student’s responsibility to see that his or her username and password are working properly and that his or her password is protected. It is also the student’s
responsibility to back-up needed files. The school will not be responsible for any computer files that get “lost” or damaged.
Back-up documentation for this class (such as the class syllabus, handouts, description of class assignments, etc.) will be available to the students through eLearn. Printers are to only be used by Engineering Technology students for assignments related to engineering and engineering technology classes or labs. Paper availability may be subject to print management activities and will be requested through assigned faculty. Please help conserve paper.

Classrooms & Labs
Food and drinks are prohibited in all Engineering Technology classrooms, with the exception of water in a closed container. All food and drinks are prohibited in labs located in the Branch Center for Technology. Any form of tobacco products are also prohibited in accordance with College and TBR policy.

To Log-in C24, C33, C54, C84 & C87: Username: ET_last name first initial middle initial (no spaces)
Password: student
Domain (log-in): CSTCC

Note: Be sure to change your password after your initial log-in.