CHATTANOOGA STATE COMMUNITY COLLEGE
CHATTANOOGA, TENNESSEE
ENGINEERING TECHNOLOGY DIVISION

COURSE SYLLABUS

RP 154 NUCLEAR PHYSICS

Instructor: **Joe Bynum**
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Class Hours/Credit Hours: 4
Semester: Spring 2012
Room: Omni 177

Catalog Course Description:
Atomic and electrical nature of matter and the elementary theory of the nucleus, fundamental particles, natural and artificial radioactivity and nuclear reactions.

Prerequisites:
None

Corequisites:
None

Entry Level Standards
None

Textbook/Materials
Fundamentals of Nuclear Science and Engineering: 2nd Edition, J. Kenneth Shultis and Richard E. Faw.

Institutional Student Learning Outcomes
ISLO1. Communication
ISLO2. Competence in a Specialty Area
ISLO6. Critical Thinking and Analytical Skills

Program Student Learning Outcomes
PSLO1. An ability to apply knowledge of mathematics, basic sciences, and technology to solve problems appropriate to the radiation protection technology program. [ISLO6]
PSLO7. An ability to communicate effectively. [ISLO1]
PSLO11. An ability to use the techniques, skills, and modern engineering tools necessary to function as a radiation protection technician. [ISLO2]

Course Student Learning Outcomes
CSLO1 Provide students with the knowledge and skills necessary to monitor radioactive contamination found in nuclear power plants. [PSLO11, PSLO7]
CSLO2 Provide students with the knowledge to solve radiation protection problems at the technician level. [PSLO1]
CSLO3 Satisfy the requirements for the Nuclear Uniform Curriculum Program Certificate. [PSLO11]

Alignment of Assessments with CSLOs (actual assessments are defined below)		
CSLO1	CSLO2	CSLO3
a) Lab Assignments b) Quizzes c) Section Tests d) Final Exam	a) Lab Assignments b) Quizzes c) Section Tests d) Final Exam	a) Lab Assignments b) Quizzes c) Section Tests d) Final Exam

Topics:

Weeks 1 through 3

1. **Basic Atomic And Nuclear Physics**
   a. Basic atomic structure including: atomic mass unit, protons, neutrons, electrons, isotopes, mass-energy equivalence, mass defect, binding energy, binding energy per nucleon.
   b. Basic nuclear interactions and reactions including: radioactive decay processes (alpha, beta, gamma, electron capture), neutron activation, half-life determination, isotope identification methods, ionization (Bremsstrlaung, ionization and excitation), radiation interactions with matter (pair production, Compton scattering, photoelectric effect), neutron interactions (elastic and inelastic scattering, charged particle emission, fission, radioactive capture).
   c. Basic fission process including: theory of fission process (delayed, prompt, thermal and fast neutrons), control of fission process, neutron flux effects on reactor power, neutron leakage, fission products, neutron sources, radiation from fission and from fission products.
   d. Residual heat/decay heat including: sources of decay heat.
   e. Major sources of natural background radiation, man-made sources of background radiation, and radioactive sources routinely found in a nuclear plant

Weeks 4 through 6

2. **Radioactivity And Radioactive Decay**
   a. Types of radioactive decay (alpha, beta, gamma, electron capture and internal conversion).
   b. Basic equations to describe each type of decay.
   c. Exponential equations and appropriate graphs (linear and semi-log) to perform radioactive decay calculations.
   d. Alpha particles, beta particles, gamma rays, and neutrons (for example, describe the physical properties of these types of radiation).
   e. Process of neutron activation using basic equations.
   f. Specific isotopes of concern in power reactors during operation and following shutdown.
   g. Complex decay schemes, such as: natural decay chains, reactor produced decay chain, equilibrium isotopes (secular, transient or no equilibrium).

Weeks 7 through 9

3. **Sources of Radiation**.
   a. Major sources of natural background radiation: cosmic radiation, uranium, thorium decay chains, potassium 40, radon gas (including daughter products).
   b. Quantify the following man-made sources of background radiation: medical diagnostic X-rays, radio pharmaceuticals, consumer products (TV, luminous dials), weapons tests, air travel.
   c. Quantify potential sources of exposure to the public from: the plant liquid and gaseous effluent releases, transportation of radioactive materials, major accident.

Weeks 10 through 14

4. **Interactions of Radiation with Matter**
   a. Excitation, ionization, secondary ionization, and specific ionization. .
   b. Processes and characteristics of heavy charged particle (alpha particles, protons) interaction with matter to include, energy transfer by ionization and excitation, range-energy relationship, range of alpha particles in air, water, and tissue, specific ionization as a function of distance.
   c. Processes and characteristics of beta particle interactions with matter including: range-energy relationship, energy transfer by ionization, excitation, and bremsstrahlung, irregular track due to scattering, bremsstrahlung production using high atomic number absorber, range of beta particles in air, water, and tissue, density thickness.
   d. Linear energy transfer and relative stopping for beta interactions. .

e. Processes and characteristics of gamma and x-ray interaction with matter to include: exponential attenuation (as opposed to maximum range), interaction by Compton scattering, photoelectric effect, and pair production, effect of atomic number of absorber on attenuation.
f. Linear absorption coefficient and mass absorption coefficient, linear attenuation coefficient and mass attenuation coefficient for gamma interactions. .
g. Fast neutron, thermal neutron, cross-section, and barn and describe how neutron energy affects probability of interaction. .
h. Processes and characteristics of neutron interaction with matter including: elastic scattering, inelastic scattering, absorption, neutron activation, fission, charged particle emission.
i. Interaction mechanics, select types of materials for shielding each type of radiation. .
j. Gamma and neutron shielding calculations using the following: exponential shielding equation, half and tenth, thickness values, Buildup factor, empirically derived graphs.
k. Common shielding practices for beta particles (low Z number materials), neutrons (hydrogenous material) and gammas (high density, high Z number materials). .
l. Phenomenon of "sky shine" and the means by which it can be minimized. .
m. Quality factors for converting dose to dose equivalent (use 10CFR20).

Weeks 15 and 16

5. Review and Final Exam

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Course Objectives

Upon successful completion of the course a student should be able to:

O1. Explain basic atomic structure including: atomic mass unit, protons, neutrons, electrons, isotopes, mass-energy equivalence, mass defect, binding energy, binding energy per nucleon. [CSLO 1, 2, 3].

O2. Explain basic nuclear interactions and reactions including: radioactive decay processes (alpha, beta, gamma, electron capture), neutron activation, half-life determination, isotope identification methods, ionization (Bremsstrlaung, ionization and excitation), radiation interactions with matter (pair production, Compton scattering, photoelectric effect), neutron interactions (elastic and inelastic scattering, charged particle emission, fission, radioactive capture). [CSLO 1,2,3].

O3. Explain the basic fission process including: theory of fission process (delayed, prompt, thermal and fast neutrons), control of fission process, neutron flux effects on reactor power, neutron leakage, fission products, neutron sources, radiation from fission and from fission products. [CSLO 1,2,3].

O4. Explain residual heat/decay heat including: sources of decay heat (describe sources of decay and residual heat and its significance). [CSLO 1,2,3].

O5. Explain, identify and quantify major sources of natural background radiation, man-made sources of background radiation, and radioactive sources routinely found in a nuclear plant. [CSLO 1,2,3].

O6. Identify the types of radioactive decay (alpha, beta, gamma, electron capture and internal conversion). [CSLO 1,2,3].

O7. Use basic equations to describe each type of decay. [CSLO 1,2,3].

O8. Use exponential equations and appropriate graphs (linear and semi-log) to perform radioactive decay calculations. [CSLO 1,2,3].

O9. Characterize alpha particles, beta particles, gamma rays, and neutrons (for example, describe the physical properties of these types of radiation). [CSLO 1,2,3].

O10. Describe the process of neutron activation using basic equations. [CSLO 1,2,3].

O11. Identify specific isotopes of concern in power reactors during operation and following shutdown). [CSLO 1,2,3].

O12. Discuss complex decay schemes, such as: natural decay chains, reactor produced decay chain, equilibrium isotopes (secular, transient or no equilibrium). [CSLO 1,2,3I1, I2, I3].

O13. Identify and quantify these major sources of natural background radiation: cosmic radiation, uranium, thorium decay chains, potassium 40, and radon gas (including daughter products). [CSLO 1,2,3].

O14. Identify and quantify the following man-made sources of background radiation: medical diagnostic x-rays, radio pharmaceuticals, consumer products (TV, luminous dials), weapons tests, air travel. [CSLO 1,2,3].
O15. Identify and quantify potential sources of exposure to the public from: the plant liquid and gaseous effluent releases, transportation of radioactive materials, major accident. [CSLO 1,2,3].
O16. Define the following terms: excitation, ionization, secondary ionization, and specific ionization. [CSLO 1,2,3].
O17. Describe the processes and characteristics of heavy charged particle (alpha particles, protons) interaction with matter to include, energy transfer by ionization and excitation, range-energy relationship, range of alpha particles in air, water, and tissue, specific ionization as a function of distance. [CSLO 1,2,3].
O18. Describe the processes and characteristics of beta particle interactions with matter including: range-energy relationship, energy transfer by ionization, excitation, and bremsstrahlung, irregular track due to scattering, bremsstrahlung production using high atomic number absorber, range of beta particles in air, water, and tissue, density thickness. [CSLO 1,2,3].
O19. Define linear energy transfer and relative stopping for beta interactions. [CSLO 1,2,3].
O20. Describe the processes and characteristics of gamma and x-ray interaction with matter to include: exponential attenuation (as opposed to maximum range), interaction by Compton scattering, photoelectric effect, and pair production, effect of atomic number of absorber on attenuation. [CSLO 1,2,3].
O21. Define linear absorption coefficient and mass absorption coefficient, linear attenuation coefficient and mass attenuation coefficient for gamma interactions. [CSLO 1,2,3].
O22. Define fast neutron, thermal neutron, cross-section, and barn and describe how neutron energy affects probability of interaction. [CSLO 1,2,3].
O23. Describe the processes and characteristics of neutron interaction with matter including: elastic scattering, inelastic scattering, absorption, neutron activation, fission, charged particle emission. [CSLO 1,2,3].
O24. Based on knowledge of interaction mechanics, select types of materials for shielding each type of radiation. [CSLO 1,2,3].
O25. Perform gamma and neutron shielding calculations using the following: exponential shielding equation, half and tenth, thickness values, Define buildup factor, empirically derived graphs. [CSLO 1,2,3].
O26. Identify common shielding practices for beta particles (low Z number materials), neutrons (hydrogenous material) and gammas (high density, high Z number materials). [CSLO 1,2,3].
O27. Describe the phenomenon of "sky shine" and the means by which it can be minimized. [CSLO 1,2,3].
O28. Apply quality factors for converting dose to dose equivalent (use 10CFR20). [CSLO 1,2,3].

Assessment

Grades will be determined in the following manner:

		Assessment Method
A1. Tests	=50%	Test
A2. Lab	=20%	Performance
A3. Assignments/Quizzes	=10%	Test/Performance
A4. Final Exam	=20%	Test
	100%	

A1. Tests: A minimum of three [3] tests and a 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. [CSLO1,2,3]

A2. Lab: Lab expectations will include lab attendance, activities, and reports. All students will submit a lab report following the lab studies. The lab report must contain the following: Lab Title,

lab purpose, lab procedure, data collected during the lab study, analysis of the data (calculations, graphs, and percent error, and conclusion). Students will be graded on writing skills, adherence to safety, procedure compliance, and oral communication skills with others. Lab will count 20% of the final grade. Lab will count 20% of the final grade. [CSLO 1,2,3]

A3. 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% of the overall 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 comprehensive. 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 Program Certification of Completion.

Grading Scale

A: 90 – 100
B: 80 – 89
C: 70 – 79
D: 65 – 69
F: Below 65

Course Delivery Format

Standard Format – This format is the traditional format and may use an on-line format **(eLearn)** to provide access to "static" materials which include the syllabus, course material, contact information, and presentations. Faculty must make available, when requested, a copy of the syllabus and any other instructor provided course materials, including instructor contact information. Faculty may require on-line activities and assignments to include on-line tests and submission of all written and on-line communications. The extent of on-line activities/assignments may vary by course but will be specified on the syllabus.

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 al 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.

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. Since this is a new course, the weekly topics calendar may be changed.

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.