**SYLLABUS**
**Columbia Basin College**
**Career and Technical Education Division**

**Prepared by Bobby McDaniel** **Document created: March 12, 2012**

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**COURSE TITLE: RPT-111—Radiation Fundamentals**

**CATALOG DESCRIPTION**
This course provides future radiological protection technicians with an overview of radioactivity, sources of radiation, and radioactive decay. Emphasis will be placed on plant safety, radiological hazards and radioactivity containment.

**PREREQUISITE OR ASSET/COMPASS SCORE (AS APPROPRIATE)**
Completion of NT 111, NT 114, NT 131 and NT 141 or 142 with 2.5 grade or better

**CREDITS AND HOURS**
5 CREDITS (4 credits lecture – 44 hours/ 1 credit lab – 22 hours)

**TEXT(S) AND MATERIALS**
10CFR20, *Standards for Protection Against Radiation*
10CFR835, *Occupational Radiation Protection*
Cember, *Introduction to Health Physics 4th Edition (Instructor Reference Only)*
Gollnick, *Basic Radiation Protection Technology 5th Edition (**Required Student Text**)*
Shleien, et. al., *Handbook of Health Physics and Radiological Health 3rd Edition (Instructor Reference Only)*
*17th Edition of Nuclides and Isotopes (Chart of the Nuclides) (**Required Student Text**)*

**GENERAL TEACHING METHODS**
Lecture, Discussion, Group Projects, Assigned Homework

**STUDENT LEARNING OUTCOMES**

**CBC Student Learning Outcomes**
Students who graduate from Columbia Basin College will have been exposed to skills, concepts, and methods of inquiry in many different disciplines. The totality of their learning experience is expressed in a set of general Student Learning Outcomes (SLOs), which all students, regardless of program, are expected to demonstrate:

1. Think Critically
2. Reason Quantitatively and Symbolically
3. Communicate Effectively
4. Apply Information Tools and Resources
5. Develop Cultural Awareness
6. Master Program Learning Outcomes

**Course Outcomes**
Radiation Fundamentals is intended to develop abilities to think critically, communicate effectively, reason quantitatively and symbolically, apply information tools and resources and master program learning outcomes through the following outcomes:

- Explain the importance of following systems to plant safety and radioactivity containment, and identify any radiological hazards and precautions associated with maintenance tasks for each. (SLO 1, 3, 4 & 6)
- Properly select, inspect, use, and care for tools and equipment used in radiological protection technician task performance. (SLO 1, 4 & 6)
- Explain and apply the theory of radioactivity and radioactivity decay. (SLO 2 & 6)
- Identify and quantify sources of radiation. (SLO 1, 3 & 6)

**COURSE OUTLINE**

1. Radioactivity and Radioactive Decay
    a. Chart of the Nuclides.
    b. Types of radioactive decay, to include alpha, beta, gamma, electron capture, and internal conversion.
    c. Characteristics of alpha particles, beta particles, gamma rays, and neutrons.
    d. Radioactive decay notation.
    e. Neutron activation, including activation notation.
    f. Radiological quantities and their units, including activity (curies and becquerels, disintegrations per second, disintegrations per minute), exposure (roentgens), dose (rads and grays), and dose equivalent (rems and sieverts).
    g. Complex decay schemes, such as natural decay chains, reactor-produced decay chain, and equilibrium isotopes (secular, transient, or no equilibrium).
    h. Exponential equations and graphs (linear and semi-log) to support radioactive decay calculations.
2. Internal and External Exposure Control
    a. Equating radioactivity to dose rate through simple rules of thumb and associated calculations for various source geometries.
    b. Identifying and using significant dose terms:
        - Deep
        - Eye (lens, shallow, effective (using weighting factors))
        - Committed (for example, using in vivo and in vitro measurements and intake retention fractions)
        - Committed effective (using in vivo and in vitro measurements and intake retention fractions)
        - Total effective
        - Total organ dose equivalents
3. Operational Health Physics
    a. Major sources of natural background radiation: cosmic radiation, uranium, thorium decay chains, potassium 40, and radon gas, including daughter products.
    b. Man-made sources of background radiation, including medical diagnostic X-rays, radio pharmaceuticals, consumer products (television, luminous dials), weapons tests, and air travel.

c. Sources of public exposure from plant liquid and gaseous effluent releases, transporting radioactive materials, and major accidents.

d. Isotopes of concern in power reactors during operation and following shutdown (such as $^{3}H$, $^{16}N$, $^{41}Ar$, $^{51}Cr$, $^{54}Mn$, $^{55}Fe$, $^{58}Co$, $^{60}Co$, $^{65}Zn$, $^{85}Kr$, $^{88}Kr$, $^{95}Zr$, $^{110m}Ag$, $^{131\text{-}135}I$, $^{134}Cs$, $^{137}Cs$, and transuranics).

e. Major sources of radiation in the plant that contribute to worker exposures:

- Primary system piping and components
- Inside containment during power operation
- Primary system filters and demineralizers
- Radwaste process systems
- Radiography

f. Conditions that preclude safe work in the vicinity of system components.

g. Plant systems safety and containment, including understanding the radiological significance of the following systems:

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

**COURSE OBJECTIVES**

1. Upon completion of the Module 1 Presentation (Radioactivity and Radioactive Decay), the student should be able to:

   a. DEMONSTRATE the ability to read and interpret the information contained in the Chart of the Nuclides.

   b. EXPLAIN the types of radioactive decay ($\alpha$, $\beta$, $\gamma$, $\varepsilon$, and IT)

   c. CHARACTERIZE the physical properties of $\alpha$, $\beta$, $\gamma$, $\varepsilon$, and n radiation

   d. USE basic equations to describe each radiations decay scheme

   e. DESCRIBE neutron activation using basic equations

   f. IDENTIFY and Use radiological quantities and units, including activity (Ci and Bq, dps, dpm), exposure (roentgens), absorbed dose (rads and grays), and dose equivalent (rems and sieverts)

   g. DISCUSS complex decay schemes, such as natural decay chains, reactor-produced decay chain, and equilibrium isotopes (secular, transient, or no equilibrium)

h. TRACE decay schemes to stability using the Chart of the Nuclides

i. USE exponential equations and appropriate graphs (linear and semi-log) to perform radioactive decay calculations

2. Upon completion of the Module 2 Presentation (Internal and External Exposure Control), the student should be able to:

   a. EQUATE radioactivity to dose rate through simple rules of thumb and associated calculations for various source geometries (e.g., 6CEN, point source, line source, plane source)

   b. IDENTIFY, CALCULATE, and Use the following significant dose terms:

      i. Deep dose

      ii. Eye [lens, shallow, effective (using weighting factors)]

      iii. Committed (using in vivo and in vitro measurements and intake retention fractions)

      iv. Committed effective (using in vivo and in vitro measurements and intake retention fractions)

      v. Total effective

      vi. Total organ dose equivalents

3. Upon completion of the Module 3 Presentation (Operational Health Physics), the student should be able to:

   a. IDENTIFY and QUANTIFY major sources of natural background radiation, including:

      i. Cosmic radiation

      ii. Uranium and thorium decay chains

      iii. $^{40}K$

      iv. Radon gas, including daughter products

   b. IDENTIFY and QUANTIFY the following man-made sources of background radiation:

      i. Medical diagnostic X-rays

      ii. Radio pharmaceuticals

      iii. Consumer products (television, luminous dials)

      iv. Weapons tests

      v. Air travel

   c. IDENTIFY and QUANTIFY potential sources of exposure to public from:

      i. Plant liquid and gaseous effluent releases

      ii. Transporting radioactive materials

      iii. Major accidents

   d. IDENTIFY specific isotopes of concern in power reactors during operation and following shutdown

   e. IDENTIFY and QUANTIFY the following major sources of radiation in the plant that contribute to worker exposures:

      i. Primary system piping and components

      ii. Inside containment during power operation

      iii. Primary system filters and demineralizers

iv. Radiological waste process systems

v. Radiography

f. IDENTIFY conditions that preclude safe work in the vicinity of system components

g. DISCUSS the radiological significance of selected plant systems.

**EVALUATION METHODS**
Tests, Homework Assignments, Group Projects and class participation

**ACADEMIC HONESTY**
As members of the Columbia Basin College learning community, students are not to engage in any form of academic dishonesty. Forms of academic dishonesty include, but are not limited to, plagiarism, cheating, fabrication, grade tampering, and misuse of computers and other electronic technology. Students who engage in academic dishonesty may receive an academic penalty or a disciplinary penalty or both. Instances of academic dishonesty may be referred to the Vice President for Student Services in accordance with the Washington Administrative Code (WAC) section 132S-40-350 and the CBC Code of Student Rights and Responsibilities. The disciplinary consequences of engaging in any form of academic dishonesty include reprimand, probation, suspension, and dismissal. A student who knowingly helps or attempts to help another individual to violate the College's policy on academic honesty also may be subject to academic as well as disciplinary penalties.

Students are expected to be familiar with CBC policy on academic dishonesty. This is available online at www.columbiabasin.edu/academichonesty.

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**PRIVACY**
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**TUTOR CENTER**
The Tutor Center offers CBC students help with their studies for most departments and programs. It is also available to facilitate study groups. The center is in room TD 434 (the Lee R. Thornton Center) on the Pasco campus. The phone number is (509) 542-4676.

You can reach the Tutor Center online at www.columbiabasin.edu/tutor.

**STUDENTS WITH DISABILITIES/HEALTH CONCERNS**
Columbia Basin College provides reasonable accommodations to students with disabilities. Students who need auxiliary aids or course accommodations, have emergency medical information, or need special arrangements in case the building must be evacuated, should notify their instructors as soon as possible. Students needing accommodations should contact the Resource Center, Disability Services Office for an appointment. They are located in the H Building on the Pasco Campus. They can reached at (509) 542-4412, or (509) 542-5525.

**CBC SAFETY**
Columbia Basin College strives to provide a safe and secure environment for students, staff, and visitors. The CBC

Health and Safety Committee's purpose is to pursue potential issues and to establish prevention tactics. For more information, visit www.columbiabasin.edu/safety. Sign up for emergency notification text messages and/or emails at www.columbiabasin.edu/ens.

Pasco Campus Security: (509) 542-4819
Richland Campus Security: (509) 539-8167
After Hours Security: (509) 521-4599

Approved 2-15-2012 by Curriculum Committee