# Virginia Western Community College
# RAD 205
# Radiation Protection and Radiobiology

## Prerequisites:
None

## Course Description:
Studies methods and devices used for protection from ionizing radiation. Teaches theories of biological effects, cell and organism sensitivity, and the somatic and genetic effects ionizing radiation. Presents current radiation protection philosophy for protecting the patient and technologist.

**Semester Credits: 3** **Lecture Hours: 3** **Lab/Clinical/Internship Hours: 0**

## Required Materials

**Textbook:**
Radiation Protection in Medical Radiography. 7th Edition. Mary A. Statkiewicz-Sherer, Paul J. Visconti & E. R. Ritenour. ISBN: 13: 9780323172202

## Course Outcomes
**At the completion of this course, the student should be able to:**

- State the general effect of radiation on the body.
- Understand the effects of ionizing radiation in biological systems.
- Be aware of the public right to minimal radiation exposure.
- Identify x-ray examination, which produce relatively high patient exposure.
- Discuss the association of diagnostic x-rays with mortality or incidence of disease.
- List examinations that deliver a relatively high exposure to the gonads.
- Apply specific procedures to minimize radiation dose to the patient and radiographer

## Topical Description

Chapter 1: Introduction to Radiation Protection

- Effective Radiation Protection
- Justification and Responsibility for Imaging Procedures
- As Low As Reasonably Achievable (ALARA) Principle
- Patient Protection and Patient Education

Chapter 2: Radiation – Types, Sources and Doses Received

- Radiation
    - Types of Radiation
    - The Electromagnetic Spectrum
    - Ionizing and Non-Ionizing Radiation
    - Particulate Radiation
    - Radiation Dose Specification: Equivalent Dose
    - Biologic Damage Potential
    - Sources of Radiation
    - New Data on Medical Radiation Exposure

Chapter 3: Interaction of X-Radiation with Matter

- Significance of X-Ray Absorption in Biologic Tissue
- X-Ray Beam Production and Energy
- Attenuation
- Probability of Photon Interaction with Matter
- Processes of Interaction

Chapter 4: Radiation Quantities and Units

- Specific areas particular to each clinical area
- Departmental particulars, including P.A.C.S. and C.R. systems

Chapter 5: Radiation Monitoring

- Personnel Monitoring
- Personnel Dosimeters
- Radiation Survey Instruments For Area Monitoring
- Instruments Used To Measure X-Ray Exposure In Radiology

Chapter 6: Overview of Cell Biology

- The Cell
- Cell Chemical Composition
- Cell Structure
- Cell Division

Chapter 7: Molecular and Cellular Radiation Biology

- Ionizing Radiation
- Radiation Energy Transfer Determinants
- Molecular Effects of Irradiation
- Cellular Effects of Irradiation
- Survival Curves for Mammalian Cells
- Cell Radiosensitivity

Chapter 8: Early Radiation Effects on Organ Systems

- Somatic and Genetic Damage Factors
- Somatic Effects

Chapter 9: Late Radiation Effects on Organ Systems

- Epidemiology
- Radiation Dose-Response Relationship
- Somatic Effects

Chapter 10: Dose Limits for Exposure to Ionizing Radiation

- Basis Of Effective Dose Limiting System
- Radiation Protection Standards Organizations
- U.S. Regulatory Agencies
- Radiation Safety Program
- Radiation Control For Health And Safety Act Of 1968
- ALARA Concept
- Consumer-Patient Radiation Health And Safety Act Of 1981
- Objectives Of Radiation Protection
- Current Radiation Protection Philosophy
- Risk
- Basis For The Effective Dose Limiting System
- Current National Council On Radiation Protection And Measurements Recommendations
- Action Limits
- Radiation Hormesis
- Occupational And Nonoccupational Dose Limits

Chapter 11: Equipment Design for Radiation Protection

- Radiation Safety Features of Radiographic Equipment, Devices, And Accessories
- Radiation Safety Features of Digital Imaging Equipment, Devices, And Accessories
- Radiation Safety Features of Fluoroscopic Equipment, Devices, And Accessories
- Radiation Safety Features of Mobile C-Arm Fluoroscopy Equipment, Devices And Accessories
- Radiation Safety Features of Cinefluoroscopy Equipment, Devices, And Accessories
- Radiation Safety of Digital Fluoroscopic Equipment, Devices, And Accessories
- Radiation Safety for High-Level-Control Interventional Procedures

Chapter 12: Management of Patient Radiation Dose during Diagnostic X-Ray Procedures

- Effective Communication
- Immobilization
- Protective Shielding
- Technical Exposure Factors
- Processing of the Radiographic Image
- Air Gap Technique
- Repeat Images
- Unnecessary Radiologic Procedures
- Amount of Radiation Received by Patients Undergoing Diagnostic Imaging Procedures
- The Pregnant Patient
- Other Diagnostic Examinations and Imaging Modalities
- Pediatric Considerations during Conventional X-Ray Imaging
- Protecting the Pregnant or Potentially Pregnant Patient

Chapter 13: Management of Imaging Personnel Radiation Dose during Diagnostic X-Ray Procedures

- Annual Limit for Occupationally Exposed Personnel
- ALARA Concept
- Dose-Reduction Methods and Techniques
- Protection for Pregnant Personnel
- Basic Principles of Radiation Protection for Personnel Exposure Reduction
- Diagnostic-Type Protective Tube Housing
- Protection during Fluoroscopic Procedures
- Protection during Mobile Radiographic Examinations
- Protection during C-Arm Fluoroscopy
- Protection during High-Level-Control Interventional Procedures
- Patient Restraint
- Doors to X-Ray Rooms
- Diagnostic X-Ray Suite Protection Design
- Posting of Caution Signs for Radioactive Materials and Radiation Areas

Chapter 14: Radioisotopes and Radiation Protection

- Medical Usage
- Radiation Emergencies: Use of Radiation as a Terrorist Weapon

## Chapter Objectives

Chapter 1: Introduction to Radiation Protection

- Identify consequences of ionization in human cells.
- Discuss the concept of effective radiation protection.
- Explain the justification and responsibility for imaging procedures.
- State the ALARA principle and discuss its significance in diagnostic
- Describe the importance of patient education as it relates to medical imaging.
- Explain how radiographers should answer patients' questions about the risk of radiation from an imaging procedure, and give some examples.
- List and describe three sources of natural background ionizing radiation.
- List and describe six sources of manmade or artificial ionizing radiation.
- Discuss the responsibility and need for radiation protection in medical imaging.

Chapter 2: Radiation: Types, Sources, and Doses Received

- Define the term radiation and give some examples of different types of radiation.
- Draw a diagram to illustrate the EM spectrum and explain how the spectrum can be divided for studying radiation protection.
- List the different forms of EM and Particulate radiations, and identify those forms that are classified as ionizing radiation.
- Explain the concepts of equivalent dose and effective dose.
- Discuss the significance of the Sievert as a unit of measure for equivalent dose.
- Describe the potential for ionizing radiation to cause biologic damage.
- List and describe three sources of natural background ionizing radiation and seven sources of manmade, or artificial, ionizing radiation.
- Discuss the local and global consequences of radiation exposure resulting from accidents in nuclear power plants.
- Discuss the responsibility and need for radiation protection in medical imaging.
- Discuss the modalities used in medical imaging that have caused an increase in radiation dose for patients from 1980 until present.

Chapter 3: Interaction of X-Radiation with Matter

- Differentiate between peak kilovoltage and miiliampere-seconds as technical factors.
- Describe the process of absorption and explain the reason why absorbed dose in atoms of biologic matter should be kept as small as possible.
- Differentiate among primary radiation; exit, or image-formation, radiation; and scattered radiation.
- List two types of x-ray photon transmission and explain the difference between them.
- Discuss the way x-rays are produced and explained the way the range of energies present in the x-ray beam
- Describe and illustrate by diagram the x-ray photon interactions with matter that are important in diagnostic radiology.
- List the x-ray photons interactions with matter that occur above the energy range used in diagnostic radiology.
- Describe the effect of kVp on radiographic image quality and patient absorbed dose.

Chapter 4: Radiation Quantities and Units

- Explain the concepts of skin erythema dose, tolerance dose, and threshold dose.
- List five examples of short-term somatic effects (early or acute effects).
- List three examples of long-term somatic effects (late effects).
- Differentiate between somatic and genetic effects.
- Differentiate among the radiation quantities exposure, absorbed dose, equivalent dose, and effective dose.
- Identify the appropriate symbol for each quantity.
- List and explain the International System (SI) and traditional units for radiation exposure, absorbed dose, equivalent dose, and effective dose.
- Explain the importance of linear energy transfer as it applies to biologic damage resulting from irradiation of human tissue.
- Explain the concept of effective dose when used for radiation protection purposes.
- State the formula for determining effective dose.

Chapter 5: Radiation Monitoring

- State the reason why a radiation worker should wear a personnel dosimeter
- Explain the function and characteristics of personnel dosimeters.
- Identify the appropriate location on the body where the personnel dosimeter(s) should be worn during the following procedures or conditions:
    - routine computed radiography, digital radiography, or conventional radiography
    - fluoroscopic procedures
    - special radiographic procedures
    - pregnancy

- Describe the various components of the film badge, optically stimulated luminescence (OSL) dosimeter, pocket ionization chamber, and thermoluminescent dosimeter (TLD).
- Explain the use of each type of dosimeter as personnel dosimeters.
- Explain the requirements of radiation survey instruments.
- Explain the purpose of the following instruments:
    - ionization chamber-type survey meter (cutie pie)
    - proportional counter
    - Geiger-Muller detector
- Identify the radiation survey instrument that can be used to calibrate radiographic and fluoroscopic equipment.

Chapter 6: Overview of Cell Biology

- Identify and describe some important functions of the major classes of organic and inorganic compounds that exist in the cell.
- List the important functions of water in the human body.
- Describe the molecular structure of deoxyribonucleic acid and explain the way it functions in the cell.
- List the various cellular components and identify their physical characteristics and functions.
- Distinguish between the two types of cell divisions, mitosis and meiosis, and describe each process.

Chapter 7: Molecular and Cellular Radiation Biology

- List the three radiation energy transfer determinants, and explain their individual concepts.
- Differentiate among the three levels of biologic damage that may occur in living systems because of exposure to ionizing radiation.
- State and describe the law of Bergonie and Tribondeau.

Chapter 8: Early Radiation Effects on Organ Systems

- List four factors on which the amount of somatic and genetic biologic damage resulting from radiation exposure depend.
- List and describe the various early nonstochastic somatic effects of ionizing radiation on living systems.
- Describe acute radiation syndrome and list three separate dose related syndromes that occur as part of this total body syndrome.
- Identify the four major body response stages of acute radiation syndrome.
- State the LD 50/30 for humans, explain the significance, and explain why the LD 50/60 is more accurate for humans as a measure of lethality.
- Explain why cells that are exposed to sublethal doses of ionizing radiation recover after irradiation, and discuss the cumulative effect that exists after repeated radiation injuries.

- List three factors on which organ and tissue response to radiation exposure depend.

- State the single absorbed dose of ionizing radiation that can cause a radiation-induced skin erythema within 24-48 hours after irradiation and describe how this dose first manifests itself.
- Discuss the impact on human skin when high-level fluoroscopy is used for extended periods during cardiovascular or therapeutic interventional procedures.
- State the dose of ionizing radiation necessary to cause both temporary and permanent sterility in the human male and female.
- Identify consequences, other than impaired fertility, for the human male and female, and discuss the benefit of gonadal shielding.
- State the whole body radiation dose that would produce a measurable hematologic depression, and identify the blood cells that are the most sensitive to radiation exposure.
- Discuss the impact on the human body if radiation exposure causes a decrease in the cells that protect it against disease.

Chapter 9: Late Radiation Effects on Organ Systems

- Explain how scientists use epidemiologic studies to predict the risk of cancer in human populations exposed to low doses of ionizing radiation
- Draw diagrams of various dose response curves.
- Explain why regulatory agencies continue to use linear dose-response models for establishing radiation protection standards.
- Differentiate between threshold and nonthreshold relationships.
- List and describe the various late nonstochastic somatic effects and late stochastic somatic effects ionizing radiation on living systems.
- Describe the concept of risk for radiation-induced malignancies, and explain the models that are used to give risk estimates.
- Identify ionizing radiation-exposed human populations or groups that prove radiation induces cancer.

Chapter 10: Dose Limits for Exposure to Ionizing Radiation

- List and describe the function of the four major organizations that share the responsibility for evaluating the relationship between radiation equivalent dose and induced biologic effects and five US regulatory agencies responsible for enforcing established radiation effective dose limiting standards.
- Explain the function of the radiation safety committee in a medical facility and describe the role of the radiation safety officer by listing the various responsibilities he or she must fulfill.
- Explain the purpose of the Radiation Control for Health and Safety Act of 1968.
- Explain the purpose of the Consumer Patient Health and Safety Act of 1981.
- Describe the current radiation protection philosophy, state the goal and objectives of radiation protection.
- Explain the concept of risk as it relates to the medical imaging industry.
- Discuss current National Council on Radiation Protection and Measurements recommendations.
- If given the appropriate data, be able to calculate the cumulative effective dose for the whole body of a radiation worker.

- Explain the concept of Radiation Hormesis.
- State the following in terms of International System (SI) units and traditional units:
    - annual occupational effective dose limit
    - cumulative effective dose limit for whole-body exposure excluding medical and natural background exposure
    - annual occupational equivalent dose limits for tissues and organs
    - annual effective dose limits for continuous exposure and for infrequent exposure of the general public from manmade sources other than medical and natural background
    - annual equivalent dose limits for tissues and organs for members of the general public
    - annual effective dose limit for an occupationally exposed student under the age of 18 years.
    - occupational monthly equivalent dose limit to the embryo-fetus (excluding medical and natural background radiation) once the pregnancy is known

Chapter 11: Equipment Design for Radiation Protection

- Explain the requirements for a diagnostic type protective tube housing, x-ray control panel, radiographic examination table, and discuss their purpose.
- List various beam-limiting devices and describe each.
- Explain the importance of the collimator's positive beam limitation feature.
- Explain the function of x-ray beam limitation in diagnostic radiology.
- List two types of filtration used in diagnostic radiography.
- Describe half-value layer and give examples of HVLs required for selective peak kilovoltages.
- Explain the function of a compensating filter and list some types.
- Explain how grids increase patient dose.
- Identify the minimum source-skin distance (SSD) that must be used for mobile radiography to ensure patient safety

Chapter 12: Management of Patient Radiation Dose during Diagnostic X-Ray Procedures

- Explain the need for effective communication between imaging department personnel and the patient.
- Explain how voluntary motion can be eliminated or minimized and how involuntary motion can be compensated for during a radiographic procedure
- Compare the various types of protective shielding available.
- Discuss the need to use appropriate technical factors and explain how these factors may need to be adjusted to reduce patient dose
- Explain how adequate immobilization and correct image processing techniques reduce radiographic exposure for the patient.
- State the reason for reducing repeat images and the benefits of a repeat analysis program.
- List six nonessential radiological examinations and list why each is considered unnecessary
- List four ways to indicate the amount of radiation received by a patient from a diagnostic examination.

- Explain the reason children require special radiation protection when undergoing conventional diagnostic imaging procedures.
- Describe special precautions employed in radiography to protect the pregnant or potentially pregnant patient during an x-ray examination.

Chapter 13: Management of Imaging Personnel Radiation Dose during Diagnostic X-Ray Procedures

- Explain the reason that occupational exposure of diagnostic imaging personnel must be limited, and state the most important reason for allowing a larger equivalent for radiation workers than for the population as a whole.
- Identify the type of x-radiation that poses the greatest occupational hazard in diagnostic radiology, and explain the various ways this hazard can be reduced or eliminated
- Discuss the responsibilities of the employer for protecting declared pregnant diagnostic imaging personnel from radiation exposure.
- List and explain the three basic principles of radiation protection that can be used for personnel exposure reduction
- State and explain the inverse square law by solving mathematical problems applying its concept.
- Differentiate between a primary and secondary protective barrier and list examples of each.
- Explain the various methods that may be used to reduce a radiographer's exposure during a mobile radiographic examination
- Explain the variation in dose rate caused by scatter radiation neat the entrance and exit surfaces of the patient during C-arm fluoroscopy, and methods of dose reduction for C-arm operators.
- List the three categories of radiation sources that may be generated in an x-ray room
- List the considerations on which the design of radiation-absorbent barriers should be based and explain the importance of each
- Differentiate between a controlled area and an uncontrolled area.

Chapter 14: Radioisotopes and Radiation Protection

- Describe how therapeutic isotopes may be categorized
- Identify the most common radioisotope used in nuclear medicine studies.
- Discuss the radiation hazards that may be personnel caring for patients receiving therapeutic treatment with isotopes.
- Discuss reasons for concerns over the use of radiation as a terrorist weapon.
- Identify what action most hospitals have taken for handling emergency situations involving radioactive contamination
- Explain what a radioactive dispersal device, or "dirty bomb", is, and discuss the possible consequences of the detonation of such a device.
- State the dose limit per event for individuals engaged in both non-lifesaving and lifesaving activities during a radiation emergency.
- Explain why the Environment Protection Agency sets limits for radiation contamination.
- Discuss medical management for persons experiencing radiation bioeffects.
- Describe various strategies used to treat internal radiation contamination.

## Note to Instructors

1. One-on-one tutorial sessions are available upon request.
2. Students may utilize the energized laboratory under supervision of a faculty member while on campus.
3. On-campus laboratory rules must be followed.
4. Students must adhere to the program's "Repeat Policy" when repeating any Radiographic Procedures.