NMED-1501: RADIATION PHYSICS

Cuyahoga Community College

Viewing: NMED-1501 : Radiation Physics

Board of Trustees:
October 2019

Academic Term:
Fall 2020

Subject Code
NMED - Nuclear Medicine Technology

Course Number:
1501

Title:
Radiation Physics

Catalog Description:
Study of physics as it relates to radiation and medical imaging. Focuses on the principles of radioactivity, effects of radiation on matter, and emerging technologies as they relate to nuclear medicine and advanced molecular imaging. Topics include applicable classical physics concepts, atomic structure, mass-energy relationships, types of radiation, calculations of radioactive decay, production of radionuclides and x-rays, and principles and operation of SPECT, PET, CT, MRI and fusion imaging systems.

Credit Hour(s):
2

Lecture Hour(s):
2

Requisites

Prerequisite and Corequisite
Departmental approval: Admission to the Nuclear Medicine program.

Outcomes

Course Outcome(s):
Apply knowledge of radiation physics concepts.

Objective(s):
1. Define and describe basic atomic physics concepts.
2. Explain modes of radioactive decay and decay schemes.

Course Outcome(s):
Describe and understand principles of physics as they relate to nuclear medicine instrumentation and emerging technologies in the field.

Objective(s):
1. Discuss emerging technologies use and purpose (TBA by instructor).
2. Explain other imaging modalities and how they combine with nuclear medicine imaging.
3. Explain principles of physics as they relate to nuclear medicine and instrumentation used in the field.
4. Discuss and explain SPECT and SPECT/CT Systems.
5. Discuss and explain PET systems.
6. Discuss and explain CT systems and integration of CT procedures into the combines PET/CT examinations.

Course Outcome(s):
Explain principles that govern radioactivity and interactions with ionizing radiation with matter.

Objective(s):

1. Discuss photon and particulate interactions with matter.
2. Explain production methods of radionuclides and x-rays.

Methods of Evaluation:

Assignments/worksheets

1. Quizzes
2. Midterm Exam
3. Final exam

Course Content Outline:

1. Quantum Theory and Matter Composition
    a. Atomic particles and structure
    b. Quantum Theory
    c. Nuclear shorthand
    d. Electron shells and stability
    e. Binding energy
    f. Energy states
    g. Nuclear stability
2. Radiation and mankind; discovery, development, realizations.
    a. Descriptions, properties, characteristics
    b. Radioactive units of activity, exposure, effect, and dose
3. Radioactive Decay
    a. Atomic nomenclature
    b. Decay factor and decay constant
    c. Half-life calculations and manipulation
    d. Exponential decay and graphing
    e. Decay schemes
    f. Parent daughter decay
    g. Transient equilibrium vs. Secular equilibrium
4. Interactions of radiation with matter
    a. Ionization vs non-ionization
    b. Particulate
    c. Electromagnetic
    d. Secondary radiation
    e. Attenuation characteristic
5. Basic Radiation Safety
    a. As Low As Reasonably Achievable (ALARA)
    b. Dose-distance relationships & related factors
    c. Source geometry
    d. Inverse-square law
    e. Gamma dose rate constant
    f. Special considerations for PET and CT (room design, safety, patient dose)
6. Production of radionuclides
    a. Naturally occurring
    b. Artificially produced
    c. Methods of production
        i. Reactor, Fission (neutron bombardment), & fusion
        ii. Particulate bombardment (cyclotron and linear accelerator)
        iii. Generator
        iv. Specific activity
7. Principals of Radiation Detectors:
    a. Gas-filled detectors/Ionization chambers
        i. Gas ionization curve
        ii. Dose calibrators

        iii. Pocket dosimeter
        iv. Geiger-Muller survey meters
    b. Semiconductor detectors
    c. Basic scintillation detection principles and components
        i. Well counters
        ii. Gamma Camera: Performance Characteristics
        iii. Crystals
        iv. PMT (photomultiplier tubes)
        v. Preamplifiers and the gain setting
        vi. Amplifiers and pulse shaping
        vii. Pulse height analyzer
        viii. Digital counters and rate meters
        ix. Creating a digital image
        x. Detection efficiency
        xi. High counting rate considerations
        xii. Detector limitations:
        xiii. Collimation design and performance
        xiv. Image Quality Performance
        xv. Spatial Resolution: correction techniques and drift
8. Pulse Height Spectrometry and problems in radiation detection and measurement
    a. Principles and application to different types of detectors
    b. Spectrometry with NaI(Tl)
    c. Detection efficiency
    d. Counting rate limitations
        i. Dead time
        ii. Effect on resolution
9. Tomographic Reconstruction: analytical and iterative
    a. Pixels and voxels
    b. Filtered (convoluted) back-projection
    c. Fourier
    d. Iterative reconstruction
    e. Reconstruction parameters
        i. Center of rotation correction
        ii. Uniformity correction
        iii. Attenuation correction
        iv. Filters and filter selection
        v. Transmission sources
        vi. Motion correction and sinograms
10. Single Photon Emission Computed Tomography (SPECT)
    a. Basic designs and principles
        i. Orbit techniques
        ii. Multihead systems: fixed and variable
        iii. Acquisition parameters
        iv. Factors that limit statistics
11. The physics of PET Systems (positron emission tomography)
    a. Pair production, Positron Emission, and annihilation reactions
    b. Time of flight
    c. Basic principles of operation and detection
    d. System configurations
    e. Coincidence detection
    f. Projection of data collection
    g. Crystal characteristics
    h. Limits of resolution
    i. Signal-to-noise ratio: differing between Compton scatter, true coincidence and random events.
    j. Imaging: 2 vs 3 dimensional
    k. Absolute calibration (standard uptake value)
    l. Attenuation and correction methods

        i. Transmission
        ii. Co-registration
    m. Iterative reconstruction
        i. Maximum likelihood expectation maximization
        ii. Ordered subsets expectation maximization
12. X-ray Characteristics
    a. X-ray production
    b. Acceleration, deceleration, and focusing of electrons
    c. Target interactions (Bremsstrahlung)
    d. X-ray beam characteristics
    e. Frequency and wavelength
    f. Quality and Quantity
    g. Primary vs. remnant
13. The physics of CT Systems
    a. Basic principles of operation
        i. History and development
        ii. CT X-ray tube design
        iii. CT scanner design and components
    a. Multislice helical CT
    b. Image reconstruction and quality
    c. Image display and volumetric data
    d. Principles and considerations of PET/CT and SPECT/CT fused systems
14. The Physics of MRI (magnetic resonance imaging)
    a. Basic Principles of operation
    b. History and development
    c. The hydrogen atom
    d. Precession
    e. The Larmor Equation
    f. RF flip Angle
    g. Relaxation Processes (T1 and T2)
    h. MRI pulse sequence and system components.
    i. MRI safety
    j. Considerations of PET/MRI and SPECT/MRI systems
15. Emerging technologies and advancements in the field of nuclear medicine and molecular imaging.

.

Resources

Thrall, James and Harvey Zeissman. *Nuclear Medicine: The Requisites.* 4th ed. St. Louis, MO: Mosby, 2013.

Mettler, Fred Jr. and Milton Guiberteau, eds. *Essentials of Nuclear Medicine Imaging*. 7th ed. Philadelphia, PA : W. B. Saunders, 2018.

Cherry, Simon, James Sorenson, and Michael Phelps. *Physics in Nuclear Medicine.* 4th ed. St. Louis, MO: Mosby, 2012.

Resources Other

Waterstram-Rich & Gilmore. Nuclear Medicine and PET/CT Technology and Techniques. 8th ed. 2016

Top of page
Key: 3234