Course Number and Title: NMT 223 Nuclear Medicine Instrumentation

Campus Location:
Wilmington

Effective Date:
2018-51

Prerequisite:
NMT 115, NMT 295

Co-Requisites:
NMT 202, NMT 211, NMT 296

Course Credits and Hours:
4.00 credits
3.00 lecture hours/week
3.00 lab hours/week

Course Description:
Through lecture and laboratory sessions, basic principles of radiation detection are applied. Imaging systems, radionuclide statistics, quality control, SPECT, and computer applications are stressed.

Required Text(s):
Obtain current textbook information by viewing the [campus bookstore - https://www.dtcc.edu/bookstores](https://www.dtcc.edu/bookstores) online or visit a campus bookstore. Check your course schedule for the course number and section.

Additional Materials:
Uniform, lab coat, goggles and film badges. Nuclear Medicine Program Policy Manual Allied Health/Science Department Policy Manual

Schedule Type:
Classroom Course

Disclaimer:
Objectives derived from: Curriculum Guide for Nuclear Medicine Technologists, Wanda Mundy & Gregory Passmore and Performance and Responsibility Guidelines, Society of Nuclear Medicine

Core Course Performance Objectives (CCPOs):

1. Describe the pulse-size characteristics for an ion chamber when operated in the ion-chamber region, the proportional counter region and the Geiger-Muller (GM) region; describe the gas detector response as a function of voltage and state the basic principles of operation of gas-detectors. (CCC 6; PGC 1)
2. Outline the component parts of a scintillation detection system and describe the function of each part. (CCC 6; PGC 1)
3. List and compare the development of the Anger scintillation camera, including the types and numbers of photomultiplier tubes, crystal diameter and depth, collimators, light pipes and changes in the electronics. (CCC 6; PGC 1)
4. Describe the use of the computer in the development of imaging, administrative and quality assurance of nuclear medicine procedures. (PGC 1, 2)
5. List and describe quality control procedures performed on gas-filled and scintillation detectors.(PGC 1)
6. List and describe all components of SPECT imaging systems. (PGC 1)
7. Determine a statistically accurate counting rate for each type of radiation detector utilized in nuclear medicine.(PGC 1)
8. List and describe all components of PET and CT imaging systems. (PGC 1)
9. Describe the use of the computer in the development of imaging, administrative and quality assurance of PET and CT procedures. (PGC 1)
10. List and describe quality control procedures performed on PET and CT imaging systems. (PGC 1)

See Core Curriculum Competencies and Program Graduate Competencies at the end of the syllabus. CCPOs are linked to every competency they develop.

Measurable Performance Objectives (MPOs):
Upon completion of this course, the student will:

1. Describe the pulse-size characteristics for an ion chamber when operated in the ion-chamber region, the proportional counter region and the Geiger-Muller (GM) region; describe the gas detector response as a function of voltage and state the basic principles of operation of gas-detectors.
    1. Describe pocket dosimeters, Cutie-pie and dose calibrator.
    2. Describe (regarding the GM tube) the components and requirements: voltage plateau, effects of background and quenching. Define the time constant and state its use.

    3. Compare and contrast the operation, function and limitations of gas-filled detectors.
    4. Demonstrate the operation of a dose calibrator, ionization survey instrument, GM tube survey instrument and counter.
2. Outline the component parts of a scintillation detection system and describe the function of each part.
    1. Describe scintillators and scintillation measuring techniques.
    2. Describe the characteristics of scintillation detector materials.
    3. Describe the basic physical concepts involved with scintillation spectrometry, the practical operation of the scintillation spectrometer detector, and the practical operation of the pulse height analyzer portion of the spectrometer.
    4. Describe the basic use of scintillation spectrometers, as well as, the importance of proportional linearity between gamma energy and voltage pulse output.
    5. Operate a solid scintillation counter; demonstrate this ability by obtaining a gamma ray energy spectrum using a single-channel analyzer.
    6. Discuss the use of scalers, timers, and rate meters in a scintillation detector.
    7. Explain the principles of liquid scintillation counting.
3. List and compare the development of the Anger scintillation camera, including the types and numbers of photomultiplier tubes, crystal diameter and depth, collimators, light pipes and changes in the electronics.
    1. Describe the characteristics of the parallel-hole, diverging, converging and pinhole collimators as they relate to the Anger scintillation camera.
    2. Explain the X, Y, and Z signals used in a gamma camera system, including significance of these signals, and how they are used to produce an accurate image on the camera's display system.
    3. Describe the differences in a persistence vs. a photographic scope.
    4. Describe methods for evaluating the spatial resolution of a collimator for an Anger scintillation camera.
    5. Differentiate collimator and camera system resolution.
    6. Describe in detail the problem of camera non-uniformity, with particular attention to the various causes of that non-uniformity and the potential effect on image quality.
    7. List count rate limitations and describe their effects on the resulting image.
    8. Discuss the effects of scattered radiation display contrast and film contrast on the final image.
    9. Describe the quality control tests performed for spatial distortion, spatial resolution and linearity, including a list of all equipment necessary to perform this test, giving examples of a normal and abnormal test result.
    10. List four types of transmission phantoms and give one advantage and disadvantage of each type.
    11. List at least six factors that should be checked daily before performing an imaging study on a gamma camera system, giving at least one reason for each type of check listed.
    12. Describe the appearance of an Anger scintillation camera image or a rectilinear scanner image when the improper low-energy collimator is used to collimate a high-energy source of radiation.
    13. Describe the appearance of the Anger scintillation camera image in the following situations:
        1. Cracked or fractured crystal
        2. Improper PMT calibration
        3. Improper pulse-height analyzer calibration d. Improper focused CRT
        4. Improperly cleaned CRT
    14. Diagram and describe the components of multicrystal imaging systems.
    15. Describe the ways in which a multicrystal imaging system is more quantitative in measuring and detecting radiation than is the Anger scintillation camera.
    16. Compare image quality and spatial resolution between a single-crystal and multicrystal imaging system.
    17. Identify the uses of a multicrystal imaging system that make them viable imaging instruments today.
4. Describe the use of the computer in the development of imaging, administrative and quality assurance of nuclear medicine procedures.
    1. Discuss buffers and zoom as they relate to nuclear medicine computers.
    2. Compare list mode acquisition to histogram and frame acquisition, explaining the advantages and disadvantages to each approach.
    3. Discuss the matrix types and sizes for word and byte mode, and give examples.
    4. Describe the acquisition and processing of all nuclear medicine studies on the computer system.
    5. Define the following computer techniques for SPECT reconstruction:
        1. Backward projection
        2. Filtered back projection c. Fourier
        3. Iterative
    6. List all computer applications in the in-vitro section of a nuclear medicine department.
5. List and describe quality control procedures performed on gas-filled and scintillation detectors.
    1. Describe the procedure for calibrating and standardizing a dose calibrator for geometry, linearity, accuracy and precision.
    2. Describe a precision check on a survey meter and discuss a means of calibrating it on an annual basis.
    3. Determine the percent energy resolution of a scintillation counter.
    4. Discuss daily calibration of a scintillation counter and calculate a chi-square on a series of daily calibration readings.
    5. Connect equipment for proper usage and recognize when equipment is not functioning properly.
    6. Develop protocols for evaluating various radiation detectors.
6. List and describe all components of SPECT imaging systems.
    1. Describe the purpose of SPECT imaging.
    2. Explain back projection and reconstruction techniques.
    3. List and explain all quality control requirements on a SPECT system.
    4. List acquisition times for all organ systems.
7. Determine a statistically accurate counting rate for each type of radiation detector utilized in nuclear medicine.

    1. Calculate mean, standard deviation and reliability factor given a set of nuclear counting events.
    2. Tell what percentage of values for a Gaussian distribution fall within ± 1 SD, ± 2 SD and ± 3 SD.
    3. Calculate a chi-square test and obtain a P value from a given set of data points.
    4. Obtain the necessary data points to calculate a chi-square test and obtain a P value.
    5. Calculate and define the FWHM of each scintillation detector.
8. List and describe all components of PET and CT imaging systems.
    1. Describe PET systems principle of operations and system configuration.
    2. Describe the use of PMT, crystal characteristics, timing windows, LOR technology, detector size and design,, Time of flight, coincidence detection.
    3. Describe attenuation and correction methods as they relate to PET and PET/CT systems.
    4. Describe the signal-to- noise ration as it relates to PET.
    5. Identify the difference between 2D and 3D imaging.
    6. Describe CT imaging systems and list all of its components.
    7. Describe the X-ray tube design, , mA, kVp.
    8. Describe the use of pre and post collimation as it relates to CT.
    9. Identify the differences in the generations of CT scanners.
    10. Identify the differences between continuous rotation, single row, and multislice CT scanners.
9. Describe the use of the computer in the development of imaging, administrative and quality assurance of PET and CT procedures.
    1. Describe the acquisition and display of sinograms utilized in PET imaging.
    2. Describe the characteristics of events in PET.
    3. Describe PET systems projection of data collection.
    4. Describe sensitivity and spatial resolution of PET systems.
    5. Describe the basics of transmission sources utilized in PET scans.
    6. Describe the types of corrections applied to PET scans.
        1. Normalization
        2. Dead time
        3. Scatter
        4. Attenuation
        5. Decay
    7. Describe the reconstruction techniques applied to PET imaging.
    8. Describe the history and development of CT.
    9. List and describe the scanner design of CT including detectors, collimation and rotation speed.
    10. List the properties of multislice helical CT.
    11. Describe the image data acquisition as it relates to CT systems.
    12. Explain the effects of attenuation on CT imaging.
    13. Describe how CT numbers are produced and their effects on images.
    14. Describe image display and volumetric data display as it relates to CT.
    15. List the properties of image quality.
    16. Describe the types of reconstruction algorithms utilized in CT.
        1. Back-Projection
        2. Iterative Algorithms
        3. Filtered Back-Projection
        4. Fourier Reconstruction
        5. Identify the types of data acquired in CT
        6. Measurement data
        7. Raw data
        8. Convoluted data
        9. Image data
10. List and describe quality control procedures performed on PET and CT imaging systems.
    1. Describe the following PET quality control procedures and list their frequency.
        1. Blank scans
        2. Normalization
        3. Gain setting
        4. Crystal mapping
        5. Absolute activity calibration
        6. Energy window calibrations
        7. Uniformity check
        8. Uniform cylinder check
    2. Describe the following CT quality control procedures and list their frequency.
        1. CT number calibration
        2. Standard deviation of CT number in water
        3. High contrast resolution
        4. Low contrast resolution
        5. Accuracy of Distance-measuring device
        6. Accuracy of localization device
        7. Light field accuracy
        8. Slice width

9. Pitch
10. Radiation scatter and leakage

Evaluation Criteria/Policies:
Students must demonstrate proficiency on all CCPOs at a minimal 75 percent level to successfully complete the course. The grade will be determined using the Delaware Tech grading system:

92	–	100	=	A
83	–	91	=	B
75	–	82	=	C
0	–	74	=	F

Students should refer to the Student Handbook - https://www.dtcc.edu/handbook for information on the Academic Standing Policy, the Academic Integrity Policy, Student Rights and Responsibilities, and other policies relevant to their academic progress.

Core Curriculum Competencies (CCCs are the competencies every graduate will develop):

1. Apply clear and effective communication skills.
2. Use critical thinking to solve problems.
3. Collaborate to achieve a common goal.
4. Demonstrate professional and ethical conduct.
5. Use information literacy for effective vocational and/or academic research.
6. Apply quantitative reasoning and/or scientific inquiry to solve practical problems.

Program Graduate Competencies (PGCs are the competencies every graduate will develop specific to his or her major):

1. Integrate principles of theoretical knowledge and demonstrate entry-level skills pertaining to nuclear medicine in-vivo and in-vitro procedures, radiation safety, quality control, quality assurance, NRC regulations, patient care, radiopharmaceutical preparation and administration, instrumentation, and medical informatics.
2. Perform all entry-level procedural computer analysis.
3. Exhibit critical thinking and problem solving skills during the practice of nuclear medicine.
4. Abide by the profession's code of ethics as stated in the American Registry of Radiologic Technologists (ARRT) and Nuclear Medicine Technology Certification Boards (NMTCB).
5. Competently perform all in-vivo and in-vitro procedures.
6. Exhibit verbal, nonverbal, and written communication skills during patient care, research, and professional scope of practice.

Disabilities Support Statement:
The College is committed to providing reasonable accommodations for students with disabilities. Students are encouraged to schedule an appointment with the campus Disabilities Support Counselor to request an accommodation needed due to a disability. A listing of campus Disabilities Support Counselors and contact information can be found at the disabilities services - https://www.dtcc.edu/disabilitysupport web page or visit the campus Advising Center.