Course Number and Title: NMT 222 Nuclear Physics

Campus Location:
Wilmington

Effective Date:
2018-51

Prerequisite:
NMT 101, PHY 112 or PHY 205

Co-Requisites:
None

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

Course Description:
This course introduces the atom and radioactivity. Major topics include atomic structure, decay processes and products, half-life, interaction of radiation with matter, and dosimetry.

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

Additional Materials:
Nuclear Medicine Program Policy Manual Allied Health/Science Department Program Student Policy Manual

Schedule Type:
Classroom Course

Disclaimer:
None

Core Course Performance Objectives (CCPOs):

1. Identify and describe the structure of the atom. (CCC 2, 6; PGC 1, 6)
2. Evaluate and interpret the decay processes and products of radionuclides. (CCC 2, 6; PGC 1, 6)
3. Identify and explain the half-life of radionuclides. (CCC 2, 6; PGC 1, 6)
4. Identify and explain the interaction of radiation with matter. (CCC 2, 6; PGC 1, 6)
5. Identify, explain, and calculate dosimetry and the medical internal radiation dose (MIRD) formula. (CCC 2, 6; PGC 1, 6)
6. Identify and relate the function of each major constituent of the cell and their relationship within a radioactive field. (CCC 6 ; PGC 1)
7. Distinguish between acute and late effects from radiation, in terms of types of effects, dose levels, cell and tissue sensitivity, and stage of cell development at the time of exposure. (CCC 6: 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. Identify and describe the structure of the atom.
    1. Describe the meters, kilograms, seconds (MKS), and international system of units (SI) systems of measurement.
    2. Describe general atomic structure.
    3. Describe the structure outside of the atom.
    4. Distinguish and compare different nuclear models.
    5. Differentiate between electrostatic and centrifugal force as they apply to the structure of the atom.
    6. Diagram an atom, placing electrons in proper shells.
    7. Relate the Pauli exclusion principle to the organization of the atom.
    8. Explain the composition of the periodic table.
    9. Identify various symbols used in the periodic table.
    10. Describe the process of ionization.
    11. Identify cations and anions.
    12. Write an element using ${}^{A}_{Z}X$ notation.

13. Find the number of neutrons in an atom given the mass number (A) and atomic number (Z).
14. Describe and use nuclear shorthand.
15. Explain the terms nuclide, isotope, isobar, isotone, and isomer.
16. Describe the orbital energy levels of the electron.
17. Explain binding energy and energy state of the electron.
18. Discuss nuclear structure and the forces associated with nuclear structure and content.
19. Describe mass defect and nuclear binding energy.
20. Describe the binding energy per nucleon versus mass number graph.
21. Define *atomic mass units* and *energy equivalents*, and derive the value of one, given the other by mathematical conversion.

2. Evaluate and interpret the decay processes and products of radionuclides.
    1. Describe the quantum theory of electromagnetic radiation.
    2. Identify, compare, and contrast corpuscular and secondary electromagnetic radiation.
    3. Explain the various modes of electromagnetic radiation production.
    4. Describe Henri Becquerel's experiments.
    5. Describe Rutherford's and Soddy's experiments and theories.
    6. Describe Madam Curie's discoveries.
    7. Define *natural* and *artificial radioactivity*.
    8. Define *radiation*.
    9. Describe the types of nuclear transformations.
    10. Describe the properties of beta (β) particles.
    11. Describe the process whereby β particles are absorbed.
    12. Describe the type of transformations for isomeric and isobaric transitions.
    13. Discuss the importance of parent-daughter relationships in the radioactive equilibrium process.
    14. Describe and explain the methods for production of radionuclides.
    15. Explain a typical radionuclide generator system with regard to components and elution technique.
    16. Define *nuclear fission*, and relate this process to the production of radionuclides by writing the typical reactions for commonly used radionuclides.
3. Identify and explain the half-life of radionuclides.
    1. Illustrate the radioactive decay formula and point out how it is derived by identifying each component.
    2. Define the term *decay constant.*
    3. Define the term *decay factor.*
    4. Discuss radioactive decay of mixed radionuclides.
    5. Describe and explain secular equilibrium states.
    6. Describe and explain transient equilibrium states.
4. Identify and explain the interaction of radiation with matter.
    1. Describe the characteristics of electromagnetic radiation.
    2. Compare the similarities and differences between x-rays and photons.
    3. Define and illustrate a photoelectric interaction of radiation with matter.
    4. Describe, diagram, and fully explain a pair production interaction of radiation with matter.
    5. Describe, illustrate, and explain a Compton interaction of radiation with matter.
    6. Describe the characteristics of incident energy and absorber material most likely to result in pair production.
    7. Describe, diagram, and explain an annihilation interaction.
    8. Describe the characteristic energy attributed to annihilation radiation.
5. Identify, explain, and calculate dosimetry and the medical internal radiation dose (MIRD) formula.
    1. Select the MIRD formula in calculating the absorbed dose.
6. Identify and relate the function of each major constituent of the cell and their relationship within a radioactive field.
    1. Differentiate between mitosis and meiosis.
    2. Describe the interactions of various types of radiation with matter.
    3. Define *linear energy transfer*, and state its relationship to different factors.
    4. Describe and compare direct and indirect action of ionizing radiation on the cell.
    5. Describe how free radicals are formed and produce damage in molecules.
    6. State the rationale of the target theory.
    7. Define a hit in relationship to the target theory.
    8. Discuss the ionization effects on DNA, chromosomes, proteins, lipids, carbohydrates, and enzymes.
    9. Describe how the genetic code is arranged on DNA molecules.
    10. Define *genetic mutation*.
    11. Describe and compare point mutations and chromosomal aberrations.
    12. List factors that determine the relative radiosensitivities of tissues in terms of the law of Bergonie and Tribondeau.
    13. Compare the radiosensitivities of cells during the four stages of cell division.
    14. Discuss the influence of hydration and dehydration on radiosensitivity.
    15. List four factors that influence cell radiosensitivity.
    16. Differentiate between interphase and reproductive death.
    17. Define relative biological effectiveness (RBE) and the effect of oxygen on cell repair.
    18. Discuss factors influencing survival of irradiated cells.
    19. Recognize, label and explain the components of a survival curve.
    20. Define *R, RBE, QF, linear energy transfer* (LET) and specific ionization in terms of traditional and System International units/equivalents.

7. Distinguish between acute and late effects from radiation, in terms of types of effects, dose levels, cell and tissue sensitivity, and stage of cell development at the time of exposure.
    1. Define *LD 50*.
    2. Define *syndrome*.
    3. Cite the four clinical stages of a syndrome along with their time sequence.
    4. Discuss the irradiation of the hematopoietic system.
    5. List in order of radiosensitivity the components of blood.
    6. Discuss the effect of whole-body irradiation on the digestive system.
    7. Identify the most sensitive portion of the small intestine.
    8. Discuss the effects of irradiation on the vascular system.
    9. Discuss the effects of irradiation on the skeletal system.
    10. Discuss the effects of irradiation on the teeth, skin, hair, eyes, and ears.
    11. Discuss the effects of irradiation on the respiratory, urinary, and muscular system.
    12. Discuss the effects of irradiation on the nervous system.
    13. Discuss the effects of irradiation on the reproductive system.
    14. Describe the effects of irradiation on an embryo in utero.
    15. State four chronic somatic effects of radiation exposure.
    16. Compare normal aging with radiological aging.
    17. Discuss life shortening as associated with radiation exposure.
    18. Describe the relationship between radiation exposure and incidence of cancer.
    19. Describe the relationship between radiation exposure and genetic mutations.
    20. Discuss factors that influence the absorbed dose in terms of concentration, time, radiation type, energy of radionuclide, and fraction of the dose absorbed.
    21. Given a list of commonly used radiopharmaceuticals or nuclear medicine procedures, list the critical organ and target organ.
    22. Discuss the risk to benefit ratios of radiation exposure in terms of diagnostic and therapeutic procedures.

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.