

**WAYNE STATE UNIVERSITY
DEPARTMENT OF RADIATION ONCOLOGY
ROC 6710 PHYSICS IN MEDICINE
Winter Semester 2018**

TIME/DAYS:

Monday and Wednesday, 2:30-4:00 PM

LOCATION:

Gershenson ROC Large Conference Room

INSTRUCTORS:

BL – Brian Loughery, M.S., Physicist, Karmanos Cancer Institute
brian.loughery@wayne.edu

JB – Jay Burmeister, Ph.D., Professor, Oncology
burmeister@karmanos.org

OM – Otto Muzik, Ph.D., Professor, Pediatrics & Radiology
otto@pet.wayne.edu

MJ – Michael Joiner, Ph.D., Professor, Oncology
joinerm@wayne.edu

OFFICE HOURS: By appointment.

REFERENCES:

- Introduction to Physics in Modern Medicine, Second Edition, *Suzanne Amador Kane*

References/Additional Reading material shall be posted on the blackboard periodically or handouts may be given in class as per the discretion of each instructor.

EXAMINATIONS AND QUIZZES:

Two Section Examinations will be given according to the established schedule. These exams will be constructed to cover the specific content addressed in that section of the course; however, some content may inherently involve cumulative knowledge and/or skills.

GRADING POLICY:

The course grade will be primarily determined according to the following:

Midterm Exam	45%
Final Exam	45%
Project	10%

The instructor will utilize the grading guidelines stated below in the determination of the final course grade. The quality of the student's class participation may be considered in the determination of the final course grade.

Grades will be determined based on the following scale:

A	88-100%	B-	68-73%
A-	83-88%	C+	63-68%
B+	78-83%	C	58-63%
B	73-78%	F	<58%

The instructor reserves the right to scale the grades at the end of the term. A lower course grade will not be assigned based on such scaling. Final course grades will NOT be rounded to the nearest whole number. A grade of "I" (Incomplete) will be given only in the most extraordinary of circumstances.

ACCOMODATION POLICY:

If you have a documented disability that requires accommodations, you will need to register with Student Disability Services for coordination of your academic accommodations. The Student Disability Services (SDS) office is located at 1600 David Adamany Undergraduate Library in the Student Academic Success Services department. SDS telephone number is 313-577-1851 or 313-577-3365 (TDD only). Once you have your accommodations in place, I will be glad to meet with you privately during my office hours to discuss your special needs. Student Disability Services' mission is to assist the university in creating an accessible community where students with disabilities have an equal opportunity to fully participate in their educational experience at Wayne State University.

COURSE WITHDRAWAL POLICY:

The instructor will not permit withdrawal from the course as per the Wayne State University guidelines.

ACADEMIC DISHONESTY POLICY:

In any instance of academic dishonesty, occurring in this course as defined in Section 3.0 of the University Student Due Process Statute, the provisions of 10.1 of the Statute will be implemented as follows.

The grade for the course will be reduced to a "D" or to an "E" if the grade status would otherwise have been a "D". In addition, charges MAY be filed, as provided for in-section—10.2 of the Statute

which may lead to further sanctions up to and including expulsion from the College or University.

COURSE OUTLINE:

Mon. Jan. 8 **COURSE INTRODUCTION** **JB**

BASIC ATOMIC AND NUCLEAR PHYSICS **JB**

Atomic Structure, Rutherford Nuclear Atom, Bohr Atomic Model, Excitation and Ionization, Modifications of the Bohr Atom, Periodic Table of Elements, Characteristic X-rays, Auger Electrons*, Wave Mechanics Atomic Model, The Neutron and Nuclear Force, Isotopes, The Atomic Mass Unit, Nuclear Binding Energy, The Nuclear Liquid Drop Model, The Nuclear Shell Model, Nuclear Stability.

Reading Assignment:

*Introduction to Health Physics, III Edition by Herman Cember
Chapter 3, pp. 51-72*

**Atoms, Radiation, and Radiation Protection, III Edition by James E. Turner
pp. 45-47*

Wed. Jan. 10 **NO CLASS**

Mon. Jan. 15 **UNIVERSITY HOLIDAY (Martin Luther King Day)**

Wed. Jan. 17 **PRODUCTION OF X-RAYS** **BL**

The X-ray Tube, The Anode, the Cathode, Focal spot size, Line Focus Principle, Basic X-ray Circuit, Voltage Rectification, Physics of X-ray Production, Bremsstrahlung Radiation, Characteristic X-rays, X-ray Energy Spectra, Kramer's Equation, Relationship between Output vs Filament Current, tube current, tube voltage.

Reading Assignment:

*The Physics of Radiation Therapy, III Edition by Faiz Khan
Chapter 3, pp. 28-37*

Mon. Jan. 22 **RADIOACTIVITY** **BL**

Basis for Radioactivity, Alpha Emission, Beta Emission, Positron Emission, Orbital Electron Capture, Gamma Ray Emission*, Internal Conversion*, Half-Life, Average Life, Activity, Specific Activity, Natural Radioactivity, Serial Transformation, Secular Equilibrium, Transient Equilibrium, No Equilibrium*.

Reading Assignment:

Introduction to Health Physics, III Edition by Herman Cember

Chapter 4, pp. 75-113

**Atoms, Radiation, and Radiation Protection, III Edition by James E. Turner
pp. 68-72, 93*

Wed. Jan. 24 RADIOACTIVITY (contd...) BL

Basis for Radioactivity, Alpha Emission, Beta Emission, Positron Emission, Orbital Electron Capture, Gamma Ray Emission*, Internal Conversion*, Half-Life, Average Life, Activity, Specific Activity, Natural Radioactivity, Serial Transformation, Secular Equilibrium, Transient Equilibrium, No Equilibrium*.

Reading Assignment:

*Introduction to Health Physics, III Edition by Herman Cember
Chapter 4, pp. 75-113*

**Atoms, Radiation, and Radiation Protection, III Edition by James E. Turner
pp. 68-72, 93*

Mon. Jan. 29 RADIATION SOURCES FOR MEDICINE JB

Applications of radiation in medicine, X-ray generators, linear accelerators, cyclotrons and other cyclic accelerators, radioactive nuclei for nuclear medicine, sealed and unsealed radioactive sources for medical applications.

Wed. Jan. 31 NO CLASS

**Mon. Feb 5 RADIATION DETECTION/
RADIATION MEASUREMENT QUANTITIES JB**

Ionization and its fate, radiation quantities and units, exposure, dose, kerma, collision kerma, radiative kerma, RBE, dose equivalent, radiation detection, gas filled detectors, scintillation detectors, solid state detectors, thermoluminescent dosimeters, film, calorimetry, chemical dosimeters.

**Wed. Feb. 7 INTERACTION OF RADIATION WITH MATTER I
(PHOTONS & NEUTRONS) JB**

Indirectly ionizing vs. directly ionizing radiation, interaction cross section, exponential attenuation, photoelectric effect, Compton effect, pair production, Rayleigh scatter, photodisintegration, neutrons, scattering kinematics, scattering cross section, resonance and compound nuclei

**Mon. Feb. 12 INTERACTION OF RADIATION WITH MATTER II
(CHARGED PARTICLES) JB**

Types of charged particle interactions, stopping power, factors affecting stopping power, heavy and light charged particle interactions, Bragg peak, range.

Wed. Feb. 14 **MIDTERM EXAM REVIEW** **BL/JB**

Mon. Feb. 19 **MIDTERM EXAM** **BL**

Wed. Feb. 21 **PHYSICS OF MEDICAL IMAGING (X-RAYS)** **BL**

Mon. Feb. 26 **PHYSICS OF MEDICAL IMAGING (CT)** **BL**

Wed. Feb. 28 **PHYSICS OF MEDICAL IMAGING (ULTRASOUND)** **BL**

Mon. Mar. 5 **PHYSICS OF MEDICAL IMAGING (MRI)** **BL**

The Larmor equation, the Bloch equation and the basics of generating a signal will be presented first. Once the signal is obtained method of reconstructing images will be discussed using Fourier transforms. Both 2D and 3D acquisition methods will be discussed as well as some of the basic MR contrast mechanisms.

MR discussion:

We will introduce the basic elements behind magnetic resonance imaging including: MR system components, bulk magnetic resonance, spin phase, spin phase refocusing, relaxation properties, and image contrast.

Wed. Mar. 7 **PHYSICS APPLICATIONS IN CLINICAL RADIOLOGY** **BL**

Mon. Mar. 12 **UNIVERSITY HOLIDAY (Spring Break)**

Wed. Mar. 14 **UNIVERSITY HOLIDAY (Spring Break)**

Mon. Mar. 19 **PHYSICS OF MEDICAL IMAGING (PET)** **OM**

Fundamental particles, Stability of the nucleus, Stochastic nature of radioactivity, Weak force, Positron decay, Creation of positron emitters, Cyclotron, Nuclear reaction cross section, Poisson distribution, Radiochemistry, PET tracers, Scintillation detectors, PET signal, Coincidence detection, Attenuation correction in PET, PET normalization, Dedicated PET scanner, 2D/3D imaging mode, Sinogram, True/scatter/random coincidence events, PET signal corrections, Whole body PET.

Wed. Mar. 21 PHYSICS OF NUCLEAR MEDICINE OM

Signal in Nuclear Medicine, Reconstruction from projections, Radon transformation, Fourier transformation, Simple and Filtered backprojection, Iterative reconstruction, OSEM, 3D reconstruction, Virtual projections, Noise Equivalent Counts (NEC), Partial volume effect, Gamma Camera components, Scintillation camera corrections, Quality control, Image contrast, Integral and differential uniformity, Spatial resolution, Modulation transfer function.

Mon. Mar. 26 PHYSICS APPLICATIONS IN CLINICAL NUCLEAR MEDICINE OM

Quantification in Nuclear Medicine, Dynamic protocols, Regions of Interest, Kinetic modeling,, Compartmental tracer models, PET/CT basics, PET/CT attenuation correction, MIRDose dose estimates, CT dose index, PACS, Examples of PET imaging in Neurology, Oncology and Cardiology.

Wed. Mar. 28 RADIOBIOLOGY I MJ

Basic Clinical Radiobiology, 4th Edition"
Eds MC Joiner and AJ van der Kogel.
Published by Oxford University Press, USA; expected February 15, 2009
ISBN-10: 0340929669
ISBN-13: 978-0340929667

Mon. Apr. 2 RADIOBIOLOGY II MJ

Basic Clinical Radiobiology, 4th Edition"
Eds MC Joiner and AJ van der Kogel.
Published by Oxford University Press, USA; expected February 15, 2009
ISBN-10: 0340929669
ISBN-13: 978-0340929667

Wed. Apr. 4 RADIOBIOLOGY III MJ

Basic Clinical Radiobiology, 4th Edition"
Eds MC Joiner and AJ van der Kogel.
Published by Oxford University Press, USA; expected February 15, 2009
ISBN-10: 0340929669
ISBN-13: 978-0340929667

Mon. Apr. 9 OPEN

Wed. Apr. 11 PHYSICS APPLICATIONS IN CLINICAL RADIATION ONCOLOGY I BL

Medical Linear Accelerators, History, Principles of Operation, Operational/Auxiliary

Systems, The Modulator, Klystrons and Magnetrons, Electron Gun, Accelerator Waveguide, Travelling Waveguide, Standing Waveguide, Energy Selection, Electron Energy, Beam Delivery, Bending Magnet Assembly, Target and Flattening Filter, MU chamber, Electron Beam Delivery, Collimation, Blocks, Multileaf Collimators (MLC), Wedges, Compensators, Electronic Portal Imaging Devices, On-Board Imaging Systems (OBI), Helical Tomotherapy, GammaKnife & Cyber Knife.

Reading Assignment:

The Physics of Radiotherapy X-rays and Electrons by Metcalfe, Kron & Hoban, Chapter 1, pp 1-50.

Mon. Apr. 16 **RADIATION SAFETY** **MJ**

Wed. Apr. 18 **NO CLASS** (Study Day)

Mon. Apr. 23 **FINAL EXAM** **BL**