MEDICAL PHYSICS (GS02)

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GS02 1011 Rad Induced Late Effects and Survivorship Journal Club (1 Credit)
Prerequisite: Medical Physics Program or consent of instructor. Students will meet weekly to present and discuss a contemporary publication on the subject of late effects, cancer survivorship, and dosimetry following medical radiation exposures. Publications may include scientific articles, books, reports, review papers, etc. The late effects of interest to the participants of this course are radiation-induced second cancers, infertility, organ dysfunction, cardiovascular effects, lung damage, pregnancy and neonatal outcomes, cognitive deficit, auditory impairment, dental abnormalities, diabetes, other chronic disease, and other long-term radiogenic effects and public health concerns. Medical radiation exposures include those related to radiotherapy and diagnostic imaging. Radiation dosimetry, late effects, and survivorship publications will be based on radiological measurements, analytic calculations, Monte Carlo calculations, predictive risk models, epidemiological data, and any related studies. The presentation outline comprises 25 minutes of prepared slides and 25 minutes of discussion. Each student will be required to present at least once during the semester and will be expected to actively participate in the discussion period. A minimum of 80% attendance is required for a passing grade. Students and faculty will not present their own work. This course is intended for Medical Physics students but is open to students from other programs with instructor consent. Pass/Fail

GS02 1021 Supervised Clinical Experience in Radiation Therapy Physics (1 Credit)
Prerequisites: Introduction to Medical Physics I Basic Interactions (GS02 1093) and Introduction to Medical Physics III: Therapy (GS02 1113). The Supervised Clinical Experience in Radiation Therapy Physics course is an elective course intended for students to be exposed to the practical working environment of a radiation oncology clinic. The time commitment for this elective is 4 hours a week with no didactic portion. Students will have 2 options: (1) a general supervised clinical experience whereby the student will rotate one morning every week with each site-specific physicist from the Department of Radiation Physics at MD Anderson Cancer Center, or (2) a student/mentor-led experience that focuses on one specific treatment procedure. Students pursuing the second option will submit a proposal to be approved by the course director before the start of the course (to ensure that it is consistent in effort and scope to the general experience) and a report of their experiences at the end of the course. Pass/Fail

GS02 1031 Supervised Clinical Experience in Imaging Physics (1 Credit)
Prerequisites: GS02 1093: Intro to Medical Physics I: Basic Interactions; GS02 1103: Intro to Medical Physics II: Medical Imaging; GS02 1113: Intro to Medical Physics III: Therapy; GS02 1194: Intro to Medical Physics IV: The Physics of Nuclear Medicine and Consent of Instructor. This course provides graduate students with a high-level understanding of clinical imaging physics operations through hands-on experience and clinical observation. Each week will focus on a different aspect of imaging physics focusing on clinical operations and observation. The course will culminate in an oral exam similar to the ABR part III exam. The course intends to target senior Medical Physics students who are nearing completion of their course work. Pass/Fail

GS02 1032 Principles Magentic Resonance Imaging (2 Credits)
Prerequisite: Introduction to Medical Physics II (GS02 1103) or consent of instructor. The goal of this course is to provide a comprehensive understanding of the physics involved in magnetic resonance imaging (MRI), and prepare the students to carry out research or practice medical physics in this area. The topics include basic spin physics, contrast mechanisms, hardware, data acquisition, image reconstruction, and artifact recognition. Emphasis will be placed on practical issues encountered in research and clinical applications. Letter Graded

GS02 1052 Imaging Science (2 Credits)
Prerequisites: Calculus, Linear Algebra. This course provides a concise and coherent review of some commonly-encountered topics in applied mathematics, with a particular emphasis on their applications and relevance to medical imaging. The course covers and is equally divided into two major sections: 1. Optimization methods and algorithms, 2. Fourier and wavelet transforms. Letter Graded

GS02 1053 Radiation Detection, Instrumentation, and Data Analysis (3 Credits)
Prerequisites: Introduction to Medical Physics I (GS02 1093) or equivalent, and permission of instructor. This course encompasses a study of the characteristics and applications of charged particle, photon, and neutron detectors. Modular analog and digital electronics required for signal processing and data recording will be used. Techniques of data analysis and error propagation of counting statistics will be introduced. The course will include two lectures and one laboratory exercise weekly. The applications of radiation detectors in radiotherapy, health physics, nuclear medicine, and radiobiology will be emphasized. Letter Graded

GS02 1063 Fundamental Anatomy, Physiology, and Biology for Medical Physics I (3 Credits)
Prerequisite: None. This is Part I of a two-part course that covers the fundamental biological principles that are essential for medical physicists, presenting them in an integrated progression from the molecular level to the organismal level. This course may also be of interest for graduate students of biophysics, radiation biology, and biomedical engineering. Beginning with a review of basic biochemistry, the course proceeds through molecular biology then cellular biology and physiology. Applications of these principles to radiation biology are covered, then the course moves to cell-cell and cell-matrix interactions, tumor growth and development, and radiation carcinogenesis. The course concludes with the language of anatomy. Letter Graded

GS02 1072 Statistics for Medical Physicists (2 Credits)
Prerequisites: Calculus, Linear Algebra. This course is a one-semester overview of statistical concepts in biomedical and imaging studies. The material is intended to provide an introduction to applied methods of biostatistics that are prevalent in an engineering curriculum but are now increasingly encountered in medical physics literature and various areas of medical physics research, including non-model-based solutions to one sample and two sample problems. Students will gain experience in general understanding of the underlying statistical principles, the general approach to data analysis and interpretation of appropriate statistical methods. Letter Graded

GS02 1073 Fundamental Anatomy, Physiology, and Biology for Medical Physics II (3 Credits)
Prerequisites: None. This is Part II of a two-part course that covers the fundamental biological principles that are essential for medical physicists, presenting them in an integrated progression from the molecular level to the organismal level. This course may also be of interest for graduate students of biophysics, radiation biology, and biomedical engineering. Part II builds on the concepts from Part I of the course, and focuses on systems biology, including anatomy, physiology, and oncology, with special focus on the use of radiotherapy to treat cancer. This course has a unique focus on radiologic anatomy, and students will learn to identify normal anatomic structure in medical images acquired using radiography, computed tomography, and magnetic resonance imaging. Molecular and functional imaging and cancer biology are also introduced in this course. Letter Graded

GS02 1093 Introduction to Medical Physics I:Basic Interactions (3 Credits)
Prerequisite: None. This semester covers the basic interactions of ionizing radiation important in medicine. Topics include production of radiation, photo, charged particle, and neutron interactions, cavity theory, radiation interactions with solids. Letter Graded

GS02 1103 Introduction to Medical Physics II: Medical Imaging (3 Credits)
Prerequisite: Introduction to Medical Physics II (GS02 1103) or consent of instructor. This course includes the production of x-rays, x-ray interactions, radiography, fluoroscopy, mammography, computed tomography (CT), and picture archiving and communication systems (PACS). It covers the basic principles of diagnostic x-ray and CT imaging physics, the fundamental characteristics of each imaging modality, the major components of imaging chain systems, the principles of image formation and reconstruction, the attributes used to assess the performance and image quality of an imaging system, radiation dosimetry, and clinical applications in diagnostic x-ray and CT imaging. Letter Graded

GS02 1113 Introduction to Medical Physics III: Therapy (3 Credits)
Prerequisite: Introduction to Medical Physics I: Basic Interactions (GS02 1093). The physics of treatment modalities to include external beam radiotherapy, brachytherapy, and internal emitters will be discussed. The necessary therapy equipment will be described with methods of calibration, dose specification, and dose prescription. The effects of machine geometry and patient anatomy on dose calculations will be discussed. Machine calibration and quality assurance procedures are emphasized. Letter Graded

GS02 1132 Proton Therapy Physics (2 Credits)
Prerequisites: GS02 1103: Intro to Medical Physics II: Medical Imaging and GS02 1113: Intro to Medical Physics III: Therapy. The proton therapy physics course will provide students knowledge about proton beam dose deposition in different media, radiobiology of proton beams, clinical proton beam generation and delivery, commissioning proton therapy delivery systems, quality assurance, simulation and treatment planning for proton therapy, uncertainties in proton beam therapy, clinical indications for proton therapy, image guidance for proton therapy, treatment delivery and clinical outcome. In addition to lectures, practical hands-on sessions will be held for dosimetric measurements, beam calibration, quality assurance checks and treatment planning for different disease sites. Pass/Fail

GS02 1133 Introduction to Radiation Protection (3 Credits)
Prerequisite: Radiation Detection, Instrumentation, and Data Analysis (GS02 1053) or permission of instructor. The science of radiation protection including terminology, biological effects, shielding dose limits, and dose measurement will be studied. The role of state and federal enforcement agencies will be discussed. The application of radiation protective concepts in a medical environment will include room design, isotope handling, instrumentation calibration, and room surveys. Letter Graded

GS02 1193 Introduction to Medical Physics IV: The Physics of Nuclear Medicine (3 Credits)
Prerequisites: Introduction to Medical Physics I (GS02 1093); Radiation Detection, Instrumentation, and Data Analysis (GS02 1053) [may be concurrent]; and Consent of Instructor. This course introduces graduate students to the basic science and instrumentation of nuclear medicine and magnetic resonance imaging. It presents scientific principles underlying quantitative radionuclide organ imaging methods for dosimetry and treatment planning. Letter Graded

GS02 1202 Electronics for Medical Physics (2 Credits)
Prerequisite: Undergraduate electronics course covering basics of analog and digital circuits, or permission of instructor. This course emphasizes the analog and digital electronics associated with scientific instrumentation, particularly as related to medical physics. Topics include analog DC and AC circuits and circuit analysis, transformers, and basic semiconductor devices such as diodes, transistors, and operational amplifiers; electrical safety; the use of filters and voltage regulators; digital logic; digital circuits, and the interface between analog and digital domains; and an overview of the electrical characteristics of systems that are used in the practice of medical physics. Letter Graded

GS02 1213 Therapy Medical Physics II (3 Credits)
Prerequisites: GS02 1113: Introduction to Medical Physics III: Therapy. This course will cover concepts and applications in "modern" radiation therapy physics. It will start with an introduction to model based planning with CT and followed with rigorous treatment of convolution based-algorithms, Monte-Carlo, and deterministic algorithms. This will include further discussion of heterogeneity corrections and limitations in commercially implemented algorithms utilized in treatment planning systems. This will be followed by discussion on modern radiation therapy planning and delivery approaches in IMRT, VMAT, stereotactic, and image-guided RT principles. Proton radiation therapy will be covered in detail. The final section of the class will cover advanced RT topics including MR in RT, patient specific QA, artificial intelligence/automation applications, biological based treatment planning, and FLASH. Auditing this course is permitted with instructor's consent. Letter Graded

GS02 1223 Diagnostic Medical Physics II (3 Credits)
Prerequisite: Working knowledge of calculus up through partial differential equations as well as Fourier Series and Fourier Transform at the level covered in GS02 1052: Imaging Science. This course provides graduate students with a foundation in the fundamental physics, principles of image formation,a nd reconstruction, instrumentation, safety, and quality assurance of ultrasound and magnetic resonance imaging. Letter Graded

GS02 1731 Medical Physics Seminar (1 Credit)
Prerequisite: None. In the fall term, students present talks on selected topics in general medical physics, therapy, and medical imaging. The objectives are to acquaint students with a wide range of medical physics topics and to develop public speaking skills. In the Spring term, students will learn the fundamentals of Medical Physics leadership, professionalism, and ethics. The objectives are to familiarize the students with several professional and ethical concerns within the field, develop an understanding of how to create a robust Radiation Oncology safety culture and quality assurance program, and provide them with lectures from subject area experts on each topic. Pass/Fail