

## **Medical Physics Program at Duke University**

**MP 200. Radiation physics (3 c.h.).** A course covering the basics of ionizing and non-ionizing radiation, atomic and nuclear structure, basic nuclear and atomic physics, radioactive decay, interaction of radiation with matter, and radiation detection and dosimetry.

**MP 205. Anatomy and physiology for medical physicists (3 c.h.).** A course focused on medical terminology, biochemistry pertaining to MP, basic Anatomy and physiology, elementary tumor and cancer biology, and overview of disease in general. Upon completion, the student should: (a) understand anatomic structures, their relationships, their cross-sectional and planar projections, and how they are modified by attenuation and artifacts in the final images; (b) understand the physiology underlying radionuclide images, (c) understand how (a) – (b) are modified by disease, (d) identify anatomical entities in medical images (different modalities), and (e).identify basic disease features in medical images (e.g., Pneumothorax in chest radiographs, microcalcifications in mammograms).

**MP 210. Radiation protection (3 c.h.).** Course discusses the principles of radiation protection dealing with major forms of ionizing and non-ionizing radiation, the physics and chemistry of radiation biology, biological effects of ionizing and non-ionizing radiations (lasers, etc.) at cellular and tissue levels, radiation protection quantities and units, medical HP issues in clinical environments, radiation safety regulations, and basic problem solving in radiation safety.

**MP 220. Radiation therapy physics (3 c.h.).** This introductory course has a clinical orientation, and reviews the rationale, basic science, methods, instrumentation techniques and applications of radiation therapy to the treatment of a wide range of human diseases. Major radiation modalities are covered including low and high energy photon therapy, electron and proton therapy, and low and high-dose rate brachytherapy. The clinical process of treatment, methods of calculating dose to patient, and the role of the medical physicist in radiation oncology clinic, are covered in detail.

**MP 230. Medical imaging physics (3 c.h.).** A course describing basics of imaging science, x-ray imaging modalities including basic principles, detectors, scattered radiation, planar imaging, CT, fluoroscopic imaging, nuclear medicine imaging, US and MRI, and computers in imaging.

**MP 241. Nuclear medicine physics (3 c.h.).** Topics include basics of nuclear medicine imaging, gas, scintillation, and solid state radiation detectors, counting statistics, gamma camera principles including modern digital designs, SPECT, coincidence imaging principles, PET instrumentation, radionuclide and x-ray CT transmission scanning techniques, nuclear medicine treatments, and surgical probes.

**MP 251. Medical physics seminar (1 c.h.).** Weekly seminar on various topics pertaining to medical physics.

**MP 322. Advanced photon beam radiation therapy (3 c.h.).** This course will cover the physics and clinical application of advanced external beam photon therapies with special emphasis on IMRT. Prerequisite: MP 220.

**MP 323. Advanced brachytherapy and special procedures (3 c.h.).** This course will cover advanced LDR and HDR brachytherapy, and other, selected special procedures and special topics. Prerequisite: MP 220.

**MP 327. Observership in clinical radiation oncology (1 c.h.).** The course aims to provide an appreciation for the practical procedures, realities, and workflow that pertains the clinical practice of radiation oncology. Though a shadowing arrangement, the students will be directed by a clinical oncologist to experience the decision making processes, the interface with various member of the treatment team, the treatment planning, and the interface with the physics staff. Pre-requisite: MP 220 and MP 322 (or MP 322 concurrently)

**MP 328. Clinical practicum and shadowing (Radiation Therapy) (3 c.h.).** The course gives hands on experience in practical aspects of medical physics as applied to radiation therapy. Special emphasis is given to the operation of various therapy units and dose measuring devices, techniques of measuring the characteristics of radiation beams, commissioning and quality assurance checks for radiation producing devices in the clinic. The course includes shadowing a clinician, technologist, or physicist, while performing their routine clinical tasks.

**MP 329. MP clinical internship (10 c.h.).** The course offers an internship opportunity to students who wish to gain a more hands-on, practical experience in clinical aspects of the practice of medical physics. The internship will be conducted in a clinical facility under the supervision of a clinical medical physicist.

**MP 331. Advanced medical imaging physics (3 c.h.).** The course includes advanced topics in diagnostic imaging including linear system theory, image quality metrology, digital radiography and mammography, new advances on three-dimensional imaging modalities, MRI, CT, ultrasound, and evaluation of diagnostic imaging methods. Prerequisite: MP 230.

**MP 332. Molecular imaging (1 c.h.).** The course covers topics related to imaging molecular processes in small animal and human applications.

**MP 338. Clinical practicum and shadowing (Diagnostic Imaging) (3 c.h.).** Review and real-life exercises on principles of modern medical imaging systems with emphasis on the engineering and medical physics aspects of image acquisition, reconstruction and visualization, observations of imaging procedures in near clinical settings, and hands-on experience with the instruments. Modalities covered include ultrasound, CT, MRI,

nuclear medicine and optical imaging. Medical Physics students will substitute X-ray imaging for the Nuclear imaging module. Prerequisite: BME 233/MP230 or equivalent.

**MP 348. Clinical practicum and shadowing (Nuclear Medicine) (3 c.h.).** The course gives hands on experience in clinical nuclear medicine. Students will work with gamma cameras, PET systems, surgical probes, dose calibrators, technetium generators, well counters to learn operation principles, calibration, and quality control methods. Students will spend time in the PET facility, nuclear cardiology, nuclear medicine, and the radiopharmacy. The course includes shadowing a clinician, technologist, or physicist, while performing their routine clinical tasks.

**MP 359. Independent study.** An independent research project with a faculty advisor.

**MP 360. Public speaking for medical physicists (1 c.h.).** An overview of effective communication techniques for scientists and engineers. Course will focus on speech and delivery, structure of effective presentations, and proper use of visual aids. Students will be required to actively participate in exercises on extemporaneous speaking, formal research presentations, and question and answer sessions.

**MP 361. Biostatistics for medical physicists (3 c.h.).** The course covers topics in biostatistics foundational to all sub-specialties of medical physics.

#### 1. List of potential future courses to be added

To be added in 2008-09 academic year:

**MP 370. Frontiers of Biomedical Sciences (3 c.h.).** A course covering the frontier topics of biomedical sciences that are currently not within the domain of medical physics, but medical physicists, nonetheless, need to have knowledge of. Topics include genomics, bioinformatics, proteomics, and others.

To be added in 2009-10 academic year:

**MP 312. Radiobiology (2 c.h.).** Effects of ionizing radiation on biological material from molecular interactions, through sub-cellular and cellular levels of organization, to the response of tissues, organs and the whole body. Includes the application of radiation biology in oncology and the biological aspects of environmental radiation exposure.

**MP 318. Clinical practicum and shadowing (Medical Health Physics) (3 c.h.).** This practicum course provides hands-on experiences in various hospital health physics functions, in RAM lab oversight, in x-ray room shielding and verification, and in license preparation experience under NRC/States oversight. The course includes shadowing a clinician, technologist, or physicist, while performing their routine clinical tasks.

**MP 342. Radionuclide and radiotracer production (3 c.h.).** Production of radionuclides for imaging and therapy. Cyclotron and target principles, operation, and maintenance. Reactor-produced radionuclides. Radiochemistry. Production of PET tracers. Tracer kinetic modeling. Quantitating physiological parameters.

To be added beyond 2009-10 depending on student interest and faculty availability:

**MP 252. Health physics seminar (1 c.h.).** Weekly seminar on various topics pertaining to health physics. The seminar provides students exposure to operational and current issues in Radiation Safety and opportunity to interact with professionals in the Triangle area and beyond.

**MP 314. Internal and external dosimetry (3 c.h.).** This course provides foundations for internal and external dosimetry methods, experience in using available software packages, overviews of internal and external organ dose estimation methods in nuclear medicine and diagnostic radiology, and overviews of issues pertaining to occupational dose monitoring.

**MP 315. Non-ionizing radiation bioeffects and applications (3 c.h.).** This course reviews the interactions, biological effects, and medical applications of non-ionizing electromagnetic radiation, and discusses the uses, hazards, safety precautions, and formal exposure limits associated with each section of the electromagnetic spectrum.

**MP 316. Advanced radiation detection and dosimetry (3 c.h.).** Provide and overview of radiation detection methods for charged particles, photons and neutrons. Understand underlying principles of each method, including its advantages and disadvantages for specific applications. Illustrate general concepts by specific examples of detectors, measurement techniques and signal processing.

**MP 324. 3D treatment planning/ IMRT (3 c.h.).** Modern techniques in 3-dimensional and inverse treatment planning, Monte Carlo methods and beam optimization will be discussed.

**MP 325. Special topics in cancer treatment (3 c.h.)** The course discusses special treatment modalities for cancer therapy including hyperthermia treatment and nuclear oncology. Topics relating to Hyperthermia including thermal biology, methods of heating, heat transport theory, and implementing the program into the clinic will be discussed. Nuclear oncology covers the use of radionuclides in cancer treatment, including radiolabeled monoclonal antibodies, and the use of beta and alpha emitters.

**MP 326. Monte Carlo methods in medical physics (3 c.h.).** Provide an introduction to the use of the Monte Carlo method in radiation transport. The acquired knowledge will be applicable to dosimetry problems, detector simulations or shielding calculations. Demonstrate setup and solutions of sample problems using MCNP or other MC codes.

**MP 333. Medical image processing and display (3 c.h.).** A course covering basic medical imaging processing methods (e.g., 2D, 3D FF, Filtering, MTF), image reconstruction (e.g., FBP, iterative), image corrections and enhancements (e.g., scatter, attenuation), image registration, quantitative image analysis, statistical processing methods including Monte Carlo methods, display methods and technology, and 3D visualization. The course includes a 1 c.h. computer-based lab component.

**MP 334. PACS and hospital informatics (3 c.h.).** The course covers topics in modern medical informatics systems of Picture Archiving and Communication System (PACS), Radiology Information System (RIS), and Hospital Information System (HIS). Topics covered include the hardware and software components of these systems, DICOM and HL-7 protocols, database structure, data storage and distribution, and web applications.

**MP 335. Advanced digital imaging applications (3 c.h.).** The course covers advanced topics in diagnostic imaging and emerging technologies. They include methods for depth discrimination (e.g., bi-plane and tomosynthesis), methods for tissue discrimination (e.g., dual-energy and contrast imaging), advanced image processing, and computer aided detection and diagnosis.

**MP 336. Magnetic resonance imaging (3 c.h.).** This course will cover the hardware, methods and medical uses of magnetic resonance imaging (MRI) and spectroscopy (MRS). The emphasis will be on 1.5 Tesla human imaging, but aspects of higher and lower magnetic field strengths will be examined as appropriate. Topics: Basic concepts of NMR (spins, gyromagnetic ratio, chemical shift, T1, T2, liquids and protein solutions, tissue), Magnets, Gradients, RF Coils, Pulse sequence concepts and the k-space view of MRI/MRS, basic pulse sequences, Fast imaging, special contrast imaging (diffusion, FLAIR), flow imaging (including perfusion), contrast agents, spectroscopy, task-activation MRI, image artifacts, quality assurance.

**MP 345. Special topics in functional and molecular imaging (3 c.h.).** The course discusses the fundamentals of functional and molecular imaging methods, recent advances, and new methodologies. The modalities considered include NM imaging, fMRI, contrast CT, contrast US, etc.

**MP 351. Special topics in clinical research (1 c.h.).** A seminar series, web-based course covering topics pertaining to clinical research. Issues discussed include human subject experimentation, animal experimentations, patient privacy, scientific ethics and fraud, plagiarism and copyright, researching in a patient-oriented environment.

**MP 358. Clinical problem solving (3 c.h.).** A course offered as a practical introduction to MP instrumentation or practice. The student will be paired with a faculty engineer or physicist and a practicing clinician for a semester project focused on some current clinical physics question. As an example, working with the technical and clinical mentors the student will design a research project that will explore via

phantom evaluation, simulation, or software modeling the impact of the choice of imaging parameters on clinical imaging. Clinical imaging protocols will be evaluated to determine where the medical physicist/biomedical engineer can provide useful insight in translating technical understanding to clinical protocols. The course will require a scholarly report which will be posted on the Imaging Physics web site for future reference.