Committee on Medical Physics

Chair
Samuel G. Armato III

Professors

- Timothy Carroll, Radiology
- Maryellen L. Giger, Radiology
- Howard J. Halpern, Radiation & Cellular Oncology
- Gregory S. Karczmar, Radiology
- Patrick La Riviere, Radiology
- Xiaochuan Pan, Radiology

Associate Professors

- Samuel G. Armato III, Radiology
- Bulent Aydogan, Radiation & Cellular Oncology
- Chin-Tu Chen, Radiology
- Satish Chitneni, Radiology
- Yulei Jiang, Radiology
- Chien-Min Kao, Radiology
- Zheng Feng Lu, Radiology
- Ingrid Reiser, Radiology
- Steffen Sammet, Radiology
- Kamil M. Yenice, Radiation & Cellular Oncology

Assistant Professors

- Kenneth B. Bader, Radiology
- Behzad Ebrahimi, Radiation & Cellular Oncology
- Cameron Kofler, Radiology
- James Sohn, Radiation & Cellular Oncology
- Joseph Steiner, Radiology
- Zhen Tian, Radiation & Cellular Oncology

Emeritus Professors

- Kunio Doi, Radiology
- David N. Levin, Radiology
- Chester S. Reft, Radiation & Cellular Oncology

The Committee on Medical Physics includes the graduate program in medical physics, which is recognized internationally for its research excellence. Faculty with primary interest in diagnostic imaging hold appointments in the Department of Radiology, and faculty with primary interest in the physics of radiation therapy hold appointments in the Department of Radiation & Cellular Oncology. Many of the faculty are leaders in their respective specialties. Because the departments are located in the University of Chicago Medical Center, there is strong interaction among the clinical and research faculty and staff. The Committee on Medical Physics program leads to the Ph.D. degree in medical physics. Although most students are admitted directly for study toward the Ph.D. degree, the S.M. degree may occasionally be awarded as a terminal degree. Normally five or six years of residency are required for the Ph.D. degree.

Please visit our website http://medicalphysics.uchicago.edu/ for more information.

Inquiries concerning the graduate program should be addressed to Sam Armato, Ph.D., Chair of the Committee on Medical Physics, Director of the Graduate Program in Medical Physics, Department of Radiology, MC 2026, 5841 South Maryland Avenue, Chicago, IL 60637, or e-mail: s-armato@uchicago.edu

Medical physics researchers at the university have available to them a variety of state-of-the-art equipment:

- 1.5T MR scanners
- 3T MR scanner
- 9.4T MRI/MRS system
- Electron paramagnetic resonance imaging spectrometers

- 16-, 32-, and 64-slice helical CT scanners
- Advanced 256-slice helical cone-beam CT scanner
- Advanced 256-slice dual-energy helical cone-beam CT scanner
- Dual-energy chest radiography system
- Full-field digital mammography systems
- PET/CT scanner
- 30% sensitivity dual-head small animal PET scanner
- Computer controlled dual-energy linear accelerators with multileaf collimators, dynamic treatment capability, and solid-state megavoltage imagers and kilovoltage 2D and cone-beam imaging capabilities
- Computer controlled high-dose-rate remote after loading brachytherapy system
- Virtual reality display system
- Computed radiography systems
- 7 dual-head SPECT systems
- Real-time quantitative PCR machine
- Zeiss surgical microscope
- Harvard small animal ventilator
- Micro-interventricular pressure and volume catheters
- MRI-compatible fiber optic pressure transducer
- Physiologic data acquisition and analysis system
- Class II cell culture hood
- Zeissfluorescence microscope with associated CCD camera and image acquisition and analysis computer system
- Microplate reader
- Sorvall RC-6 high-speed ultracentrifuge
- Bio-rad gel documentation and analysis workstation
- Harshaw automated thermoluminescent reader
- Philips 250 kVp orthovoltage machine
- Diagnostic and mammography x-ray systems
- Dual-head SPECT systems
- Xenogen IVIS 200 for bioluminescence and fluorescence animal imaging
- VisEn FMT for fluorescence molecular tomography in animal imaging
- Olympus OV-100 for fluorescence animal imaging
- GMI/GE Triumph Flex microPET/SPECT/CT pre-clinical imaging system
- Vevo 770 ultrasound imaging system for animal imaging
- Super-resolution single-photon emission microscope (SPEM)
- High-resolution digital x-ray imaging system
- Computer-aided detection system for mammography
- High-resolution display monitors and workstations
- General use and specialized image processing and display computers linked via a high-speed network

Medical Physics Courses

MPHY 30000. Medical Physics Clinical Observation. 50 Units.
The scope of this course is to expose students to the day-to-day work of clinical medical physicists. Students are offered observation in the clinic of a variety of tasks that medical physicists perform, such as equipment quality control testing. A range of observation topics in diagnostic, therapy and nuclear medical physics are offered. Participation in five observations is required to receive course credit. This is a special topics course and students are expected to prepare themselves for each observation. Enrollment in this course is by instructor permission only. Prerequisite: Completion of HIPAA training (online CITI course)
Instructor(s): Ingrid Reiser

MPHY 32000. Overview of the Physics of Medical Imaging. 100 Units.
This course is for students in the medical physics certificate program. The course presents a comprehensive overview of physics in medical imaging, covering a wide range of clinical imaging modalities including radiography, fluoroscopy, computed tomography (CT), mammography, ultrasound, magnetic resonance imaging (MRI) and nuclear medicine imaging. The course will introduce the student to the fundamental principles of clinical radiological imaging as well as cutting-edge diagnostic imaging technology.
Instructor(s): Z.F Lu, B. O'Brien-Penney, I. Reiser and S. Sammet Terms Offered: Spring

MPHY 34100. Bioethics for Medical Physicists. 50 Units.
This course explores ethical issues that arise in the practice of medical physics in research, education and clinical settings. Topics include misconduct (fabrication, falsification and plagiarism) and questionable conduct in scientific research; authorship and publication practices; human subject research (informed consent and IRB review, patient/subject privacy and confidentiality; quality improvement vs research; vulnerable subjects); history of human radiation experiments and medical physics; research with animals; incidental findings in radiation therapy and imaging research; conflicts of interest; mentorship; professionalism and the AAPM code of ethics; ethics of innovative technologies (charged particle therapy); off-label uses of radiation; radiation errors and patient safety; and the ethics of radiation protection, optimization and justification of medical radiation exposure in therapy and imaging. The course aims to increase students' awareness of ethical issues they might face as medical physicists and to help them, through case discussions, better recognize, analyze and resolve ethical issues, conflicts and dilemmas.
Instructor(s): N. Ozturk Terms Offered: Spring

MPHY 34200. Practicum in the Physics of Medical Imaging I. 100 Units.
This laboratory course is designed for students to enhance the understanding of materials covered in the Physics of Medical Imaging I (MPHY 38600) and to acquire hands-on experience on related subjects. These subjects include diagnostic x-ray sources and imaging systems, MRI, and the applications of computer-aided diagnosis.
Instructor(s): S. Sammet, M. Giger, Y. Jiang, P. La Rivière, Z.F. Lu Terms Offered: Spring

MPHY 34300. Practicum in the Physics of Medical Imaging II. 100 Units.
This laboratory course is designed to familiarize the medical physics student with certain equipment and procedures in diagnostic radiology, with emphasis on nuclear medicine (both PET and SPECT), ultrasound, and x-ray (helical) computed tomographic (CT) imaging. The students will conduct routine quality control procedures and educational exercises. Data analysis will be conducted using clinical software and freeware that will process DICOM images.
Instructor(s): B. O'Brien-Penney, Z.F. Lu Terms Offered: Summer

MPHY 34400. Practicum in the Physics of Radiation Therapy. 100 Units.
This course combines lectures and intensive hands-on experiments. It includes an introduction to thermoluminescent detectors, film and ionization chamber dosimetry, and quality assurance for intensity modulated radiation therapy (IMRT). Training in data acquisition, error analysis, experimental techniques and the safe handling of sealed radiation sources is also included. The basic concepts of Monte Carlo calculations will be presented and measurements made in simple slab phantoms to compare with (MC) calculations.
Instructor(s): H. Al-Hallaq, B. Aydogan Terms Offered: Winter

MPHY 34500. Nuclear Instrumentation and Methods for Molecular Imaging. 100 Units.

MPHY 34900. Mathematics for Medical Physics. 100 Units.
This course focuses on the mathematics that will be used throughout the training of students in the Graduate Program in Medical Physics. Lectures are given on linear algebra, Fourier analysis, sampling theory, functions of random variables, stochastic processes, estimation theory, signal detection theory, and ROC analysis.
Instructor(s): X. Pan, M. Giger, P. La Rivière Terms Offered: Autumn

MPHY 35000. Interactions of Ionizing Radiation with Matter. 100 Units.
Ionizing radiation is the basis for radiation therapy and for many diagnostic imaging studies. This course explores the fundamental modes of interaction between ionizing radiation (both electromagnetic and particulate) and matter, with an emphasis on the physics of energy absorption in medical applications. Topics will include exponential attenuation, x-ray production, charged particle equilibrium, cavity theory, dosimetry, and ionization chambers.
Instructor(s): S. Armato, H. Al-Hallaq Terms Offered: Autumn

MPHY 35100. Physics of Radiation Therapy. 100 Units.
This course covers aspects of radiation physics necessary for understanding modern radiation therapy. Rigorous theoretical foundations of physical dose calculation for megavoltage-energy photons and electrons, biological predictions of therapy outcomes, and brachytherapy are presented. Methods of modeling and implementing radiation therapy treatment planning, evaluation, and delivery are described. Emphasis is placed on current developments in the field including intensity modulated radiation therapy. The course is intended to provide comprehensive knowledge of radiation therapy physics, enabling the student to grasp current research in the field.
Instructor(s): K. Yenice, N. Ozturk, R. Wiersma Terms Offered: Winter

MPHY 35601. Anatomical Structure and Physiological Function of the Human Body. 100 Units.
Study and primer of the basic anatomy of the human body, as demonstrated from diagnostic radiographic imaging. Physiological processes of body systems will be examined with an emphasis on its relationship with imaging. Emphasis is placed on critical landmark structures involved in body, limb and nervous system imaging, allowing for effective clinically oriented research.
Instructor(s): C. Straus, B. Roman Terms Offered: Autumn

MPHY 35900. Cancer And Radiation Biology. 100 Units.
This course provides students with an overview of the biology of cancer and of the current methods used to diagnose and treat the disease. Lectures from faculty throughout the Biological Sciences Division will include presentations on cancer incidence and mortality, cancer prevention, a molecular biology perspective, the role of genetic markers, methods of treatment (radiation, chemotherapy) and prognosis. The course will be primarily for medical physics graduate students.
Instructor(s): D. Grdina Terms Offered: Winter

MPHY 37400. Charles E. Metz Special Topics. 100 Units.
The Third Charles E. Metz Special Topics Course: "Tracer Methodology "Tracer" is a minute amount of chemical compound used in tracking the specific physiology or life process of interest without altering that specific process to be assessed or measured. Specific tracer methodology is often associated with an imaging technology that captures the quantitative information relevant to the specific life process under investigation. We will survey the tracer methodology employed in PET, SPECT, MRI, EPRI, ultrasound, optical imaging, X-ray, CT and other new imaging techniques. Computational methods to extract and derive biological or functional information from the tracer image data, as well as applications of the tracer methodology in clinical practice and biomedical research will also be discussed.
Instructor(s): Chin-Tu Chen Terms Offered: Winter (every other year)

MPHY 37500. Back and Harper Special Topics Course "Fundamentals of Molecular Imaging and Theranostics" 100 Units.
This is an introduction course on the emerging field of molecular imaging and theranostics (MI&T) and their applications in medicine and biology. Molecular imaging is the visualization, characterization, and measurement of biological processes at the molecular and cellular levels in humans and other living systems. Theranostics combines both therapeutics and diagnostics in the form of a pair of same or similar chemical compounds conjugated with imaging and therapeutic agents respectively, or with a single agent with both functions, to deliver both imaging and therapeutic capabilities for diagnosis, image-enabled treatment planning, and image-assisted therapeutic effect monitoring of major diseases with the goal to produce improved treatment outcomes. Various molecular imaging modalities and therapeutic approaches, as well as the relevant issues in physics, instrumentation, chemistry, nanotechnology, biology, computing, data science, as well as their applications in biomedical research and clinical medicine, will be reviewed and discussed. No official prerequisites required; but experience in taking one or more of BIOS 29326, MPHY 35100, MPHY 38600, MPHY 38700, MPHY 38800 preferred. Consent by one of the course organizers listed below, communicated via emailing, is required. Course Organizers: Chin-Tu Chen, c-chen@uchicago.edu Satish Chitneni, schitneni@uchicago.edu Chien-Min Kao, c-kao@uchicago.edu
Instructor(s): Chin-Tu Chen, c-chen@uchicago.edu Satish Chitneni, schitneni@uchicago.edu Chien-Min Kao, c-kao@uchicago.edu Terms Offered: Autumn
Prerequisite(s): No official prerequisites required; but experience in taking one or more of BIOS 29326, MPHY 35100, MPHY 38600, MPHY 38700, MPHY 38800 preferred.
Note(s): Consent by one of the course organizers listed below, communicated via emailing, is required.

MPHY 38600. Physics of Medical Imaging-1. 100 Units.
This is an introductory course to the basic elements of x-ray imaging, electron paramagnetic resonance (EPR) imaging, and magnetic resonance imaging (MRI) and spectroscopy (MRS). X-ray imaging topics include x-ray spectra, image formation, analog and digital detectors, physical measures of image quality, fluoroscopy, digital subtraction angiography, dual-energy imaging and image restoration. Magnetic resonance imaging topics include nuclear magnetic resonance, relaxation times, pulse sequences, functional imaging and spectroscopy.
Instructor(s): Y. Jiang, H. Halpern and P. La Rivière Terms Offered: Spring

MPHY 38700. Physics of Medical Imaging II. 100-300 Units.
This course covers the physics, mathematics and statistics in nuclear medicine, x-ray computed tomography, ultrasound imaging, and optical imaging. Specific topics include: radioactive isotopes and tracer methodology; physics, instrumentation, and performance properties of gamma camera; quality control in nuclear medicine; SPECT imaging; physics, instrumentation and performance properties of PET imaging; biokinetics and compartmental analysis; physics, reconstruction, proformance properties for CT imaging and tomosynthesis; principles and instrumentation of ultrasound imaging; and optical imaging.
Instructor(s): K. Bader and T. Carroll Terms Offered: Summer

MPHY 38800. Physics of Medical Imaging III. 100 Units.
This course will cover fundamentals and labs of nuclear medicine imaging.
Instructor(s): C-M Kao and P. La Riviere Terms Offered: Summer

MPHY 39200. Diagnostic Clinical Physics. 300.00 Units.
This course provides an understanding of the physical principles and theories involved in diagnostic imaging modalities. It will acquaint the student with the daily work of a clinical medical physicist in a Radiology department. This course will introduce concepts of quality control and will enable students to perform quality control scans on different imaging modalities.
Instructor(s): B. O'Brien-Penney, Z.F. Lu, S. Sammet Terms Offered: Autumn

MPHY 39500. Special Topics Course at the MBL: Image Acquisition/Analysis. 100 Units.
Students will register for this "course" when they are enrolled in an Advanced Research Training Course (on a topic related to image acquisition or image analysis) at the Marine Biological Laboratory in Woods Hole, MA. See http://www.mbl.edu/education/courses/ for course offerings.

MPHY 39600. Image Processing/Computer Vision. 100 Units.
Equivalent Course(s): CMSC 35600

MPHY 39700. Health Physics. 100 Units.
This course provides an introduction to fundamental principles of health physics and radiation protection in medical physics environments. A broad spectrum of topics is covered, including radiation detection and measurement, instrumentation, counting statistics, radiation protection criteria, exposure limits and regulations, shielding techniques, monitoring of personnel dose and radiation safety.
Instructor(s): B. Aydogan, N. Ozturk Terms Offered: Spring

MPHY 39800. Reading class in MRI: Fundamentals and Signal Processing. 100 Units.
Reading class in MRI: Fundamentals and Signal Processing This reading course involved working through the advanced text "Principles of Magnetic Resonance Imaging" by Zhi-Pei Liang and Paul Lauterbur. It will build on concepts and material from the Physics of Medical Imaging sequence. Student participation is an essential component of this course. Students will take turns presenting and discussing the material under guidance of the instructor(s). There will also be problems assigned from the text aimed at sharpening understanding of the material. The weekly schedule will allow for reading of the entire ten-chapter book during a nine-week quarter. Week 1: Introduction and Mathematical Fundamentals (Chapters 1 and 2) Week 2: Signal Generation and Detection (Chapter 3) Week 3: Signal Characteristics (Chapter 4) Week 4: Signal Localization (Chapter 5) Week 5: Image Reconstruction (Chapter 6) Week 6: Image Contrast (Chapter 7) Week 7: Image Resolution, Noise, and Artifacts (Chapter 8) Week 8: Fast-scan imaging (Chapter 9) Week 9: Constrained reconstruction (Chapter 10)
Instructor(s): Patrick La Riviere Terms Offered: Spring

MPHY 39900. Reading and Research: MPHY. 100 Units.
This reading course is aimed at working through critical chapters of the text Foundations of Image Science by Harrison Barrett and Kyle Myers. It aims at building on concepts and material from the "Mathematics for Medical Physicists" course toward a deeper understanding the objective assessment of image quality. We will focus on Chapters 1 (Vectors and Operators), 7 (Deterministic Descriptions of Imaging Systems), 8 (Stochastic Descriptions of Objects and Images), 13 (Statistical Decision Theory), 14 (Image Quality), and 15 (Inverse Problems). Student participation is an essential component of this course. Students will take turns presenting and discussing the material under guidance of the instructor(s). There will also be computer exercises aimed at sharpening understanding of the material.
Instructor(s): P. La Riviere, C.M. Kao Terms Offered: Winter (every other year)

MPHY 41600. Pre-Candidacy Research in Medical Physics. 100-300 Units.
Research topics span various areas of medical physics and can include those from diagnostic imaging to radiation therapy treatment methods, as well as cross-disciplinary projects. Students in the Graduate Program in Medical Physics will enroll in this course (after selecting a lab for their thesis reserach) each quarter until the successful passage of the thesis proposal.
Instructor(s): S. Armato, and staff Terms Offered: All Quarters

MPHY 41700. Dissertation Research in Medical Physics. 100-300 Units.
Research topics span various areas of medical physics and can include those from diagnostic imaging to radiation therapy treatment methods, as well as cross-disciplinary projects. Students in the Graduate Program in Medical Physics will enroll in this course every quarter after the successful passage of the thesis proposal.
Instructor(s): S. Armato, and Staff Terms Offered: All Quarters

MPHY 41800. Research in Advanced Tomographic Imaging. 100-300 Units.
Possible research topics include investigation, development, and evaluation of algorithms for advanced tomographic imaging with emphases on the fundamental physics, mathematics, and statistics of advanced tomographic imaging; cone-beam computed tomography (CT); tomosynthesis; phase-contrast CT; magnetic resonance imaging (MRI); electron paramagnetic resonance imaging (EPRI); positron emission tomography (PET); single-photon emission computed tomography (SPECT); and emerging tomographic imaging techniques.
Instructor(s): X. Pan and Staff Terms Offered: All Quarters

MPHY 41900. Research in Computer Aided Diagnosis. 100-300 Units.
Research topics include the application of advanced image processing techniques and computer vision approaches to the development of methods for the detection of abnormalities in medical images (e.g., mammograms, chest radiographs, computed tomography (CT) scans, and magnetic resonance imaging (MRI)); the development of methods to classify abnormalities as benign or malignant; the investigation of enhanced visualization techniques such as temporal subtraction imaging; the segmentation of anatomic or pathologic structures of interest; and the assessment of tumor response.
Instructor(s): S. Armato and Staff Terms Offered: All Quarters

MPHY 42000. Research in the Physics of Nuclear Medicine. 100-300 Units.
Possible research topics include the fundamental physical aspects of nuclear medicine, including radiation detection and spectrum analysis; image formation, processing, and display; criteria for image evaluation; and quantitative in vivo assay using methods of gamma ray and positron tomography, stimulated x-ray fluorescence, and activation analysis.
Instructor(s): X. Pan and Staff Terms Offered: All Quarters

MPHY 42100. Research in the Physics of Diagnostic Radiology. 100-300 Units.
Possible research topics include the development of methods to improve diagnostic accuracy and/or to reduce patient radiation exposure; quantitative image analysis and computer-aided diagnosis, methods of tomographic reconstruction, analysis and evaluation of imaging system components; and joint physical/clinical studies of new techniques in diagnostic medical physics.
Instructor(s): M. Giger and Staff Terms Offered: All Quarters

MPHY 42200. Research in the Physics of Radiation Therapy. 100-300 Units.
Possible research topics include radiation treatment planning; radiation dose calculations; intensity-modulated radiotherapy; image-guided radiotherapy; biological basis of radiation therapy; and analysis of treatment outcomes.
Instructor(s): C. Pelizzari and Staff Terms Offered: All Quarters

MPHY 42300. Research in the Physics of MRI. 100-300 Units.
Possible research topics include fundamental aspects of magnetic resonance imaging (MRI) and magnetic resonance spectroscopy (MRS) including the development and optimization of methods to non-invasively characterize the structure and function of tissue invivo. The developments range from novel MRI/MRS pulse sequences to image reconstruction to data processing methods, multi-modal imaging approaches, and modeling of contrast mechanisms. Other research topics are the development and application of quantitative MRI/MRS methods for image-guided interventions and the analysis of treatment outcomes.
Instructor(s): G. Karczmar, S. Sammet and Staff Terms Offered: All Quarters

MPHY 42400. Research in Image-Guided Radiation Therapy. 100-300 Units.
Possible research topics include fundamental aspects of image guidance in radiation therapy planning and delivery, management of inter-treatment and intra-treatment patient motion, use of respiratory correlated CT, cone beam CT, kV/MV real-time imaging, and dynamic patient modeling for treatment planning.
Instructor(s): C. Pelizzari and Staff Terms Offered: All Quarters

MPHY 42500. Research in Quantitative Image Analysis. 100-300 Units.
Possible research topics include fundamental and developmental aspects of computer vision and artificial intelligence on biomedical image data to yield image-based phenotypes for Computer-aided diagnosis (CAD) and other decision support methods in medical imaging. Additional developments include aspects of data mining, dimension reduction, classifier training, metrics of validation, human-computer interface, and imaging genomics.
Instructor(s): M. Giger, S. Armato and Staff Terms Offered: All Quarters

MPHY 42600. Research in Computer-aided Diagnosis/Radiomics. 100-300 Units.
Possible research topics include development and application of image processing and computer vision techniques for the detection, diagnosis, and response assessment of disease in medical images, the image-based evaluation of normal tissue complications that result from therapy, the quantification of imaging signatures (imaging biomarkers) that correlate with disease phenotypes or patient genetic profiles, the integration of multi-modality imaging for enhanced decision support, and the application of deep learning for computer-aided diagnosis challenges.

MPHY 42700. Research in Molecular Imaging. 100-300 Units.

MPHY 70000. Advanced Study: Medical Physics. 300.00 Units.
Advanced Study: Medical Physics