Radiation Sciences

College of Medicine

Master of Science (MS) in Radiological Medical Physics

Admission Requirements

In addition to the general requirements of the Graduate School, the Radiological Medical Physics Program requires the following for MS candidates. At a minimum, candidates must show the equivalence of a minor in physics (as defined by CAMPEP). To meet this requirement, candidates must have completed the following: 1) Calculus through Ordinary Differential Equations; 2) The Calculus-based introductory General Physics sequence with labs (2 semesters); and 3) Three upper division Physics electives (junior level or above). Courses in Human Anatomy, Human Physiology, Computer Science, and Scientific Statistics are preferred but, if missing, may be incorporated into the graduate program at the discretion of the Director of Graduate Studies.

Application Information

Application to the Radiation Sciences program is online through the Graduate School using the link https://app.applyyourself.com/AYApplicantLogin/fl_ApplicantConnectLogin.asp?id=ukgrad . The applicant will be required to submit GRE General Test scores, transcripts for all undergraduate work, a personal statement, and contact information for three persons willing to provide letters of recommendation. Only self-reported, unofficial General GRE scores and transcripts are required at the time of application. Official versions must be submitted upon entry into the program. A CV may be included but is not required. A personal interview, typically on-campus, is required. However, on-line interviews may be allowed in cases of severe travel restrictions. Fluent spoken English skills are required and are assessed during the interview.

Admission to the program occurs once annually with new classes beginning in the Fall semester. The deadline for applications is April 30th, however, offers for admission are usually made early in the preceding spring semester with completion of the class roster by April 1st. There are a limited number accepted into our program (typically 8), therefore it is recommended that applications be completed by January 31st to assure full consideration. Applications received after the class roster is filled will not be reviewed.

Degree Requirements

The Master of Science in Radiological Medical Physics is interdisciplinary. Plan B (non-thesis) guidelines are utilized for the graduate work, incorporating specific courses in several departments. There is no language requirement. A coursework outline is given as follows.

Required Program Coursework

- PHY/RM 472G Interactions of Radiation with Matter (3)
- RAS/RM/PHY 545 Radiation Hazards and Protection (3)
- RAS/RM/PHY 546 General Medical Radiological Physics (3)
- RAS/RM 601 Advanced Radiation Dosimetry (2)
- RAS/RM 647 Physics of Diagnostic Imaging I (3)
- RAS/RM 648 Physics of Diagnostic Imaging II (3)
- RAS/RM 649 Physics of Radiation Therapy (3)
- RAS 651 Advanced Laboratory in Diagnostic Imaging Physics (2)
- RAS/RM 695 Research in the Health-Related Radiation Sciences (2)
- RAS 710 Radiation Science Seminar (1)
- RM/BIO 740 Mammalian Radiation Biology (2)
- Elective(s) (3)

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TOTAL CREDIT HOURS: 30

Available Electives (Partial Listing)

- RM 660 Graduate Practicum in Radiation Medicine (1-6)
- RAS/RM 650 Brachytherapy Physics (2)
- RM 842 Radiation Oncology (1)
- RM 848 Practicum in Brachytherapy Physics (1-3)
- RM 849 Practicum in External Beam Therapy Physics (1-6)
- EE 630 Digital Signal Processing (3)
- EE 635 Image Processing (3)

Doctor of Philosophy (PhD) in Radiation and Radiological Sciences

Medical Physics is a profession that includes clinical, industrial and academic practices. The Radiation and Radiological Sciences PhD program is designed primarily for students who desire to enter a clinical career, but who want to acquire the additional skills and credentials that accompany a PhD.

This educational program is provided by the Departments of Radiation Medicine and Radiology, both of which are clinical departments within the UK Healthcare enterprise, thus providing a unique culture and context to the training. Research areas involve collaborative efforts between students, clinical physicists and physicians, and often possess direct clinical applicability. The collaborative nature of the program structure allows for didactic, clinical and research training in therapeutic and diagnostic medical physics.

The didactic coursework consists of 34 core credit hours plus an additional 18 hours of guided electives. Research will be conducted primarily under the mentorship of faculty in the Radiation

Medicine or Radiology Departments. Research projects can be conducted using clinical equipment, combined with other available technical resources, including computer programming and simulations, and interdisciplinary collaborations.

Admission Requirements

In addition to the general requirements of the Graduate School, the Radiation and Radiological Sciences Program requires the following. At a minimum, candidates must show the equivalence of a minor in physics. To meet this requirement, candidates must have completed the following: 1) Calculus through Ordinary Differential Equations; 2) The Calculus-based introductory General Physics sequence with labs (2 semesters); and 3) Three upper division Physics electives (300 level or above). Courses in Human Anatomy, Physiology, Computer Science, and Scientific Statistics are preferred but, if missing, may be incorporated into the graduate program at the discretion of the Director of Graduate Studies.

Most of our entering students possess undergraduate physics degrees, although students possessing related physical science backgrounds are eligible and qualified. These students are counseled prior to their arrival of the need to comply with the entrance requirements. Most students have some missing prerequisites that are remediated in their first year. These most typically include anatomy, physiology, and sometimes include an upper level physics course. The deficiencies described above are remediated via formal coursework. These courses are almost exclusively taken here at the University, although may be completed via coursework at another accredited college.

Application Information

Application to the program is online through the Graduate School at http://www.gradschool.uky.edu/ProspectiveStudents/prospective.html . The applicant will be required to submit GRE General Test scores, transcripts for all undergraduate work, and three letters of recommendation. Only self-reported, unofficial General GRE scores and transcripts are required at the time of application. Official versions must be submitted upon entry into the program. A personal statement and/or a CV may be included but are not required. A personal interview, typically on-campus, is required. However, on-line interviews may be allowed in cases of severe travel restrictions. Fluent spoken English skills are required and are assessed during the interview.

Admission to the program occurs once annually with new classes beginning in the Fall semester. The deadline for applications is April 30th, however, offers for admission are usually made early in the preceding Spring semester with completion of the class roster by May. Therefore, it is recommended that applications be completed by January 31 to assure full consideration.

Degree Requirements

A minimum of 52 credit hours are required for the PhD degree consisting of 34 core credit hours and 18 elective credit hours. The elective credit hours (18) must include at least 6 hours of graduate level (i.e., 4xxG, 5xx, 6xx or 7xx) didactic coursework covering related topics in science, engineering, or medicine. The intent of this requirement is to encourage interdisciplinary collaboration and to develop rigorous scientific skills. The selection of the specific courses is variable. The remaining 12 elective credit hours may be fulfilled by any combination obtained from the list of “Available PhD Electives”

below. These credits must be approved by the student's dissertation advisor. In addition, completion of 36 hours is required for pre-qualifying residency. Post-qualifying residency must be a minimum or 4 credit hours of RAS 767. Students must maintain at least a 3.0 GPA for retention in the program. A student's progress will be reviewed annually by their graduate committee and any deficiencies or concerns identified will be followed up with the student.

The qualifying exam will consist of two major components, one written and one oral. Students must pass both to be allowed to progress in the PhD program. The written component will be a problem-based exam consisting of 4 subject areas. These are:

1. General Radiological Physics and Dosimetry
2. General Physics of Medical Imaging
3. General Physics of Radiation Therapy
4. Elective Subject (select one from the following list)
    a. Advanced Radiation Therapy Physics
    b. Advanced Medical Imaging Physics
    c. Other topic approved by the Advisory Committee

The written exam is given over a two non-sequential day period. Day one will cover subject areas 1, 2, and 3 while day two will cover section 4. The written exam will typically be taken in the second year of the program and a score of 50% or greater will be required in order to pass. Students who do not pass on the first attempt will be allowed a second attempt. If the second attempt is unsuccessful then the student will not be allowed to proceed in the PhD program. Such students will, however, be allowed to attempt to complete the degree requirements for an en passant MS degree in Radiation Sciences and be awarded that degree upon successful completion.

The qualifying oral exam will be taken after successful completion of the written exam, but typically not to exceed 3 years from the initial date of enrollment. The student must orally defend a proposal for the selected dissertation topic. The proposal defense will be delivered to the student's dissertation advisory committee.

PhD Core Coursework Requirements

- PHY/RM 472G Interactions of Radiation with Matter (3)
- RAS/RM/PHY 545 Radiation Hazards and Protection (3)
- RAS/RM/PHY 546 General Medical Radiological Physics (3)
- RAS/RM 601 Advanced Radiation Dosimetry (2)
- RAS/RM 647 Physics of Diagnostic Imaging I (3)
- RAS/RM 648 Physics of Diagnostic Imaging II (3)
- RAS/RM 649 Physics of Radiation Therapy (3)
- RAS 651 Advanced Laboratory in Diagnostic Imaging Physics (2)
- RAS/RM 695 Research in the Health-Related Radiation Sciences (4)
- RAS 710 Radiation Science Seminar (1)
- RAS 711 Research Methods in Medical Physics (1)

- RM/BIO 740 Mammalian Radiation Biology (2)
- RAS 767 Post Qualifying Residency (4)

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TOTAL CORE CREDIT HOURS REQUIRED: 34

Available PhD Electives (Partial Listing)

- RM 660 Graduate Practicum in Radiation Medicine (1-6)
- RAS 650 Brachytherapy Physics (2)
- RM 842 Radiation Oncology (1)
- RM 848 Practicum in Brachytherapy Physics (1-3)
- RM 849 Practicum in External Beam Therapy Physics (1-6)
- EE 630 Digital Signal Processing (3)
- EE 635 Image Processing (3)
- BME 530 Biomedical Instrumentation (3)
- BMI 730 Principles of Clinical Informatics (3)

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TOTAL ELECTIVE CREDIT HOURS REQUIRED: 18

Other Electives can be used with approval of the Dissertation Advisor

Course Descriptions

BME 530 BIOMEDICAL INSTRUMENTATION. (3) A comprehensive introduction to major aspects of biomedical instrumentation. Topics include basic concept of medical instrumentation, biopotentials, physiological pressure/flow/respiratory measurement, optical sensing, and clinical applications of all the above. The fundamental mathematics underlying each instrument will be reviewed and an engineering picture of the hardware and software needed to implement each system will be examined. Prereq: Consent of instructor.

BMI 730 PRINCIPLES OF CLINICAL INFORMATICS. (3) This course offers an overview of Clinical informatics, which is the application of informatics principles, methods, and tools to support healthcare practice and research activities as well as business processes.

EE 630 DIGITAL SIGNAL PROCESSING. (3) An introductory treatment of the basic concepts of signal processing via time and frequency domain (Z-transform) methods and a survey of procedures for designing, implementing and using digital signal processors. Prereq: EE 512 or consent of instructor.

EE 635 IMAGE PROCESSING. (3) The course outlines applications of image processing and addresses basic operations involved. Topics covered include image perception, transforms, compression,

enhancement, restoration, segmentation, and matching. Prereq: Graduate standing and consent of instructor. (Same as CS 635.)

PHY 472G INTERACTION OF RADIATION WITH MATTER. (3) Basic aspects of the interaction of ionizing radiation with matter. Bohr atom, atomic spectra, radioactivity, energetics of decay. Sources of radiation, penetration of charged particles, electromagnetic radiation, and neutrons through matter; excitation and ionization processes; selected nuclear reactions; basic radiation detection and dosimetry. Prereq: PHY 213 or 232; MA 114 (may be taken concurrently); or equivalent. (Same as RAS/RM 472G.)

RAS 545 RADIATION HAZARDS AND PROTECTION. (3) An analysis of common radiation hazards encountered in medicine, research, industry, and the environment. Regulations and procedures for the safe use of ionizing and nonionizing radiations. Lecture, two hours; laboratory, two and one-half hours. Prereq: PHY/RM 472G or consent of instructor. (Same as PHY/RM 545.)

RAS 546 GENERAL MEDICAL RADIOLOGICAL PHYSICS. (3) The uses and dosimetric aspects of radiation in medicine will be analyzed, including many basic applications in the fields of diagnostic radiology physics, therapy physics, and nuclear medical physics. Prereq or concur: RM/PHY 472G or consent of instructor. (Same as PHY/RM 546.)

RAS 601 ADVANCED RADIATION DOSIMETRY. (2) Advanced aspects of the interaction of radiation with matter and specialized topics in the dosimetry of ionizing radiations. Modifications of Bragg-Gray theory for application to megavoltage sources. Beta dosimetry. Specialized calibration techniques. Relative response functions of various media. Nontraditional techniques. Dosimetry of radiation fields including complex spectra. Prereq: PHY 472G, RM 546, or equivalent. (Same as RM 601.)

RAS 647 PHYSICS OF DIAGNOSTIC IMAGING I. (3) Specialized and advanced topics in diagnostic imaging, including modulation transfer function analysis, image processing algorithms, acceptance testing, CT, NMR, ultrasound, etc. Prereq: PHY/RM/RAS 546 or consent of instructor. (Same as RM 647.)

RAS 648 PHYSICS OF DIAGNOSTIC IMAGING II. (3) A continuation of RAS/RM 647. Specialized and advanced topics in nuclear medicine imaging physics, including positron emission tomographic procedures, emerging new modalities, and quality control. Prereq: RM/RAS 647 or consent of instructor. (Same as RM 648.)

RAS 649 PHYSICS OF RADIATION THERAPY. (3) Specialized external beam and brachytherapy treatment planning; advanced Bragg-Gray cavity applications, including Ngas and TG-21; calibration, acceptance testing, and quality control of therapy physics equipment. Prereq: RAS/RM/PHY 546 and RAS/RM 601, or consent of instructor. (Same as RM 649.)

RAS 650 PHYSICS OF RADIATION THERAPY II: BRACHYTHERAPY PHYSICS. (2) A presentation of the full scope of use of implanted radiation sources for medical purposes. The course includes consideration of all aspects of brachytherapy dosimetry and treatment planning as well as modern and cutting-edge brachytherapy clinical practice. Characteristics of interstitial, intracavitary, and intraluminal implants,

as well as remote afterloaders, are considered. Prereq: RAS/ RM/PHY 546; RM/PHY 472G; RAS/RM 649 (may be co-requisite). (Same as RM 650.)

RAS 651 ADVANCED LABORATORY IN DIAGNOSTIC IMAGING PHYSICS. (1-3) Specialized experiments involving the use, calibration, and quality control of x-ray and other diagnostic imaging equipment, and the appropriate use of radiation detectors in diagnostic physics measurements. Laboratory, approximately 30 hours per credit. May be repeated to a maximum of three credits. Prereq: RM/PHY 472G, RAS/RM 546; and concurrent: RAS/RM 647, or equivalent, plus graduate standing in the radiation science program.

RAS 695 RESEARCH IN THE HEALTH-RELATED RADIATION SCIENCES. (1-4) Independent directed research on theoretical and practical problems in the health-related radiation sciences. May be repeated to a maximum of eight credits. Prereq: Graduate standing in one of the radiation-related sciences, plus consent of instructor. (Same as RM 695.)

RAS 710 RADIATION SCIENCE SEMINAR (Subtitle required). (1) Topics of current interest relating to radiation and its applications in the areas of radiological medical physics and health physics. May be repeated to a maximum of four credit hours with consent of instructor. Prereq: Graduate standing in a radiation-related science.

RAS 711 RESEARCH METHODS IN MEDICAL PHYSICS. (1) This course will introduce the student to, and give them practical experience in, writing research proposals, research reports and carrying out research work. The course will be jointly taught by various medical physics faculty and guest lecturers. Students will be asked to present their own work to be critiqued by the class. The goal is to give the student a hands-on experience of what is involved in doing funded clinical research on human subjects and getting it published in an academic journal. Prereq: Approval of instructor.

RAS 767 DISSERTATION RESIDENCE CREDIT. (2) Residency credit for dissertation research after the qualifying examination. Students may register for this course in the semester of the qualifying examination. A minimum of two semesters are required as well as continuous enrollment (Fall and Spring) until the dissertation is completed and defended.

RM 660 GRADUATE PRACTICUM IN RADIATION MEDICINE. (1-6) Applied field work at the graduate level in the sciences relating to radiation medicine. May be repeated to a maximum of six credits. Prereq: Graduate standing in the bioradiation or medical sciences, plus consent of instructor.

RM 740 MAMMALIAN RADIATION BIOLOGY. (2) The physical and biological sequelae of radiation effects will be discussed emphasizing human and mammalian responses and radiation health. Emphasis will be for health and medical workers. Prereq: Consent of instructor; BIO/RM 540 or RM 546 or equivalent background. (Same as BIO 740.)

RM 842 RADIATION ONCOLOGY. (1) Use of radiation therapy in clinical treatment of malignancy. Staging, histology, spread, treatment techniques, acute and late effects of radiation therapy. Prereq: RM 740 and an introductory anatomy course, or equivalent, and consent of instructor.

RM 848 PRACTICUM IN BRACHYTHERAPY PHYSICS. (1-3) This course offers practicum training in the clinical use of therapy physics and health physics in brachytherapy. May be repeated to a maximum of three credits. Laboratory: 40 hours per week. Prereq: RM/HRS 649, or equivalent, and consent of instructional staff.

RM 849 PRACTICUM IN EXTERNAL BEAM THERAPY PHYSICS. (1-6) This course offers practicum training in the professional use of therapy physics in external beam radiation therapy. May be repeated to a maximum of six credits. Laboratory: 40 hours per week. Prereq: RM/HRS 649, or equivalent, and consent of instructor.