Commission on Accreditation of Medical Physics Educational Programs, Inc.

Standards for Accreditation of Graduate Educational Programs in Medical Physics

Revised 30 November 2014

Preamble

Medical Physics is a branch of physics that applies the concepts and principles of physics to the diagnosis and treatment of human diseases. Medical Physics encompasses four fields: Imaging Physics, Nuclear Medicine Physics, Radiation Oncology Physics and Medical Health Physics. This document focuses on the essential educational and experience requirements needed to engage in medical physics research and development, and to enter a residency program in preparation for clinical practice of one of the first three fields.

Terms such as “shall”, “must”, “require”, “should”, “may” and “recommend” are frequently used in these standards. The terms “shall”, “must”, and “require” denote items or activities that CAMPEP believes are mandatory components of an educational program. That is, they are required components. The terms “should”, “may” and “recommend” are considered desirable but not essential components of an educational program.

* Items marked with an asterisk are not required for graduate certificate programs.

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Sponsoring Organizations: American Association of Physicists in Medicine, American College of Radiology, American Society for Radiation Oncology, Canadian Organization of Medical Physicists, Radiological Society of North America

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1. Program Goal and Objectives

The objective of a graduate educational program in medical physics is to provide its graduates with the basic and applied scientific knowledge that is necessary both for further education and research in medical physics and for entry into a medical physics residency leading to a career in clinical medical physics. The knowledge and skills that the student should attain during graduate education include:

1.1 Physics, mathematics and other basic science knowledge required for research or clinical practice in medical physics;
1.2 *A conceptual and methodological understanding of how research and enquiry lead to the creation of new knowledge and the reinterpretation of existing knowledge;
1.3 *The assimilation and analysis of current research and scholarship in medical physics;
1.4 *Competent use of the research process to answer new questions and to solve specific problems in research and clinical settings;
1.5 The professional attributes and the ethical conduct and actions that are required of medical physicists;
1.6 The communication and interpersonal skills that are necessary to function in a collaborative environment;
1.7 An awareness of the complexity of knowledge in the field and a receptiveness to other interpretations, new knowledge, and different approaches to solving problems.

2. Program Structure and Governance

2.1 Institutions in the United States that offer graduate education in medical physics must be accredited by an accreditation organization recognized by the US Department of Education or the Council for Higher Education Accreditation. Programs in other jurisdictions must have obtained appropriate equivalent recognition.

2.2 *Graduate programs in medical physics shall be sited in a well-defined university structure where the term university refers to a high level institute of learning and research with standing in the academic community, a full time faculty, multiple schools and departments offering study in a comprehensive range of multidisciplinary areas and generally with a reputation for distinct areas of research. Although a Medical Physics Graduate Program may be newly established within the institution, it is expected that the institution be well established with a history of stability, an infrastructure to support students through their studies offering health care, counseling and with well defined services for protecting students interests, e.g., an ombudsman.

2.3 *On average, two years is needed for full-time students with appropriate backgrounds to earn a master’s degree in medical physics. The time beyond the master’s degree for students to complete the doctoral degree requirements is variable, but usually is at least three years.

2.4 Students entering a medical physics graduate educational program shall have a strong foundation in basic physics. This shall be demonstrated either by a degree in physics or by a degree in engineering or another area of the physical sciences with a physics component that
is equivalent to a minor in physics (i.e., one that includes at least three upper level undergraduate physics courses or equivalent that would be required for a physics major).

2.5 *If applicants with deficiencies in their academic background are admitted conditionally into a graduate program, the provision for remedial physics education shall be rigorous and well-defined.

2.6 Graduate education shall be supervised and monitored by an appropriate steering committee, chaired by the Program Director or delegate, that meets at least twice a year. Committee membership shall include but not be limited to the program director and other faculty involved in medical physics education. The process for appointment of the members of the steering committee shall be documented. A pathway for expression of student concerns to the committee shall be available. Minutes of meetings shall be maintained.

2.7 The steering committee shall review the graduate educational program in its entirety at least annually, and initiate appropriate remedial action and improvement where needed through the process of Continuous Quality Improvement. Minutes of the program review, including the actions taken, shall be maintained.

2.8 A procedure shall be in place to appropriately counsel, censure and, after due process, dismiss students who fail to demonstrate appropriate learning ability, competence, or ethical behavior.

2.9 All courses and clinical practica should use well-defined and consistently applied metrics for evaluating student progress and performance.

2.10 *A graduate program with multiple tracks some of which are not part of the accredited program must clearly identify those students who are following the accredited program. The mechanism by which the program designates the graduates of the accredited track, e.g., an issued certificate of completion or a unique notation on the diploma, must be clearly stated on the program’s website.

2.11 A program must publicly describe the program and the achievements of its graduates and students, preferably through a publicly accessible web site. This information must be updated no less often than annually and must include, for each degree program (MS and/or PhD), the number of: applicants to the program, students offered admission, students matriculated, and graduates. Where possible, information on the destinations of graduates must also be provided, i.e., residencies, industry positions, etc.

3. Program Director

3.1 A single program director shall be responsible and accountable for ensuring that the graduate program satisfies CAMPEP standards and shall ensure that high quality education occurs in all courses and laboratory exercises.

3.2 *The program director must possess a PhD or other doctoral degree in medical physics or a closely-related discipline.

3.3 The program director should have at least five years of experience in medical physics.
3.3 The program director shall be responsible for coordinating the faculty, recruiting students into the program, advising the students, and evaluating and promoting the program.

3.4 The program director shall determine that each student offered entry into the graduate program satisfies the CAMPEP prerequisites for graduate education in medical physics or is offered rigorous remedial education to meet the prerequisites.

3.5 The program director shall ensure that all student statistics, annual reports, and other information that is required by CAMPEP are reported accurately and in a timely fashion.

3.6 The process for the appointment of the program director shall be documented.

4. Program Faculty

4.1 Adequate, qualified faculty shall be available with sufficient time for teaching and mentoring graduate students in medical physics.

4.2 The process for the appointment of the program faculty shall be documented.

4.3 Faculty members shall be engaged in scholarly activities including participation in scientific societies and meetings, scientific presentations and publications, and continuing education.

5. Institutional Support

5.1 The institution sponsoring the graduate program shall provide administrative support, including educational resources, budget, graduate office or cubicle space, conference room(s), audiovisual facilities, and office support (e.g., copiers, internet access, e mail accounts, telephone).

5.2 The institution must express its commitment to long-term financial and administrative support of the graduate program.

5.3 If there is any financial support of students, it shall be described clearly to the program’s applicants prior to their entry into the graduate program.

5.4 Entering students shall be oriented to the program to ensure their efficient and safe integration into the program.

5.5 The program shall instruct its students on the potential hazards that they might encounter and the appropriate measures for them to take to minimize risks to themselves and equipment.

5.6 The program shall instruct its students in patient privacy issues, professional and research ethics, and the regulations that are germane to medical physics research and clinical practice.

6. Educational Environment

6.1 A graduate program shall be situated in an environment that encourages open discussion and communication, and facilitates the exchange of knowledge, experience and ideas.

6.2 *Conferences and journal clubs should be used for students to practice their presentation and leadership skills.
6.3 Students shall have access to a variety of journals, books, and resource materials appropriate to medical physics, as well as to the internet and to a general scientific library.

6.4 *Students shall have access to clinical facilities appropriate for a medical physics graduate program. Procedures shall be in place to (1) allow the student reasonable access to clinical equipment, (2) provide students with sufficient training and technical support to ensure the safe and proper use of the equipment, and (3) ensure that the clinical use of that equipment is not compromised.

6.5 Students shall be provided with a mechanism for feedback concerning the quality of their instruction and the diligence of their teachers and mentors. The students shall be protected from repercussions if that mechanism is used. Feedback on individual courses and on the entire graduate program should be sought from the program’s graduates.

6.6 Issues and concerns that are identified in the feedback from graduates shall be evaluated by the steering committee, and remedial action shall be taken where appropriate.

7. Scholarly Activities

7.1 *Graduate students should be encouraged to engage in research projects, to develop a systematic approach to solving problems and to gain a familiarity with scientific method.

8. Core Graduate Curriculum

The structure of course work in a graduate education program in medical physics may be defined by the program but shall, as a minimum, include the topics listed below. These core topic courses will, for example, typically require about 18 semester credit hours or more. A typical university requires in excess of 30 credit hours of didactic courses to fulfill graduate degree (M.S., Ph.D.) requirements. Additional courses provided by the graduate program to fulfill these requirements may vary widely from program to program. For example some programs may require graduate level physics courses, while others may offer advanced courses in medical physics, statistics, or other allied topics. These additional courses may be required or elective at the discretion of the program.

8.1 Radiological physics and dosimetry

8.1.1 Atomic and nuclear structure
8.1.2 Classification of radiation
8.1.3 Quantities and units to describe radiation fields
8.1.4 Quantities and units to describe radiation interactions
8.1.5 Indirectly ionizing radiation: photons
  8.1.5.1 Exponential attenuation
  8.1.5.2 Photon interactions
8.1.6 Indirectly ionizing radiation: neutrons
  8.1.6.1 Neutron interactions
8.1.7 Directly ionizing radiation (electrons, protons, others)
  8.1.7.1 Interactions of directly ionizing radiation
8.1.8 Radioactive decay
8.1.9 Charged particle equilibrium
8.1.10 Radiation dosimetry – general
8.1.11 Radiation dosimetry – calorimetry
8.1.12 Radiation dosimetry – chemical
8.1.13 Cavity theory
8.1.14 Ionization chambers
   8.1.14.1 Calibration of photon and electron beams with ionization chambers
8.1.15 Dosimetry and phantoms for special beams
8.1.16 In vivo dosimetry (TLD, OSL)
8.1.17 Relative dosimetry methods
8.1.18 Neutron dosimetry
8.1.19 Pulse mode detectors

8.2 Radiation protection and safety
8.2.1 Introduction and historical perspective
8.2.2 Interaction physics applied to radiation protection
8.2.3 Protection principles (time, distance, shielding)
8.2.4 Handling radiation and radioactive sources
8.2.5 Radiation survey/contamination equipment
8.2.6 Personnel monitoring
8.2.7 Radiation dose limits
8.2.8 Protection regulations
8.2.9 Shielding Principles: beams and sources
8.2.10 Application of statistics
8.2.11 External exposure
8.2.12 Internal exposure
8.2.13 Environmental dispersion
8.2.14 Radioactive waste
8.2.15 Protection regulations

8.3 Fundamentals of medical imaging
8.3.1 History of medical imaging
8.3.2 Mathematical Models
8.3.3 Reconstruction mathematics
8.3.4 Radiography
   8.3.4.1 X-ray tube construction and X-Ray beam production; kV, mA, pulse width
   8.3.4.2 X-ray beam properties and interactions in matter
   8.3.4.3 Sources of image contrast and noise; detector efficiency and dose, noise power spectrum analysis
   8.3.4.4 Spatial and temporal resolution
8.3.4.5 Detector technologies and anti-scatter grids
8.3.4.6 Digital radiography and computed radiography
8.3.4.7 Mammography
8.3.4.8 Performance testing and equipment QA

8.3.5 Fluoroscopy
8.3.5.1 Detector technologies; Flat panel imager, image intensifier/TV
8.3.5.2 Radiographic contrast agents
8.3.5.3 Automatic exposure control and basic imaging modes
8.3.5.4 Digital angiography and digital subtraction angiography
8.3.5.5 Operating technique and dose to patient and staff
8.3.5.6 Performance testing and equipment QA

8.3.6 Computed tomography
8.3.6.1 Basic data acquisition principles and scanning modes
8.3.6.2 Basic reconstruction modes
8.3.6.3 In-plane spatial resolution, slice thickness, image noise, dose
8.3.6.4 Artifacts
8.3.6.5 Cone-beam computed tomography
8.3.6.6 Performance testing and equipment QA
8.3.6.7 CT scanning technique and patient dose

8.3.7 Nuclear medicine imaging
8.3.7.1 Modes and processes of radioactive decay
8.3.7.2 Basics of nuclear reactions and radioactivity
8.3.7.3 Nuclear counting statistics
8.3.7.4 Counting systems and gamma cameras
8.3.7.5 Image quality and reconstruction
8.3.7.6 Physics of SPECT and PET systems
8.3.7.7 Radiotracer techniques
8.3.7.8 Radiopharmaceutical design and mechanisms of localization
8.3.7.9 Performance testing and equipment QA

8.3.8 Magnetic resonance imaging
8.3.8.1 Magnetization, precession, Larmor equation, rotating frame of reference, spin tipping
8.3.8.2 T1 and T2 relaxation
8.3.8.3 Pulse sequences and image formation (slice selection, phase encoding, frequency encoding)
8.3.8.4 Spin echo image formation
8.3.8.5 Image contrast (proton density, T1, T2 and T2*)
8.3.8.6 Definition of common acquisition parameters (TE, TR, field of view, spatial resolution) and signal-to-noise ratio
8.3.8.7 Rapid imaging techniques (gradient echo, fast spin echo)
8.3.8.8 Magnetization preparation techniques (inversion recovery, saturation)
8.3.8.9   Artifacts
8.3.8.10  Performance testing and equipment QA
8.3.8.11  MR contrast agents
8.3.8.12  Safety and biological effects

8.3.9   Ultrasound
8.3.9.1   Propagation of ultrasound through tissue; sources of contrast
8.3.9.2   Diagnostic transducers, including materials and probe types
8.3.9.3   2-D, 3-D ultrasound imaging
8.3.9.4   Spatial and temporal resolution
8.3.9.5   Doppler and color flow imaging
8.3.9.6   Performance testing and equipment QA
8.3.9.7   Elasticity imaging methods
8.3.9.8   Artifacts
8.3.9.9   US contrast agents
8.3.9.10  Safety and biological effects

8.4   Radiobiology
8.4.1   History of radiation injuries in humans
8.4.2   Radiation interactions in cells/tissues
8.4.3   Radiation injury to DNA
8.4.4   Repair of DNA damage
8.4.5   Indirect effects of radiation
8.4.6   Chromosomal damage and repair
8.4.7   Target theory and cell survival curves
8.4.8   Free radical formation
8.4.9   Apoptosis, reproductive cell death
8.4.10  Cell kinetics
8.4.10.1  Cell recovery processes
8.4.10.2  Cell cycle sensitivity
8.4.11  Radioprotectors, radiosensitizers
8.4.12  RBE, OER, LET
8.4.13  Tissue injuries
8.4.13.1  Acute effects of radiation
8.4.13.2  Delayed effects of radiation
8.4.13.3  Radiation carcinogenesis
8.4.13.4  Radiation mutagenesis
8.4.13.5  Radiation teratogenesis
8.4.13.6  Other embryo/fetal effects
8.4.14  Risk estimates of radiation
8.4.15  History of linear no-threshold theory
8.4.16  Predictions of cancers in populations
8.4.17 Radiation epidemiology
8.4.18 Evidence of cancers in populations
8.4.19 Concept of radiation hormesis
8.4.20 Tumor radiobiology
8.4.21 Time, dose, fractionation
8.4.22 Molecular mechanisms
8.4.23 Drug/radiation interactions

8.5 Anatomy and physiology
  8.5.1 Anatomy nomenclature
  8.5.2 Pathology nomenclature
  8.5.3 Skin
  8.5.4 Skeleton/joints
  8.5.5 Muscles and ligaments
  8.5.6 Brain/CNS
  8.5.7 Autonomic nervous system
  8.5.8 Visual system
  8.5.9 Thorax
  8.5.10 Abdomen
  8.5.11 Pelvis
  8.5.12 Respiratory system
  8.5.13 Digestive system
  8.5.14 Urinary system
  8.5.15 Reproductive system
  8.5.16 Circulatory system
  8.5.17 Lymph system

8.6 Radiation therapy physics
  8.6.1 History of radiation oncology
  8.6.2 Principles of radiation oncology
  8.6.3 External beam treatments
    8.6.3.1 Sources of external beams
    8.6.3.2 Calibration of external beams
    8.6.3.3 Acquisition of external beam data
    8.6.3.4 Treatment planning principles
    8.6.3.5 Multifield radiation therapy
    8.6.3.6 IMRT, VMAT
    8.6.3.7 Image fusion, registration, segmentation, quantitation
    8.6.3.8 Motion management
    8.6.3.9 Performance testing and equipment QA
8.6.4 Brachytherapy
  8.6.4.1 Brachytherapy sources
  8.6.4.2 Storing and shielding brachytherapy sources
  8.6.4.3 Brachytherapy delivery devices
  8.6.4.4 Brachytherapy treatment planning principles
  8.6.4.5 Performance testing and equipment QA
8.6.5 Special techniques in radiotherapy
8.6.6 Radiation therapy with neutrons, protons, light ions
8.6.7 Radiation protection in radiation therapy

8.7 *Professionalism and Ethics

These topics should be introduced in graduate educational programs and taught in greater detail in resident educational programs. For persons entering a residency program through the alternate pathway, all aspects of the CAMPEP standards in professionalism and ethics must be taught during the residency program.

Professionalism
8.7.1 Definition of a profession and professionalism
8.7.2 Elements of a profession
8.7.3 Definition of a professional
8.7.4 Elements of professionalism (altruism, honesty, integrity, excellence, humanism, duty, accountability, respect for others)
8.7.5 How is professionalism judged?
8.7.6 Do’s and don’ts of professionalism
8.7.7 Physician’s charter and applicability to physicists

Leadership
8.7.8 Qualities of leaders
8.7.9 Rules of leadership
8.7.10 Causes of leadership failure

Ethics
8.7.11 Ethics of a profession
8.7.12 Ethics of an individual
8.7.13 Interactions with colleagues and co-workers
8.7.14 Interactions with patients and the public
8.7.15 Confidentiality
8.7.16 Peer review
8.7.17 Negotiation skills
8.7.18 Relationships with employers
8.7.19 Conflicts of interest (recognition and management)
8.7.20 Ethics in research (fabrication, fraudulence, plagiarism)
8.7.21 Use of animals in research
8.7.22 Use of humans in research
8.7.23 Relationships with vendors
8.7.24 Publication ethics