Professional Science Master’s Program in Medical Dosimetry

*Department of Physics*

*College of Science & Technology*

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Steering Committee:

The program Steering Committee includes faculty from the department of Physics at Temple University. The Steering Committee members are responsible for developing and administering the program, in consultation with the respective departments, the College of Science and Technology, and the Graduate School. The Steering Committee will form and work with a Scientific Advisory Committee made up of partners from the Radiation Oncology departments at Temple University Hospital and Fox Chase Cancer Center as well as other local industries, hospitals and research centers.

- Prof. Jim Napolitano, PhD, Department of Physics, CST, Temple University
- Prof. Athanasia Polychronopoulou, MSc, Department of Physics/CIS, CST, Temple University
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External Advisory Committee:

- Dr. C-M Charlie Ma, Professor, Vice Chairman, Department of Radiation Oncology, Director, Radiation Physics, Fox Chase Cancer Center
- Dr. Cynthia Keppel, Partner, K&N Physics Consulting
- Dr. Yan Chen, Medical Marketing Director, Clinical Application Research and Support Leader, Elekta Instrument Limited (Yan.Chen@Elekta.com)
- Dr. James E. McDonough, Associate Professor of Clinical Radiation Oncology, Department of Radiation Oncology, Hospital of University of Pennsylvania
- Dr. Ying Xiao, Professor of Radiation Oncology, Department of Radiation Oncology, Hospital of University of Pennsylvania
Executive Summary

Medical dosimetry, as part of radiation oncology is a continuously growing and rapidly evolving field. The Qualified Medical Dosimetrist (QMD) is an individual who has the knowledge and skills to work closely with a Radiation Oncologist and a Qualified Medical Physicist in order to perform the necessary medical dosimetry procedures. QMD's use their knowledge of physics, anatomy, and radiobiology to develop an optimal arrangement of radiation portals to spare normal and radiosensitive tissues while applying a prescribed dose to the targeted disease volume. These individuals may practice independently and use critical thinking and problem solving skills while exercising discretion and professionalism.

The Professional Science Master’s (PSM) in Medical Dosimetry program at Temple University will provide the necessary training for students who complete the program to assume high level technical staff positions in both industrial and academic settings. The PSM-Medical Dosimetry program will emphasize both practical and clinical skills at an advanced level to enable graduates to find rewarding careers with competitive salaries at major medical centers.

To add value to the PSM-Medical Dosimetry program, an external advisory board will be constituted with experts in the field of Medical Dosimetry representing industry, academia, and other research institutions in the Greater Philadelphia and Delaware Valley region. An independent internship program (Capstone) will be an integral part of the training of PSM candidates. The Capstone will provide valuable experience outside the classroom for our PSM students, and will cover real world problems commonly experienced in the field.

Professional Science Masters (PSM)

This degree will be recognized as a Professional Science Master’s degree in Medical Dosimetry. The primary objective of a typical PSM program is to develop a portfolio of knowledge and experiences for each student that will enable them to tackle the problems encountered during their career. In medical dosimetry such problems are related with both the design and implementation of complex procedures of oncology treatment. Therefore, the complex nature of a medical dosimetrist career, impels program objectives that include: (a) providing a foundation
for understanding the major theoretical and applied concepts in medical dosimetry, (b) offer a range of practical skills, (c) offer advanced clinical experience, and (d) provide business and work skills applicable to both academia and industry. The final goal of this program is the successful placement of graduates into reputable jobs so that they achieve career advancement.

Program Rationale

The complex nature of the cancer disease process involves multiple treatment modalities with surgery, medical oncology and radiation oncology among the most common. Depending on the location, pathology and stage of disease, these methods may be used individually, concurrently or sequentially. Radiation Oncology employs ionizing radiation to not only destroy cancerous tumors while sparing surrounding tissue, but is also utilized to treat specific benign conditions. An interdisciplinary team of radiation oncologists, radiation oncology medical physicists, medical dosimetrists, radiation therapists, nurses, and support staff plan and deliver the course of treatment. While each team member plays a critical role in the delivery of health services, it is the medical dosimetrist who performs, assists, or directs the dosimetric treatment planning process as designated by the radiation oncologist or the qualified medical physicist.

This program of the Physics department at Temple University will provide graduates with the necessary knowledge base and clinical experience to accurately generate radiation dose distributions and dose calculations and embark on successful careers. The curriculum is designed for students with a BA or BS degree in science, technology, engineering and mathematics (STEM), or related fields. Elective courses will serve to strengthen student expertise and the clinical hours will provide the students with the necessary experience not only on treatment design but also on professional issues related with patient care and support.

The PSM in Medical Dosimetry program will be fully accredited through the Joint Review Committee on Education in Radiologic Technology (JRCERT). Furthermore the program will meet all the formal education eligibility criteria for the national certification exam, as they are set by the Medical Dosimetry Certification Board, following graduation. Therefore it will provide the students with the opportunity to become board certified members of the medical dosimetry domain.

Potential Student Pool

Our pool of students is expected to be diverse, consisting of domestic and foreign applicants, and will include individuals seeking a career in Medical Dosimetry. They will be students with undergraduate degrees in science, technology, engineering and mathematics (STEM), or related fields. Furthermore the students could also be individuals who are currently Certified
Medical Dosimetrists with a Baccalaureate degree and who want to pursue higher education and research experience. Admittance will be based on evidence of a strong academic record and preparation in the sciences, as well as a demonstrated strong desire to fully engage in the field of medical dosimetry.

**Demand for Professional Science Masters (PSM) Degree in Medical Dosimetry**

According to the January 2013 American Association of Medical Dosimetrists (AAMD) report, that was based on 2010 data, the average salary of the medical dosimetrists is slightly over 100K. Similar numbers are reported in online media such as salary.com. In spite of the increased average salary there is a continuous nation-wide shortage of medical dosimetrists (AAMD official reports). The 2011 workforce data estimated 3,460 medical dosimetrists working in the United States. The same study indicated that medical dosimetrists that work at understaffed facilities cover approximately 20% more patients per medical dosimetrist than those who work at facilities that are adequately staffed. The AAMD Workforce Report of 2008 indicated that since 2006 the percentage of facilities that are understaffed had remained a constant 39%.

Effective for 2017, all United States candidates for medical dosimetry certification will be required to have a Bachelor's Degree and have graduated from a formal dosimetry program accredited by JRCERT. However according to JRCERT official data, currently the number of accredited programs in the country is 17, out of which the Thomas Jefferson University - Medical Dosimetry program is the only one located in Pennsylvania. This program however offers only a Bachelor of Radiologic Science degree. There are in total three accredited programs that offer Master of Science degree: Southern Illinois University Carbondale - Medical Dosimetry, University of Oklahoma Health Sciences Center - Medical Dosimetry and University of Wisconsin-LaCrosse - Medical Dosimetry. In addition to the already accredited programs there are three more programs with a pending accreditation application. Out of those three programs, two will be offering Master’s degree, the Grand Valley State University and the Radiological Technologies University VT.

The existing programs are not able to cover the high demand for medical dosimetry professionals. Official JRCERT reports for 2010 indicated that, the 15 programs that were accredited at this point, had a student capacity of 130 students. The competition for student acceptance into JRCERT accredited medical dosimetry programs was already high with 2009 data reporting a program with 99 applicants for 16 possible positions.

**Administrative Structure**
• The Department of Physics will be the program home department. The Steering Committee is responsible for oversight of the program and for communicating and coordinating with all the involved institutions and departments to implement the curriculum.
• The Steering Committee is also responsible for oversight of all the necessary steps for the accreditation of the medical dosimetry PSM.
• The Graduate Committee of the Physics Department will oversee the admissions process and will be monitoring and reporting of student progress.
• The Program Co-Directors will be appointed from the ranks of the Physics and Radiation Oncology Departments of Temple University
• As required for a PSM degree program, an External Advisory Board will be formed that will include appropriate individuals from local industries and research centers, including hospitals.

Program Curriculum/Degree Requirements

PSM degrees were developed following an increasing demand by business and industry for degrees that are able to produce competent employees who bring both scientific knowledge and professional skills. The PSM degree’s innovative curriculum is based on a solid core of science courses coupled with a series of courses and projects that allow the development of communication and business skills.

The PSM-Medical Dosimetry program is expected to train students in a highly technical area and this goal will be achieved by a core of required courses that will cover the topics listed in the table below. Further specialization will be acquired via the medical dosimetry laboratory, the clinical hours and elective courses in various sub-disciplines.

The PSM-Medical Dosimetry program will handle the professional skills element, in part by requiring the clinical hours and also by requiring a course in Professional Ethics, as well as by incorporating a Capstone project in the curriculum. The course will address the social, legal, and privacy concerns that professional medical dosimetrists encounter and will help the students prepare on issues such as: Oncology patient care, body image and emotions in illness and treatment. The capstone project will provide them valuable experience on treatment planning of actual patients in a professional clinical environment.

Finally the design of the curriculum of the PSM-Medical Dosimetry is completely aligned with the Medical Dosimetry Certification Board exam, allowing the students to start their professional careers shortly after graduation from the program.
Course Schedule

The following table summarizes the core courses, their credit hours and the schedule for each of the semesters:

<table>
<thead>
<tr>
<th>Year 1 Fall</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 5312 - Biostatistics</td>
<td>3 cr</td>
</tr>
<tr>
<td>SCTC XXXX - Physics of Medical Imaging I</td>
<td>3 cr</td>
</tr>
<tr>
<td>OTHR 5007 - Human Anatomy</td>
<td>3 cr</td>
</tr>
<tr>
<td>SCTC 5XXX Medical Dosimetry – Clinical hours I</td>
<td>1 cr</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>10</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year 1 Spring</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SCTC 5XXX Medical Dosimetry I</td>
<td>3 cr</td>
</tr>
<tr>
<td>SCTC XXXX Physics of Medical Imaging II</td>
<td>3 cr</td>
</tr>
<tr>
<td>PHYS 5XXX Ionizing Radiation on living systems</td>
<td>3 cr</td>
</tr>
<tr>
<td>SCTC 5XXX Medical Dosimetry – Clinical hours II</td>
<td>1 cr</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>10</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year 2 Fall</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PHIL 5249 - Ethics in Medicine or LGLS 5614 - Ethics in Healthcare</td>
<td>3 cr</td>
</tr>
<tr>
<td>SCTC 5XXX Medical Dosimetry II</td>
<td>3 cr</td>
</tr>
<tr>
<td>1 Elective</td>
<td>3 cr</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>9</strong></td>
</tr>
</tbody>
</table>
Course Descriptions

Core Courses Year 1 – Fall:

**BIOL 5312 - Biostatistics**: Biostatistics is an important part of the research activities related to biological and medical issues. Statistics is used to analyze phenomena with random properties and is often essential to draw the right conclusions based on a data set. The course will be designed to cover different statistical methods for data analysis mainly applied to medical and biological problems. Advanced undergraduate and graduate students with interests in medicine and biomedical research will benefit most from the course. However statistical methods that can be applied to behavioral science and ecology will also be covered.

Other relevant courses: STAT 5002 - Intro to Biostatistics, STAT 5002 - Intro to Biostatistics

**SCTC XXXX - Physics of Medical Imaging I**: This will be the first of a series of two courses that will be based on the current SCTC2101 and will be focused on physics principles and their use in medical imaging. This first course will be primarily focused on the physics principles that are involved with all the applications of physics in medicine. Examples include optics, lasers, interaction of radiation with matter, radiation detection and radioactivity.

**OTH 5007 or MEDS 5007 - Human Anatomy**: This is an existing course offered by the Department of CPH: Rehabilitation Sciences. It offers a regional study of the gross structure of the human body covering the back, upper and lower limbs, head, neck, thorax, abdomen, and pelvis. Emphasis is on structure, function and basic development of the skeletal, muscular, cardiovascular, respiratory, and peripheral nervous systems. Material is presented and discussed in a classroom setting (lecture), and cadaver dissection and anatomical identification is performed during laboratory.

**SCTC 5XXX Medical Dosimetry I – Clinical**: The purpose of the clinical assignment is to correlate didactic knowledge with practical skills. The students will be assigned to a clinical site at Fox Chase Cancer Center, Temple University Hospital or any other collaborative site. All
students must attend a minimum number of clinical training hours. This clinical practical will allow the students to familiarize with safe clinical practices and policies and also professional behavior.

While in the clinical setting students will observe and work directly with a medical dosimetrist. They will be closely cooperating with the rest of the radiation treatment team, the radiation oncologist and the medical physicist. Emphasis is given on learning and understanding the role and responsibilities of a medical dosimetrist in the clinical setting.

This is the first course of a two course sequence. During the two course sequence, students will complete practical training in a broad range of medical dosimetry aspects such as Brachytherapy, Simulation, Gamma Knife, Proton Therapy, Medical Physics, Special Measurements and Quality Assurance. In this first course emphasis is given on physics and radiation safety in the clinical environment, and computers and networking within the radiation oncology field. Students will begin basic calculations and treatment planning while being introduced to brachytherapy procedures.

Core Courses Year 1 – Spring:

SCTC 5XXX - Medical Dosimetry I: In this course the students should become familiar with treatment planning principles for the most common cases of cancer patients. Techniques of simulation of treatment set-ups are reviewed and advanced methods of virtual simulation are explored.

The course is accompanied by a laboratory giving students the opportunity to practice the material. The laboratory sections will be designed to accompany the corresponding lectures and will allow the students to gain hands on experience on treatment planning and simulation problems, while using the state of the art software currently used in clinical facilities.
Prerequisite: A grade of “B” or better in OTHR 5007 or MEDS 5007 - Human Anatomy.

SCTC XXXX - Physics of Medical Imaging II: This will be the second of a series of two courses that will be based on the current SCTC2101 and will be focused This course will be based on SCTC2101 and will be focused on physics principles and their use in medical imaging. This second course reviews the production of medical images with radiographic equipment as well as ultrasound, MRI and nuclear medicine scans. Additional fundamental principles of physics important to the production and use of radiation for treatment and diagnostic purposes are reviewed. More detailed radiation detection methods, focused on dose measurement, utilizing a variety of methods, are discussed along with the appropriate instrumentation.
More specialized topics of Radiation Safety and Radiation Protection in Diagnostic Radiology will be covered in association with The Environmental Health and Radiation Safety Department of Temple University.
Prerequisite: A grade of “B” or better in SCTC XXXX – Physics of Medical Imaging I
SCTC 5XXX - Medical Dosimetry Clinical - II: In this second course, of the two course sequence, students continue to gain clinical experience at an affiliated clinical internship site. Emphasis is now given on more advanced treatment planning, Brachytherapy procedures, Proton therapy, advanced simulation studies and anatomical contour segmentation. In parallel students continue to learn the various concepts of clinical oncology specific to patient treatments.  
Prerequisite: A grade of “B” or better in Medical Dosimetry Clinical – I

PHYS 5XXX – Ionizing Radiation on Living Systems: This course will include topics related to the study of the action of ionizing radiation on living things and more specifically the human body. Some of the topics covered are: Cellular response to radiation, Radiation carcinogenesis, Radiation effects on the developing embryo and fetus, Whole-body radiation effects. Additional emphasis is given in the effect of ionizing radiation in the context of radiation treatments and in particular on factors affecting the therapeutic ratio.  
Prerequisite: A grade of “B” or better in Medical Dosimetry – I and Physics of Medical Imaging

Core Courses Year II - Fall

SCTC XXXX - Medical Dosimetry II: This course will continue building upon the material introduced during Medical Dosimetry – I. More details are discussed about the factors that affect dose delivered in radiation treatments and how these factors are accounted for in dose calculations. Methods of treatment planning techniques for various diseases using single and multiple field arrangements using photons and electrons are discussed. Advanced treatment planning techniques of conformal radiation therapy including 3D treatment planning, IMRT, IGRT, Gating, Protons, and Stereotactic are also discussed. The use of Brachytherapy in radiation therapy is addressed. Characteristics of sources utilized for treatment as well as determination of source activity and dose delivered are included. Methods and instruments utilized to apply Brachytherapy treatment planning techniques to clinical treatment situations are discussed. Finally, the Ethical Standards and procedures that have been set by the Medical Dosimetrist Certification Board (“the MDCB”) must also be discussed.

The course is accompanied by a laboratory giving students the opportunity to practice the material. The laboratory sections will be designed to accompany the corresponding lectures and will allow the students to gain hands on experience on advanced treatment planning problems, while using the state of the art software currently used in clinical facilities.

Prerequisite: A grade of “B” or better in Medical Dosimetry – I.

PHIL 5249 - Ethics in Medicine: Exploration of ethical issues generated by the application of scientific and technological advances to the preservation, destruction, and programming of human life. Topics may include: ethics of medical research, abortion, euthanasia, behavior control, allocation of scarce medical resources, and the ethics of patient-physician interaction.
OR:
**LGLS 5614 - Ethics in Healthcare:** This course explores the ethical issues in the healthcare industry. The nature of the doctor-patient relationship in healthcare creates unique ethical issues. Students will learn how to recognize and confront these ethical issues. Through an open discussion and analysis of current events, students will explore the delicate balance between the patient’s interests and the business decisions facing modern healthcare providers.

**Core Courses Year II - Spring**

**Capstone Project:** A key component of PSM programs is a capstone project that will provide students with experience in applied medical dosimetry. For each student, the Capstone internship will be supervised and mentored by a medical dosimetry professional or research scientist. The Capstone may be conducted with a Temple University scientist, a scientist from Fox Chase Cancer Center or Temple University Hospital or with someone else, as approved by the Steering Committee. Co-advising is encouraged.

The Capstone project requires a total of one credit. During the first part of the Capstone (fall semester of second year), a student will identify or be assigned a mentor and begin the project. The majority of the actual work for the project will be conducted in the second semester of the second year. This project-based approach will enhance interdisciplinary learning and workplace skills, while requiring that students put their technical knowledge into practice.

This level one fieldwork experience is an opportunity to demonstrate the practice of medical dosimetry in the clinical environment at a basic level. The course provides an opportunity to integrate the didactic curriculum learned for the successful completion of the MDCB exam.

**Prerequisites:** The Capstone Research Experience is a culminating course of the PSM program, open only to PSM students with a minimum GPA of 3.0 who have taken all of the core courses (unless waivered) of the program.

**Elective Courses**

The curriculum is designed so that the elective courses are in the second year. Students may choose to take any of the elective courses offered:

**PHYS 5502 - Mathematical Physics II:** Preliminaries; numerical applicability, survey of algorithms, computer modeling, programming considerations; basic numerical methods; numerical linear algebra; numerical solution to ordinary and partial differential equations; molecular dynamics; Monte Carlo simulations; nonlinear methods.
PHYS 4702 - Introduction of Atomic, Nuclear, and Particle Physics: Properties atomic structure, atomic spectra, selection rules, atoms in electric and magnetic fields; nuclear properties, radioactive decays, nuclear reactions, fission and fusion, and fundamental properties of elementary particles and their interactions.

BIOL 5227 - Biomarkers and Biotargets: This course focuses on the evolution of biomarker and biotarget research, with emphasis on biomarker validation and biotarget druggability. The students will analyze real-life examples of biomarkers and biotargets in medicine, drug development, and environmental science. The formation of therapeutic target databases and development of multi-target agents will be critically evaluated.

BIOL 5479 - Biotechnology: This course is designed to survey current issues in technologies including therapeutics and diagnostics, and to examine consequences of developments in this area. The course is designed in a Problem Based Learning format, where students research critical areas and provide oral and written reports for other members in the class. The course is organized by topics including Concepts in Genetics, Cloning and Ethics, Gene Therapy, Prenatal Diagnosis, Gene Therapy for Cancer, Cell Replacement Therapy, Genomics and Proteomics, Vaccines, Forensics, Plant Biotechnology, and Instrumentation. At the end of the course, each student makes a formal presentation on a specific advance in biotechnology.

CIS 9664 - Knowledge Discovery and Data Mining: Basic concepts and techniques for the automated extraction of interesting patterns in large databases. Topics covered include: association-rule mining, sequence mining, web and text mining, data warehousing, information filtering, classification and clustering analysis, Bayesian and neural networks, classification and regression trees, hypotheses evaluation, feature extraction, dimensionality reduction, singular value decomposition, data compression and reconstruction, visualization of large data sets, fractals in databases, and indexing methods that support efficient data mining and queries by content. Special emphasis is given in multimedia, business, scientific, and medical databases.

CIS 9601 - Computer Graphics and Image Processing: An analysis of techniques used in computer manipulation of two- and three-dimensional images. Although elements of computer graphics are covered (e.g., two- and three-dimensional transforms), the main focus is on image processing techniques. We will also gain insight into basic techniques in computer vision. Topics covered include image filters, image segmentation, similarity of images, object detection, object recognition, and shape representation and similarity. Nowadays it is an easy task to transfer visual input of a camera to a computer's memory. However, image and video understanding belong still to unsolved problems of computer science. The main objective of the course is to convey basic intuitions behind the unsolved and solved problems and to introduce some of the techniques that provided solutions to some of the problems.
Program Outcomes

The PSM curriculum is designed to prepare individuals to work in the care of cancer patients as medical dosimetrist. It provides all the necessary knowledge that will enable the students to become members of a radiation oncology team. The curriculum content includes specific coursework to provide both classroom and direct clinical experience. It is designed to train the student in the theoretical fundamentals of medical dosimetry and also in the use of current technology, tools and techniques. Students will participate in studies related to the role of the medical dosimetrist and professional ethics, radiation oncology anatomy, treatment planning, dose calculations, clinical oncology, brachytherapy, dosimetry physics, radiation protection, quality assurance and computer applications. Graduates of the program will be able to obtain employment as a medical dosimetrist and apply to the Medical Dosimetrist Certification Board (MDCB) to sit for a national certification.

As a PSM program, the curriculum does not require a research thesis, and accordingly the training emphasis will not be to prepare graduates for careers as principal scientists. However graduates will be trained to work as part of research teams and to have sufficient breadth and depth to work as critical problem solvers in the research enterprise. Furthermore they will be able to read scientific papers across a diversity of medical dosimetry related topics and to communicate effectively with the rest of the radiation oncology team.

Program Resources, Estimated Costs, and Revenue Stream

Available Resources

**Faculty:** Course instructors will include faculty from the Department of Physics and the Radiation Oncology departments at Temple University Hospital. Arrangements will be made with each department to determine appropriate teaching load and credit for teaching effort. Additionally one new adjunct faculty position will be filled to cover the needs for the development and teaching of the medical dosimetry classes and labs.

**Instructional, Clinical and Research Space:** The new SERC building has multiple smart instructional classrooms that would be adequate for the program. A new lab classroom will be developed within the physics department to cover the needs of the Medical Dosimetry laboratory courses, as they require access to specialized hardware and software. The Tech
Center also holds multiple rooms ideal for this program, and in particular, student-led group assignments. The students will be assigned to a clinical site at Fox Chase Cancer Center or Temple University Hospital. The corresponding site will provide all the necessary space and equipment that will enable the students to complete the required number of clinical training hours.

**Costs and Budget**

The program is anticipated to be self-sufficient once an average of ten students yearly are enrolled. The program will require an initial, one-time outlay of resources and there will also be recurrent costs. The recurring costs will be paid for by tuition revenue. 

One time (initial) Costs:

1. Web page development and maintenance $ 800
2. One adjunct medical dosimetry instructor $ 8,000
3. JRCERT Accreditation cost $ 5,000

**Estimated total initial costs:** $ 13,800

**Recurring Costs**

1. Instructional costs (for lecture courses and computer labs) $ 10,000
2. Consumables (office supplies, equipment repair and upgrade) $ 15,000

**Estimated recurring costs:** $ 25,000

**Program Revenue**

Tuition represents the main revenue stream. A first estimation of the tuition revenue can be based on the assumption that 10 students will be admitted each year. Assuming that all the admitted students are Pennsylvania residents and that the tuition rate of the PSM will follow the tuition rate of CST graduate programs, we can estimate a revenue of $967/cr per student. In this case the total revenue from each student will be $29,010 leading approximately to an average two - yearly revenue of $290,000.

More detailed calculations can indicate the anticipated yearly revenue for the first two years:

Year 1 total: $193,400
10 newly admitted students completing 20 cr each
Year 2 total: $290,100
10 newly admitted students completing 20 cr each: $193,400
10 admitted students completing 10 cr each: $96,700

Notice that the above calculations do not include any increase in the tuition rates (a typical estimation for this increase is 3%). Also notice that the above numbers can increase significantly if we include out-of-state rates, which for CST graduate programs are $1,282 for 2015-1016 (Temple University Bursar’s office).

APPENDIX A
MDCB EXAMINATION DESIGN

The Medical Dosimetry Certification Board offers the certification examination to professionals in the field of Medical Dosimetry. The examination contains 155 questions and the time allowed for completion is 3 hours and 50 minutes. The test content as published by MDCB is outlined and it identifies the areas that will be included in the exam. We additionally report the corresponding core course of the PSM – Medical Dosimetry that will each of the areas. Finally the percentage of scored questions in each of the major categories is also shown below.

The following area will be covered by the two courses of Medical Imaging Physics:

<table>
<thead>
<tr>
<th>I. RADIATION PHYSICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Radioactivity</td>
</tr>
<tr>
<td>B. Production of X rays and particle beams</td>
</tr>
<tr>
<td>C. Characteristics of X rays and particle beams</td>
</tr>
<tr>
<td>D. Interaction of radiation with matter</td>
</tr>
<tr>
<td>E. Treatment machine characteristics (e.g., linear accelerator, cobalt 60, orthovoltage, superficial X-rays)</td>
</tr>
<tr>
<td>F. Radiation measurement</td>
</tr>
<tr>
<td>G. Imaging modalities (e.g., MRI, PET, CT, ultrasound, SPECT, KV/MV, CBCT)</td>
</tr>
<tr>
<td>H. Hounsfield unit conversion to CT density table in treatment planning systems</td>
</tr>
<tr>
<td>I. Radiation units (e.g., activity, exposure, absorbed dose, and dose equivalent)</td>
</tr>
<tr>
<td>J. Beam energy profiles</td>
</tr>
</tbody>
</table>
The following area will be covered by Medical Imaging Physics II and Medical Dosimetry I and II:

<table>
<thead>
<tr>
<th>II. LOCALIZATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Acquisition of patient data</td>
</tr>
<tr>
<td>B. Patient positioning</td>
</tr>
<tr>
<td>C. Patient immobilization techniques</td>
</tr>
<tr>
<td>D. Site-specific organ motion (e.g., bladder extension, respiratory motion)</td>
</tr>
<tr>
<td>E. Ancillary treatment devices (e.g., breast board, bite block)</td>
</tr>
<tr>
<td>F. Treatment simulations (e.g., conventional simulations, CT simulations, PET-CT, 4DCT, MRI)</td>
</tr>
<tr>
<td>G. Digitally reconstructed radiograph (DRR/DCR)</td>
</tr>
<tr>
<td>H. Image registration (image fusion)</td>
</tr>
<tr>
<td>I. IGRT (e.g., CBCT, ultrasound guidance, KV-KV, MV-MV, infrared, fluoroscopy, CT on rails, fiducials)</td>
</tr>
</tbody>
</table>

The following three areas will be covered by Medical Dosimetry I and II:

<table>
<thead>
<tr>
<th>III. TREATMENT PLANNING</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Isodose curve parameters</td>
</tr>
<tr>
<td>B. Isodose distributions</td>
</tr>
<tr>
<td>C. Particle beam dose distributions</td>
</tr>
<tr>
<td>D. Site-specific clinical oncology (e.g., disease, anatomy, modes of spread, common treatment techniques, dose and fractionation schemes)</td>
</tr>
<tr>
<td>E. Radiobiology (e.g., dose tolerances, hypofractionation, time dose fractionation (tDF) calculation, biologic modeling)</td>
</tr>
<tr>
<td>F. Dose volume histograms (DVH) (e.g., differential, cumulative)</td>
</tr>
<tr>
<td>G. Cross-sectional anatomy</td>
</tr>
<tr>
<td>H. Treatment machine limitations</td>
</tr>
<tr>
<td>I. Special procedures (e.g., TBI, TSE/TBE, IORT, SRS, SBRT)</td>
</tr>
<tr>
<td>J. Algorithms (e.g., treatment planning software, calculation)</td>
</tr>
<tr>
<td>K. Planning methodologies (e.g., forward, inverse, compensator, IMRT)</td>
</tr>
<tr>
<td>L. Data importing, exporting, and networking (e.g., DICOM, IP address, FTP)</td>
</tr>
<tr>
<td>M. Computer systems management (e.g., archiving and backup, routine maintenance)</td>
</tr>
<tr>
<td>N. Standard Precautions</td>
</tr>
</tbody>
</table>
The following area will be covered during the lab sessions of Medical Dosimetry I and II and also in the PHIL 5249 - Ethics in Medicine or LGLS 5614 - Ethics in Healthcare.
The material mentioned above is available online via MDCB at: