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CROSS-DISCIPLINARY CURRICULUM IN MEDICAL PHYSICS AND NANOMEDICINE FOR STEM UNDERGRADUATE STUDENTS

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Cross-Disciplinary Curriculum in Medical Physics and Nanomedicine for STEM Undergraduate Students

Synopsis:

We propose to enrich STEM education of undergraduates by developing a highly innovative interdisciplinary program to train STEM students in a multidisciplinary environment of medical physics and nanomedicine; to teach the latest scientific breakthroughs in nanotechnology and build the bridge between nanoscience, medicine and treatment of disease.

Cross-Disciplinary Curriculum in Medical Physics and Nanomedicine for STEM Undergraduate Students

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Abstract

With the rapid and constant evolution of science and technology in the 21st Century, in particular in the areas of Medical Physics and Nanomedicine, we propose to develop an educational program for STEM students devoted solely to these disciplines. We propose to enrich STEM education of undergraduates by developing a highly innovative interdisciplinary program to train STEM students in a multidisciplinary environment of medical physics and nanomedicine; to teach the latest scientific breakthroughs in nanotechnology and build the bridge between nanoscience, medicine and treatment of disease. This innovative program will offer to undergraduate students both course work and intensive research experiences to better prepare them to lead the discovery of superior diagnostic techniques and treatment of disease.

Introduction

Proposed program addresses **a challenge** of cross science training of STEM undergraduate students in health-related sciences such as medical physics and nanomedicine. A demand for medical physicists and nanomedicine experts exists in the country. To address this challenge in medical physics and nanomedicine education we propose to introduce the professions of medical physics and nanomedicine at the junior level of the Bachelors in Engineering and Science Programs.

Program goals are: (1) increase educational, research and training opportunities for undergraduate students at the crossroads of mathematics, physics, optics, biology and medicine; (2) provide more career choices and job opportunities for STEM students in interdisciplinary field of medical physics; (3) offer a research experience for STEM undergraduate students in multidisciplinary area of medical physics and nanomedicine.

Career Opportunities. Students graduating from this program will have the knowledge to be accepted into a graduate program in Medical Physics, Medical Biophysics, Health Physics, Radiation Dosimetry, Nanomedicine, Nuclear Medicine, Biophysics or Physics.

Key activities will consist of developing new (1) curriculum, (2) lectures, (3) laboratory, (4) computer practicum, (5) video teaching materials, and (6) research in nanomedicine, which will offer students both coursework and intensive hands-on experiences.

Curriculum

The medical physics and nanomedicine program at the undergraduate level can be created on the basis of the courses are already offered at the Institution. It can be developed first as a minor program and then it can be grown to the degree program. Below we are giving an example of the curriculum for the minor program in medical physics and nanomedicine, which will be offered at the Rose-Hulman Instituite of Technology for the undergraduate STEM students in Fall 2017. The proposed minor program consists of 20 credit hours of study including 12 credit hours of the required courses and 8 credit hours of elective courses.

Required Courses

Courses	Course Title		Hours
1. PH 302	Biophysics	(proposal to offer in Fall)	4
or BE 201	Biomedical Instrumentation and Measurements		
2. BE 435/OE 435	Biomedical Optics	(offered in Winter)	4
or ECE 584	Medical Imaging Systems		
3. EP 450	Nanomedicine	(offered in Spring)	4

Plus 8 hours of elective courses:

Proposed List of Courses (not limited and open for student’s choice/suggestion of courses followed by program adviser’s approval)

BE 201	Biomedical Instrumentation and Measurements	4
BIO 230	Cell Biology	4
BIO 451	Cancer Biology	2
PH 265	Fundamentals of Nuclear Physics and Radiation	4
EP 280	Introduction to Nano-engineering	4
PH 302	Biophysics	4
EP 380	Nanotechnology, Entrepreneurship and Ethics	4
PH 470	Introduction to Physics of Medical Imaging	2
BE 435/OE 435	Biomedical Optics	4
MA 482	Bioengineering Statistics	4
ECE 584	Medical Imaging Systems	4
ECE 480/OE 437	Introduction to Image Processing	4
CHEM 330	Biochemistry I	4
CHEM 331	Biochemistry II	4
CHEM 532	Biochemical Pharmacology	4

Short Descriptions of Core Courses

PH 302 Biophysics

Biological examples of the interaction of radiation and matter; medical uses of x-rays, nuclear medicine, magnetic resonance imaging, and current applications in biophysics.

BE/OE 435 Biomedical Optics

Optical techniques for biomedical applications and health care; imaging modalities; laser fundamentals, laser interaction with biological cells, organelles and nanostructures; laser diagnostics and therapy, laser surgery; microscopes; optics-based clinical applications; imaging and spectroscopy; biophotonics. Cross-listed with BE 435.

EP 450 Nanomedicine

Material presented includes the functions and properties of medical nanodevices, the design and fabrication of nanorobots and nanoparticles, the current and potential applications of nanomedicine. Introduction to cancer cell biology and techniques for selective targeting of cancer cells, simulations of the optical and thermal properties of normal and cancerous cell organelles. Nanoplasmonics: Lorentz-Mie simulations of optical properties of nanoparticles, the use of plasmonic nanoparticles in diagnosis and therapy. Introduction to the nanophotodynamic therapies and the new dynamic modes in selective nanophotothermolysis of cancer, the design and methods of activation of nanodrugs. Time and space evolutions of thermal fields in and around the nano-bio-particles and nanoclusters. Ablation of the soft and hard biological tissues by activated nanoparticles.

Conclusions

Program value: The training of professionals and contributing to this technological field of medical physics and nanomedicine requires multidisciplinary education. The proposed program lies at the vanguard and intersection of (1) interdisciplinary teaching/learning and (2) research and capitalizes on the ways in which (1) and (2) effectively reinforce each other to provide the very best and rewarding educational experience for students.

Benefits of this program goes to students, healthcare providers, pharmaceutical companies, academia and society in general. A job market and demand in the medical physics and nanomedicine are strong. The educational institutions have to address this demand and prepare our STEM undergraduate students to be successful in the multi-disciplinary environment of modern engineering.