Special topics course 497B: Modern Physics in Medicine

Spring 2012, 3 credit course

Evaluation:

homeworks, two exams (each consisting of two parts), and a course project.

INSTRUCTOR: Prof. Mark Strikman

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Poster for the course:
www.phys.psu.edu/~strikman/poster/poster497.pdf

Location & Times: 115 Osmond, Tuesday and Thursday 11:15 - 12:30 p.m.

Office hours: any time I am in the office or by appointment

Objectives

Modern physics tools are used now in numerous medical diagnostic methods, for various treatments of tumors and so on.

The course will cover various aspects of modern physics dealing with propagation of particles - photons, electrons, protons, neutrons, nuclei,
through matter, and methods use for generation of these particles. Properties of atoms and nuclei which are relevant for medicine will be reviewed as well.

This would allow the students to understand the physics underlying the medical application of modern physics rather than perceiving tools, which in fact use physics as, instead, using some kind of inexplicable magic.

Explanation of particular physical phenomena will be followed by descriptions of the applications of these phenomena in medicine. This will allow students who previously had a limited exposure to physics to follow the lectures on a practical level.

This course is self-contained and will provide necessary physics (mostly nuclear physics) information at a level accessible to students that have completed Phys 250-251 or Phys 211, 212, 213, 214; only rudimentary knowledge of calculus will be necessary.

TEXT:

There are no textbooks which exactly cover the subjects which will be covered
in the course. Hence to do well in this course is important that you try to attend all of the lectures and read all the handout materials which I will provide. This is especially important in the case of the nuclear physics topics which will form the basis of the discussion of the medical applications.

Don't get behind. You can ask me questions in class, by e-mail (if I am not traveling it is likely that I will read and respond to your e-mail send between 8 a.m. and 10 p.m. within few hours), or by coming to my office any time I am in. If you cannot find me in the office - please send me e-mail and we will set up the time.

The web page of the course:
www.phys.psu.edu/~strikman/497

is password protected. It will include links to useful web pages, files of the articles, as well as the files of the lectures in the pdf format. If the lecture would include movies they will be converted also to quick time files. The pdf versions of the lectures will be put on the web before lectures (usually at the latest by the morning of the lecture). It is recommended that you print out these files and bring them to the lectures (You can print 4 - 6 pages of the file per page). I will also provide copies of some of sections of the relevant books.
I recommend that you buy the book

S.A. Kane, "Introduction to physics in modern medicine" (2009). *($59 through Amazon)*

This is the only book I know which has roughly similar aims. The second part of the book is a good reading for the part of the course dealing with medical imaging though we will treat this subject on a somewhat higher level. It is also too brief on the radiation oncology. If we move fast enough we will also cover the two subjects which are discussed in the first part of this book - ultrasound, and lasers.

Several other books appear to be useful and will be put on hold.

A.Webb, Introduction to Biomedical Imaging.(2003)

This is a good book on imaging. It provides a rather detailed information on most of the imaging issues I will cover.

J.S.Lilley, "Nuclear physics: principles and applications" (2001).

Most of the nuclear physics aspects of the course are nicely covered in the book n a bit more detailed way than we will do in the course, the medical aspects are also covered but rather briefly.

A.Das, T.Ferbel, `` Introduction to Nuclear and Particle Physics'' (2004)

Nuclear physics aspects of the course - nuclear structure, decays, propagation of particles through matter are covered on a level of the course.

B.T.Kevles, "Naked to the bone". (1998)

A very interesting account of the history of modern applications of physics in imaging.

T.Curry,III et al, "Christensen's Introduction to the physics of Diagnostic Radiology" (1990).

This book is considered to be a classical book on the subject.

H.E. Johns, "J. R. Cunningham, Physics of Radiology" (1983).

This book is usually referred to as a bible of medical physics.

E.L.Alpen, "Radiation Biophysics" (1998).

The book describes interaction of radiation with cells. This is rather advanced book, but I could not find anything more elementary.

P.Suetens, "Fundamentals of Medical Imaging" (2002).

Up to date review of the current methods of medical imaging - it is an advanced course. It may be of use for those of you who like more rigorous treatments.

S.C. Bushong, Magnetic Resonance Imaging(2002).

This is more or less 200 level book on the subject, written in a lively style.

S.C.Bushong, Radiological science for technologists: Physics Biology and Protection. (2001)

Another more or less 200 level book of the same author, also written in a lively style.

Course Outline

● Introduction, general structure of the course. (1h)
● Elementary constituents: photons, electrons, positrons, protons, neutrons.
Electronic shell structure of atoms. Feynman visualization of interactions (2h)
● Elementary Interactions of particles - strong and electromagnetic interactions. Notation of the cross section of the interaction: total and differential cross sections. (2h)
● Particle Interaction with Matter: Bethe-Bloch, radiative, photoelectric effect,
Compton scattering, pair production.(2h)
●Overview of the application of physics in treatment and diagnostics.}
● *X-rays* : Methods of generations: X-ray tubes, radioactive sources, electron
accelerators, electron laser. (2h)
●Applications of the X-rays in diagnostics: X-rays detectors, computer
tomography(CT) - 2D Images, 3D images, angiography. (3h)
●Radiobiology - how radiation interacts with biosystems.
Dose, dose rate, exposure. Bystander effect. (3h).
●Radiation oncology: Classical treatments. Recent developments - Inverse method radiation treatment. (3h)
●Structure of nuclei, general properties of decays in quantum theory, three types of radioactive decays, radionuclides. Methods of production of radioactive sources especially the ones used in medical applications. (3h)
● Uses of isotopes in medicine. Positron emission tomography (PET), single photon emission computer tomography, radionuclides in diagnostics and study of brain activity. PET-CT multimodality. Compton camera. Oncological applications –seeds (4h)
● Nuclear reactions, boron therapy. (1h)
●Hadrotherapy. Propagation of protons, neutrons and nuclei through the matter. Proton and ion accelerators. Comparison of the physiological action of radioactivity for different incident sources.(5h)
● Shell model of nuclei. Notion of spin and behavior of atoms and nuclei in strong magnetic fields. Magnetic resonance imaging. Imaging using polarized gases. (6h)

Topics which maybe covered if we will have enough time

●Physics of lasers and applications in medicine.
●Ultrasonic imaging.

Homework

There will be ~ 7--8 homework assignments, which will be posted on the web.
These assignments have to be turned in by the stated due date and will be graded. **If you fail to submit three or more homeworks or get less than 25% for three or more homeworks you will automatically fail the course.**

Grading

Your grading will be based on Homework (Weight factor (cumulative) 0.3); Exam 1 - late February - early March (0.25); Exam 2 - April 17-23 (0.25).
Each exam will consist of the problem solving part and qualitative part (50% each). Research project will consist of presentation in class (or at the evening sessions) - about 20 minutes and a paper ~15 pages long (0.20). (a detailed schedule for the research project - selection of the topic, first draft, etc will be given later). There will be also 10-12 min quizzes in class nearly every week once a week which will cover topics of the previous week or two (you will be able to earn extra credit points for doing well on these quizzes - up to 5%).

Grading scale:

A≥ 93 >**A-≥**86>**B+≥**81> **B**≥75> **B-≥**70>**C+**≥ 70> **C**≥ 60> **D**≥50>**F**