UNIVERSITÀ DI PISA

MEDICAL APPLICATIONS OF NUCLEAR TECHNOLOGIES

FRANCESCO D'ERRICO

Anno accademico	2019/20
CdS	NUCLEAR ENGINEERING
Codice	626II
CFU	6

Moduli	Settore/i	Tipo	Ore	Docente/i
APPLICAZIONI MEDICHE DELLE TECNOLOGIE NUCLEARI	ING-IND/20	LEZIONI	60	FRANCESCO D'ERRICO

Learning outcomes

Knowledge

Medical applications of nuclear technologies

Course Description

This course illustrates the sources and applications of ionizing radiations in diagnostic and therapeutic procedures. Radiological imaging techniques described in the course include projection radiography, mammography, fluoroscopy and computed tomography; nuclear emission techniques include planar imaging with gamma cameras, single photon emission tomography and positron emission tomography. Radiotherapy techniques include brachytherapy, external beam treatments with x-rays and electrons, hadron therapy and boron neutron capture therapy.

Learning Outcomes

Upon successful completion of this course, students will be able to:

- Learn the design principles of the radiological and radioactive sources used in medicine, including accelerators and reactors used for radiotherapy
- Understand stochastic and deterministic effects of ionizing radiations on humans.
- Learn design and operation principles of imaging equipment, including image receptors, and reconstruction techniques.
- Understand advantages and limitations of the various diagnostic and therapeutic modalities.

Assessment criteria of knowledge

Ongoing assessment to monitor academic progress will be carried out in the form of continuous teacher-student interactions during the classes. Often, a group of students will be tasked with addressing a specific issue or problem.

Skills

By the end of the course:
Students will know how to select the most suitable techniques for the various diagnostic and therapeutic applications of ionizing radiations.
Students will be able to select acquisition parameters perform image quality evaluations during practical sessions at the diagnostic radiology department of the university hospital.
Students will be able to present, in a written report the results of their laboratory activity carried out involving radiation detectors and check sources.

Assessment criteria of skills

During the laboratory sessions, small groups of students will work with our dose monitoring devices and check sources in order to assess and document the exposure received by radiation workers. Students will have to prepare and present a written report that documents the results of the project activity.

Behaviors

By the end of the course:
Students will acquire an awareness of the operating parameters affecting the response and reliability of diagnostic radiology equipment.
Students will be able to manage the responsibility of leading a small team performing diagnostic radiology imaging.
Students will acquire accuracy and precision when collecting and analyzing experimental data in the laboratory.

Assessment criteria of behaviors

During the diagnostic radiology imaging laboratory sessions, the accuracy and precision of the activities carried out will be evaluated
During laboratory group work, the methods of assigning responsibility, management and organization during the experiments will be evaluated

Following laboratory activities, students will be requested to submit short reports concerning the experiments carried out and the data analysis methodologies discussed.

Prerequisites

Students should be proficient in the fundaments of atomic and nuclear physics, in electromagnetism, calculus and the principles of nuclear engineering.

Teaching methods

The course is based on highly-interactive class lectures, with visual aids such as PowerPoint™ presentations and video clips which are made available to the students.
Laboratory session take place in our didactic and research locales where students are asked to form groups, use the available didactic instrumentation, observe demonstrations of the operation of our most delicate research tools, and utilize their personal computers for data analysis.
Supporting tools and activities are regularly included, such as researching materials from recommended websites, attending topical seminars given by other teaching and research faculty members.
While the course does not have a dedicated e-learning site, a website is available from which students can download educational materials, including freely available textbooks, lecture slides, papers to revise at home.
Communications between lecturer and students, mainly occur via face-to-face meetings, email exchanges and an increasing use or social media.
The course is offered entirely in English, with translation and clarifications in Italian when required.

Syllabus

Course introduction and overview; X-ray generators ; Photon interactions and energy deposition, Rayleigh scatter, Photoelectric effect, Compton scatter, pair production, photodisintegration ; Radiography: resolution, subject and receptor contrast, contrast media, noise; radiographic emulsions ; Scatter reduction techniques, line focus principle; spatial resolution and sampling criteria ; Computed radiography and digital radiography; Dual energy subtraction ; Nuclear magnetic resonance principles ; Chemical dosimetry with MRI ; Conventional (analog) fluoroscopy ; Digital angiography; digital subtraction angiography; conventional (analog) mammography ; Computerized and digital radiography and mammography ; Computerized tomography, principles and instrumentation ; CT scan modalities, intensity modulation, cardiac imaging, dual source scans ; CT image reconstruction techniques; live computer simulation of acquisition and reconstruction ; CT imaging artifacts and image quality determinants ; Nuclear medicine basic principles; Scintigraphy, Gamma camera design ; Gamma camera operation; Anger logic; quality controls and artifacts ; SPECT Single Photon Emission Tomography (principles, instrumentation, performance) ; PET Positron Emission Tomography (principles, instrumentation, performance); Time of flight ; Radiotherapy principles and techniques: external beam electron/X-ray therapy, brachytherapy, hadron (charged particle/neutron) therapy ; Radiology techniques and dosimetry demonstration Ospedale Santa Chiara

Bibliography

Bushberg, Jerrold T. Essential physics of medical imaging. Lippincott Williams & Wilkins.

Non-attending students info

Students are not required to attend the course in order to undergo the proficiency examination. All materials are made available to non attending students who can also request meeting with instructor and assistants in order to address topis of interest and requests for clarifications.

Assessment methods

The final proficiency exam is an oral test consisting of an interview between the candidate, the lecturer, and the lecturer's collaborators. The average length of the interview is one hour and the number of professors conducting the interview is usually two. During the test, students are assessed on their understanding and critical analysis of the course contents using the appropriate terminology. The test is divided into several parts, corresponding to the various sections of the program. In order to pass the exam, it is useful although not mandatory to attend the classes and to have completed the educational laboratory activities. The test will not have a positive outcome if the candidate repeatedly demonstrates an inability to relate and link parts of the program with notions and ideas that they must combine in order to correctly respond to a question, or if the candidate does not respond sufficiently to questions regarding the most fundamental part of the course.

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