PHYS-455 **Introduction to medical radiation physics**

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Cursus	Sem.	Type
Nuclear engineering	MA1	Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
Hours	**3 weekly**
Courses	2 weekly
Exercises	1 weekly
Number of positions	

Summary

This course covers the physical principles underlying medical diagnostic imaging (radiography, fluoroscopy, CT, SPECT, PET, MRI, US), radiation therapy and radiopharmacy. The focus is not only on risk and dose to the patient and staff, but also on an objective description of the image quality.

Content

Ionizing radiations in medical physics

- Order the regions of the electromagnetic spectrum by increasing photon energy and explain the main types of interactions each region can have with water
- Explain the concepts of absorbed dose and effective dose, discuss their usefulness in a medical context, and estimate typical dose levels encountered in diagnostic imaging and therapeutic procedures
- Describe the main stochastic effects and tissue reactions associated with ionizing radiation exposure, and calculate an approximate indicator of possible risk based on the effective dose
- Describe the operating principles of an ionization chamber and a semiconductor detector, and cite examples of their applications in medical physics

Production of x-rays and image quality

- Describe the image formation chain in X-ray imaging, from X-ray production (tube physics, beam shaping) to detection and digital image display
- Interpret the key image quality parameters (contrast, resolution, noise) and relate them to acquisition parameters.
- Discuss the trade-offs between image quality and patient dose in the task-based approach

2D projection x-ray imaging

- Describe the physical principles and technical components of radiographic, mammographic and fluoroscopic systems
- Define and interpret common dose quantities such as dose area product (DAP), entrance surface air kerma (ESAK) and average glandular dose (AGD)
- Identify the basic principles of time, distance and shielding in radiation protection scenarios and explain the connection between radiation protection for patients and for personal.

3D computed tomographic imaging

- Describe the physical principles and technical components of computed tomography systems.
- Interpret the influence of the acquisition and reconstruction parameters on the image quality.
- Define dose quantities such as CTDI and DLP and explain their significance and impact on dose management.

Advanced techniques and research in x-ray imaging

- Briefly describe the most promising advanced techniques in x-ray imaging
    - Details to be provided during the lecture

Radioisotopes and biokinetics in nuclear medicine

- Distinguish between the different types of radioactive decay and their potential use in nuclear medicine
- Illustrate the mechanisms of action of a radiopharmaceutical product and their methods of production
- Explain the concept of biokinetic models and internal dosimetry formalism and use them in applied settings.

Gamma-camera/SPECT and dosimetric devices

- Explain the main components of a gamma-camera/SPECT device and its functioning
- Explain the working principle of different dosimetric devices (activimeter, dose rate meter, spectrometer, contamination monitor)
- Identify the different fields of clinical and radiological protection applications

PET and radionuclide therapy

- Explain the main components of a PET device and identify the different fields of clinical applications
- Explain the workflow required to perform dosimetry in nuclear medicine
- Apply internal dosimetry concepts to real clinical scenarios

Advanced techniques and research in nuclear medicine

- Briefly describe the most promising advanced techniques in nuclear medicine
    - Details to be provided during the lecture

Treatment machines and patient flux in external radiation therapy

- Explain the objectives of radiation therapy
- Describe the general workflow of a patient in radiation therapy
- Describe the functioning of a medical linear accelerator

Treatment planning system and dosimetry

- Present the process and aims of treatment planning
- List the key components of a treatment planning system
- Cite and describe the main dose calculation algorithms

Imaging and motion management in external radiation therapy

- Explain the different uses of imaging in radiation therapy
- Compare different imaging modalities and explain their specific interest for radiation therapy
- Describe the principle of tracking, gating and motion management

Advanced techniques and research in external radiation therapy

- Briefly describe the most promising advanced techniques in x-ray imaging
    - Details to be provided during the lecture

Non-ionizing radiations in medical physics and the job of medical physicist

- Explain the function of the main components of an MRI system and describe the basic principles involved in acquiring an MRI image
- Describe the path of an ultrasonic wave in a medical imaging system, from the transmitter to the detector, and explain

how this information is used to generate an image

• Identify and describe several medical applications of optical radiation in both diagnostics and therapy

• Explain the role of a medical physicist in a hospital, describe their typical responsibilities, and identify the qualifications required for employment in a clinical setting

Keywords

medical imaging, radiation therapy, radiation in medicine

Learning Prerequisites

Recommended courses

This course has many synergies with the Radiation biology, protection and applications course (PHYS-450) where the basics of radiation physics and some aspects of radiation protection are very useful to follow the present course.

Learning Outcomes

By the end of the course, the student must be able to:

• Describe the main parts of an x-ray device from a physical point of view

• Describe the main differences between the radiography units and the fluoroscopy units

• Explain the principle of CT image acquisition

Teaching methods

Ex-cathedra with integrated individual exercises
The course includes not only lectures and classroom exercises at EPFL, but also illustrative visits to Lausanne University Hospital (CHUV).

Assessment methods

Written, Multiple Choice Question exam

Resources

Bibliography

• The Essential Physics of Medical Imaging, Third Edition, Jerrold T. Bushberg, J. Anthony Seibert, Edwin M. Leidholdt Jr., John M. Boone, Lippicott 2012

• Physics in nuclear medicine, S.R. Cherry, J.A. Sorenson, M.E. Phelps, Saunders Elsevier 2012 (forth edition)

• Radiation Oncology Physics: a handbook for teachers and students, E. Podgorsak, IAEA, 2005, https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1196_web.pdf

Ressources en bibliothèque

• Find the references at the Library

Références suggérées par la bibliothèque

• Radiation Oncology Physics: a handbook for teachers and students / Podgorsak

Moodle Link

- https://go.epfl.ch/PHYS-455