COURSE DATA

Data Subject	
Code	43072
Name	X-ray production. Accelerators
Cycle	Master's degree
ECTS Credits	4.0
Academic year	2023 - 2024

Study (s)

Degree	Center	Acad. year	Period
2140 - Master's Degree in Medical Physics	Faculty of Physics	1	First term

Subject-matter

Degree	Subject-matter	Character
2140 - Master's Degree in Medical Physics	1 - The physics of radiation	Obligatory

Coordination

Name	Department
CIBRIAN ORTIZ DE ANDA, ROSA MARIA	190 - Physiology
GONZALEZ MILLAN, VICENTE	242 - Electronic Engineering
SANCHIS PERIS, ENRIQUE J	242 - Electronic Engineering

SUMMARY

In the field of medical physics there is a wide range of instruments such as X-ray equipment or high-energy accelerators, used in applications that go from diagnosis to therapy. An important piece of knowledge for the professional in medical physics is to understand not only the operation, design and implementation of this type of equipment but also the problems associated with propagation of the generated electrical signals, which are sometimes source of noise and distortion.

This subject first discusses, as background knowledge, the mechanisms that govern the propagation of signals and their issues, and then explains the physical principles and design of ionizing radiation emitting equipment which can be found in a clinical environment.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

There are no specified enrollment restrictions with other subjects of the curriculum.

Other requirements

No existen requisitios previos

2140 - Master's Degree in Medical Physics

- Students should apply acquired knowledge to solve problems in unfamiliar contexts within their field of study, including multidisciplinary scenarios.
- Students should be able to integrate knowledge and address the complexity of making informed judgments based on incomplete or limited information, including reflections on the social and ethical responsibilities associated with the application of their knowledge and judgments.
- Students should communicate conclusions and underlying knowledge clearly and unambiguously to both specialized and non-specialized audiences.
- Students should demonstrate self-directed learning skills for continued academic growth.
- Be able to access the information required (databases, scientific articles, etc.) and to interpret and use it sensibly.
- Students should possess and understand foundational knowledge that enables original thinking and research in the field.
- Know how to write and prepare presentations to present and defend them later.
- Be able to access to information tools in other areas of knowledge and use them properly.
- To prepare a clear and concise memory of the results of your work and the conclusions obtained.
- Use the different exhibition techniques oral, written, presentations, panels, etc., to communicate the knowledge, proposals and positions.
- Project the knowledge on specific problems and know how to summarize and extract the most relevant arguments and conclusions for their resolution.
- To acquire a critical attitude that allows you to make reasoned judgments and defend them with rigor and tolerance.
- Critically analyze both his/her work and that of the colleagues.
- Acceder a herramientas en el área de Física que puedan ser susceptibles de aplicación a la Medicina y valorar su aplicabilidad e interés.
- Planificar y gestionar la utilización de las técnicas físico-médicas teniendo en cuenta los principios básicos de control de calidad, prevención de riesgos, seguridad y sostenibilidad.

- Seleccionar la instrumentación apropiada para el estudio a realizar y aplicar sus conocimientos para utilizarla de manera correcta.

At the end of the teaching-learning process the student should be able to:

- Knwoledge of guided signal propagation.
- Knowing the basics of the X-ray equipment.
- Value the importance of the bremsstrahlung in producing X-rays and the need for particle accelerators to achieve beams of higher energies.
- Describe the basic operation of cobalt therapy units.
- Describe the basic operation of the accelerators for medical use.
- Reason the advantages and limitations of each type of accelerator.

DESCRIPTION OF CONTENTS

0. GUIDED SIGNAL PROPAGATION

In this unit guided mechanisms of signal propagation, with particular emphasis on the phenomena of reflection and noise are described. Different waveforms are studied under the terms of adaptation for both pulsed and sinusoidal signals. The student is introduced to the concepts of transmission line and waveguide.

1. X-RAY PRODUCTION

1.1. Radiation spectrum
1.2. Characteristic X-rays
1.3. Auger effect and fluorescent yield
1.4. Emission of radiation by accelerated charged particles (Bremsstrahlung radiation)
1.5. Synchrotron radiation
1.6. Cerenkov radiation

2. X-RAY UNITS

2.1. Historical development
2.2. Generators
2.3. X-ray targets
2.4. Spot size
2.5. Heat production and dissipation
2.6. Production efficiency
2.7. Heel effect
2.8. Filtration

2.9. Beam collimation
2.10. Device parameters (mA, kVp and time). Effect on radiation dose and image quality

3. X-RAY BEAMS

3.1. X-ray spectrum
3.2. Quality specifiers
3.2. Radiation output

4. TYPES OF X-RAY UNITS

4.1. X-ray units for diagnostic
4.2. X-ray units for mammography
4.3. X-ray units for therapy

5. GAMMA BEAMS AND GAMMA UNITS

5.1. Properties of gamma rays
5.2. Teletherapy units
5.3. Teletherapy sources
5.4. Penumbra
5.4. Shielded position of the source
5.6. Collimation systems

6. PARTICLE ACCELERATORS

6.1. Betatron
6.2. Cyclotron
6.3. Microtron

7. MEDICAL LINEAR ACCELERATORS

7.1. Linear accelerator
7.2. Linacs generations
7.3. Components
7.4. Cobalt unit against electron linear accelerator

8. ADDITIONAL COMPLEMENTS IN LINEAR ACCELERATORS

9.1 Sistemas de imagen de megavoltaje en aceleradores. Imágenes de Conebeam

9. SPECIAL UNITS

10.1 Special units in radiotherapy.
10.2 Protontherapy

10. LASER BASES AND APPLICABILITY TO NEW ACCELERATORS

Laser Basics
1.1 What is a laser.
1.2 Atomic energy levels and spontaneous emission.
1.3 Stimulated atomic transition.
1.4 Laser amplification.
1.5 Laser pumping. Population investment.
1.6 Laser oscillation and laser cavity modes.
1.7 Properties of the laser beam.
1.8 Some types of lasers.
1.9 Laser coherence properties.
1.10 Conclusions.
Applicability to new accelerators
1. Introduction
a. Laser-plasma accelerators. General description.
b. Biology of ultrafast high energy radiation
2. Applications to cancer treatment
3. Towards a therapy based on laser-plasma accelerators

11. Laboratory work

11.1 Equipos de Rayos X
11.2 Aceleradores
11.3 Transmisión de señales

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	24,00	100
Laboratory practices	16,00	100
Development of group work	4,00	0
Development of individual work	4,00	0
Study and independent work	20,00	0
Readings supplementary material	5,00	0
Preparation of evaluation activities	10,00	0
Preparing lectures	10,00	0
Preparation of practical classes and problem	7,00	0
TOTAL	**100,00**	

TEACHING METHODOLOGY

EVALUATION

The evaluation of the subject will be carried out as follows:

First call:

- Questionnaires delivered throughout the course: 30%.
  - Deliveries late with respect to the deadline will be penalized.
- Memories of practices: 40%
- Exam: 30%

In order to average, it will be necessary to obtain a **grade equal to or greater than 4 in each of the sections**.

Second call:

- Exam with theoretical questions, problems and laboratory questions: 100%.

REFERENCES

Basic

- Radiation physics for medical physicits. E. B. Podgorsak
- Radiation oncology physics: a handbook for teachers and students. E. B. Podgorsak
- Technological perspectives on laser speckle micro-rheology for cancer mechanobiology research
  Zeinab Hajjarian and Seemantini K. Nadkarni* Harvard Medical School, Massachusetts General Hospital, Wellman Center for Photomedicine, Boston, Massachusetts, United States
  Journal of Biomedical Optics September 2021 Vol. 26(9)
- Simulation of a radiobiology facility for the Centre for the Clinical Application of Particles
  A. Kurupa, , J. Pasternaka , R. Taylora,1, L. Murgatroyda,1, O. Ettlingerb , W. Shieldsc , L. Nevayc , S. Gruberd , J. Pozimskia , H. T. Laua , K. Longa , V. Blackmorea , G. Barbera , Z. Najmudinb , J. Yarnolde
  Physica Medica, European Journal of Medical Physics July 25, 2019
- Laser-driven electron beam and radiation sources for basic, medical and industrial sciences
  By Kazuhisa NAKAJIMA*1, (Communicated by Toshimitsu YAMAZAKI, M.J.A.
  Proc. Jpn. Acad., Ser. B 91 (2015)
- Radiobiological Effectiveness of Laser Accelerated Electrons in Comparison to Electron Beams from a Conventional Linear Accelerator
  Lydia LASCHINSKY1*, Michael BAUMANN1 , Elke BEYREUTHER2 , Wolfgang ENGHARDT1,2, Malte KALUZA3 , Leonhard KARSCH1 , Elisabeth LESSMANN2 , Doreen NAUMBURGER1 , Maria NICOLAI3 , Christian RICHTER1,2, Roland SAUERBREY2 , Hans-Peter SCHLENVOIGT3 and Jörg PAWELKE1,2
  J. Radiat. Res., 53, 395403 (2012)