COURSE DATA

DATA SUBJECT

Code: 43072
Name: X-ray production. Accelerators
Cycle: Master's Degree
ECTS Credits: 4
Academic year: 2025-26

STUDY (S)

Degree	Center	Acad. year	Period
2140 - Master's Degree in Medical Physics	Facultat de Física	1	First quarter

SUBJECT-MATTER

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

COORDINATION

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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

COMPETENCES / LEARNING OUTCOMES

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Acceder a herramientas en el área de Física que puedan ser susceptibles de aplicación a la Medicina y valorar su aplicabilidad e interés.

Be able to access the information required (databases, scientific articles, etc.) and to interpret and use it sensibly.

Be able to access to information tools in other areas of knowledge and use them properly.

Critically analyze both his/her work and that of the colleagues.

Know how to write and prepare presentations to present and defend them later.

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.

Project the knowledge on specific problems and know how to summarize and extract the most relevant arguments and conclusions for their resolution.

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

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.

Students should possess and understand foundational knowledge that enables original thinking and research in the field.

To acquire a critical attitude that allows you to make reasoned judgments and defend them with rigor and tolerance.

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.

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

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

4. TYPES OF X-RAY UNITS

4.1. X-ray units for diagnostic
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

Laser Basics
1.1 What is a laser.
1.2 Atomic energy levels and spontaneous emission.

10. LASER BASES AND APPLICABILITY TO NEW ACCELERATORS

Laser Basics
1.1 What is a laser.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

PRESENCIAL ACTIVITIES

Activity	Hours
Theory	24,00
Laboratory	16,00
Total hours	**40,00**

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	0,00
Individual or group project	8,00
Independent study and work	25,00
Preparation of lessons	17,00
Preparation for assessment activities	10,00
Resolution of case studies	0,00
Total hours	**60,00**

TEACHING METHODOLOGY

MD1 ¿ Recorded lectures and online viewing.
MD2 ¿ Practical laboratory classes.
MD3 ¿ Videoconferences to answer questions about the proposed problems.
MD4 ¿ Videoconferences with subject matter experts on current topics in dosimetry.
MD5 ¿ Videoconferences to answer practical calculations.

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%.

To pass the subject, it will be nhecessary to attend the face-to-face practices and obtain a minimum total grade of 5

Evidence of copying or plagiarism will result in failure to pass the subject and in appropriate disciplinary action being taken. Please note that, in accordance with article 13. d) of the Statute of the University Student (RD 1791/2010, of 30 December), it is the duty of students to refrain from using or participating in dishonest means in assessment tests, assignments or university official documents.

In the event of fraudulent practices, the ¿**Action Protocol for fraudulent practices at the University of Valencia**¿ will be applied (ACGUV 123/2020):

https://www.uv.es/sgeneral/Protocols/C83sp.pdf

REFERENCES

- 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)