Universidad de Navarra

Instrumentación Biomédica (Ing.Gr.)
Guía docente 2026-27

PRESENTACIÓN

Breve descripción:

En este curso estudiaremos los fundamentos y las técnicas para cuantificar variables físicas. Asimismo, se estudiarán fundamentos de física moderna para entender los procesos de interacción de radiación con materia, con el objetivo de comprender los procesos de formación de imagen médica y el funcionamiento de los grandes equipos de imagen para el diagnóstico médico.

Aplicaremos dichos fundamentos a la medición de realidades médicas, como la electrocardiografía o la formación de imágenes por rayos-X, resonancia magnética o medicina nuclear.

Titulación (Módulo/Materia):

- Ingeniería Biomédica (Biomedicina/Instrumentación)

Detalles:

- **ECTS**: 6 ECTS
- **Curso, semestre**: 4.º curso, 1.º semestre
- **Carácter**: Obligatorio
- **Idioma**: Castellano

Profesores de la asignatura:

- Díaz Dorronsoro, Javier / Profesor titular
- García-Rosales Vázquez, Carmen / Profesora Catedrática

RESULTADOS DE APRENDIZAJE (Competencias)

INGENIERÍA EN INGENIERÍA BIOMÉDICA

CG1 - La formación debe proporcionar al egresado una base científica sólida que permita abordar con rigor los retos profesionales del sector biomédico.

CG3 - Proporcionar al egresado los conocimientos tecnológicos necesarios que permitan al egresado abordar problemas del campo de la Ingeniería Biomédica.

CG8 - Saber utilizar los instrumentos clínicos y biomédicos para obtener, organizar e interpretar la información científica y sanitaria.

CE4 - Ser capaz de identificar los conceptos de la ingeniería que se pueden aplicar en el campo de la biología y de la salud.

CE5 - Conocer y saber utilizar los instrumentos clínicos y biomédicos para obtener, organizar e interpretar la información científica y sanitaria.

PROGRAM

INSTRUMENTATION TECHNIQUES FOR MEDICAL IMAGING

Universidad de Navarra

Part A

Chapter 1: Introduction: short overview of main medical imaging techniques

Chapter 2: Introductory quantum mechanics

Chapter 3: Fundamentals of atomic physics

Chapter 4: Fundamentals of nuclear physics

Chapter 5: Interaction of radiation with matter

Chapter 6: Detectors

Chapter 7: Radiation dose

Part B

Chapter 8: **Medical use of X-rays**. Generation of X-rays. Radiography. Fluoroscopy. Computed tomography.

Chapter 9: **Nuclear Imaging**. Radiopharmaceuticals. Gamma camera. Contrast, resolution, sensitivity. SPECT. PET.

Chapter 10: **Magnetic Resonance Imaging**

1) Nuclear Magnetic Resonance (NMR)

2) Magnetic Field Gradients for MRI

3) k-Space and Image Space

Chapter 11: **Ultrasound**

1) Ultrasound tissue interactions

2) A-Mode Scan, B-Mode Scan, M-Mode Scan.

3) Artifacts

INSTRUMENTATION TECHNIQUES FOR MEDICAL SIGNALS

Lesson 1: Introduction and definitions

1) Calibration curve

2) SNR

3) CMRR

Lesson 2: Differential amplifier

1) Differential amplifier

2) Gain

3) CMRR limitations

Lesson 3: Instrumentation amplifier

1) Gain Current (IG)

2) Reference vs Ground vs Differential Voltage

3) CMRR improvement

Lesson 4: Frequency filters

1) Bandwith

2) Cuttoff frequency

3) Active and passive filters

Lesson 5: Analog to digital conversion

1) Sample amd Hold Amplifier

2) Flash Analoge to Digital Converter

3) Sample frequency, Resolution and Range

Lesson 6: Error management

1) Error propagation

2) Accidental and systematic errors

3) Error bound for a population mean (EBM)

Lesson 7: Instrumentation to measure force

1) Gauges

2) Wheatstone bridge

3) Common mode

Lesson 8: Instrumentation to measure temperature

1) RTD

2) Compensation wires

3) Self heating

Lesson 9: Instrumentation to measure light

1) Phototransistor

2) Transimpedance amplifier

Lesson 10: ECG (I) Action potentials. The PQRST Complex and the 12 Lead ECG

1) PQRST

2) ECG Instrumentation

3) 12 ECG

Lesson 11: ECG (II) Equivalent Current Dipole. Electrical Axis. Right Leg Drive circuit

1) Equivalent Current Dipole

2) Electrical Axis

3) Right Leg Drive circuit

Lesson 12: ECG (III) Working on ECG.

1) Representation of an ECG

2) Obtaining BPM using the Pan-Tompinks algorithm

Lesson 13: EEG (I) Instrumentation

1) EEG instrumentation

2) EEG preprocessing

3) EEG interpretation

Lesson 14: EEG (II) Preprocessing

1) EEG preprocessing using EEGLab

2) EEG procesing using EEGLab

3) EEG interpretation using EEGLab

Lesson 15: Magnetoencephalography (MEG)

1) SQUID

2) MEG related to EEG

3) Brain Mapping

Lesson 16: Brainstorm: Steps to Construct brain activation maps related to Continuous Recognition Memory task

Lesson 17: Instrumentation for SPO2

1) LEDs to stimulate and Photransistor to meassure

2) Conditioning circuit for SpO2

3) Control scheme for SpO2

Lesson 18: Impedance pneumography

1) Bioimpedance and impedance pneumography

2) Two and four terminal measurement for impedance pneumography

3) High-frequency ac current for Impedance pneumography

ACTIVIDADES FORMATIVAS

During the course, seminars will be organized according to the needs of the students.

In addition, in those years when it is possible, a visit to the Clínica Universidad de Navarra is made to see medical imaging equipment using X-ray or nuclear medicine techniques.

Evaluation

Ordinary call

Instrumentation Techniques for Medical Imaging: 50%.

Instrumentation Techniques for Medical Signals: 50%.

In each part of the course the grade is distributed as follows:

- Exercises and tests: Medical imaging part: 30% (the exercises represent 10% and the test 20%). Medical signal part: exercises represent 20% and no test is done.
- Exam: Medical imaging part: 70%. Medical signal part: 80%

In the exam it is necessary to obtain in each part a 4 out of 10.

In addition, students will have a voluntary release exam of the first part (**Medical signals**), out of class time (to be determined). To release this part, students must obtain 4 out of 10 points. If this minimum is not reached, the student will have to take that part in December. This exam is voluntary. If you wish to get a higher grade or if you do not reach the 4, you can repeat the exam in December, but the new grade obtained in December of that part will take into account 30% of what you have obtained in the exam.

To take the voluntary exam of **Medical signals**, the student must fill the following form: (https://forms.gle/5jAN6mkqmAx293DU6) before **Monday 13th** of **October**.

If after taking the voluntary exam you wish to retake the December exam, you should send an email to **Javier Díaz Dorronsoro** (jdiaz@unav.es) before **November 28th**.

Extraordinary call

There is an ordinary exam in December and an extraordinary exam in January. In case of not passing any of the two parts in December (either signals or medical imaging), the student will have to take that part in the January exam. Once the minimum is reached, the final grade will be computed as follows:

- Instrumentation Techniques for Medical Imaging: 50%.
- Instrumentation Techniques for Medical Signals: 50%.

HORARIOS DE ATENCIÓN

Dr Javier Díaz (jdiaz@unav.es)

- Despacho 218 Edificio Miramón. Planta 2
- Horario de tutoria: Martes de 9 a 10.

Dra Carmen García-Rosales (cgrosales@ceit.es)

- Despacho 214 Edificio Ceit Ibaeta. Planta 1
- Horario de tutoria: concretar con la profesora

BIBLIOGRAFÍA

Instrumentation Techniques for Medical Imaging

- Handnotes of the lectures. Carmen García-Rosales. August 2023

Introduction to Quantum Mechanics, Atomic Physics and Nuclear Physics:

- R. A. Serway, C. J. Moses, C. A. Moyer, "Física Moderna", 3ª ed., Ed. Thomson 2018 Localízalo en la biblioteca

- Paul A. Tipler, "Física Moderna", Ed. Reverté, Localízalo en la Biblioteca

Medical Imaging Techniques:

All Imaging Techniques (X-ray, Gamma ray, MRI, US):

- Anthony B. Wolbarst, "Physics of Radiology", 2nd ed., Medical Physics Publishing 2005 Localízalo en la Biblioteca

Computed Tomography:

- Thorsten M. Buzug, "Computed Tomography - From Photon Statistics to Modern Cone-Beam CT", Springer-Verlag Berlin Heidelberg 2008. Localízalo en la biblioteca (versión electrónica)

Magnetic Resonance Image*:*

- The Basics of MRI, Joseph P. Hornak, Ph.D.->http://www.cis.rit.edu/htbooks/mri /index.html
- "Magnetic Resonance Imaging: physical principles and applications". Vadim Kuperman. San Diego: Academic Press, 2000. Localízalo en la biblioteca (version electrónica)
- Magnetic Resonance Imaging: Physical Principles and Sequence Design. Haacke, Brown, Thompson, Venkatesan. Jhon Wiley & Sons, New York 1999. Localízalo en la biblioteca

Ultrasound*:*

- Springer Handbook of acoustics. T.D. Rossing. Springer (2007) Localízalo en la biblioteca

Instrumentation Techniques for Medical Signals

- Bentley, John P. Principles of Measurement Systems. 2005. Localízalo en la biblioteca
- Miguel A. Pérez García, Instrumentación electrónica, 2004 Loalízalo en la biblioteca
- Morris, A.S. and Langari, R. Measurement and Instrumentation. Theory and Application. Elsevier, 2020. Localízalo en la biblioteca (formato papel); 2012 (formato online)
- Handnotes Biomedical Instrumentation January 2020.pdf