Universidad de Navarra

***Control of Biorobotic devices (MIB)***

*Teaching guide 2026-27*

# PRESENTACIÓN/PRESENTATION

**Breve descripción/ Brief description:**

- **Titulación**: Master in Biomedical Engineering
- **Módulo/Materia**: Especialidad en Tecnologías, Sistemas y Dispositivos Biomédicos / Tecnologías, Sistemas y Dispositivos Biomédicos (Especialidad Análisis de Datos: Módulo Optativo/Materia Optatividad)
- **ECTS**: 5 ECTS
- **Curso, bimestre**: 1º, Cuarto (abril-mayo)
- **Carácter**: Obligatorio
- **Profesorado**:
  - Sánchez Tapia, Emilio José - Email: esanchez@ceit.es, Profesor Titular
  - Ainhoa Arnaiz Lecuona - práctica modelado de robot en python
  - Julie Laurent - práctica de programación de cobot
- **Idioma**: Impartición en Castellano, material docente en Inglés
- **Requisitos previos/prerequisites**: familiarización con el método de Denavit-Hartenberg/ Denavit-Hartenberg method

# COMPETENCIAS/SKILLS

- CB6 - Students will possess and understand the knowledge that provides a basis or opportunity to be original in the development and/or application of ideas, often in a research context.
- CB7 - Students will know how to apply the knowledge acquired and will have the ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their area of study.
- CB9 - Students will know how to communicate their conclusions, as well as the knowledge and reasons which support said conclusions, clearly and unambiguously to specialized and non-specialized audiences.
- CB10 - Students will possess sufficient learning abilities to continue studying, to a considerable extent, autonomously and under their own guidance.
- CG02 - Students will be able to carry out research, development and innovation in products, processes and/or methods in biomedical engineering.
- CG05 - Students will know how to project, calculate and design products, processes, facilities and control systems in the area of biomedical engineering.
- CE10 - Students will know how to integrate technologies from the field of engineering to solve medical needs.
- CE11 - Students will know how to model biomedical systems from different technological perspectives.

# PROGRAMA/PROGRAMME

Theory covering the lecture is distributed in the following lessons:

- Chapter 1: General review to introductory concepts to robotics
  - Homogeneous transformation
  - Forward Kinematics: Denavit-Hartenberg
  - Inverse Kinematics
- Chapter 2: Differential kinematic models Jacobian Matrix
  - Differential Kinematics
  - Jacobian Matrix calculation by Speed and Force/torque propagation method
  - Singularity analysis

    - Manipulability Ellipsoids, Manipulabity Index
- Chapter 3: Introduction to robot dynamics and control
    - 1-DoF model
    - Feedforward and Feedback control strategies
    - Admittance and Impedance models: mechatronics analogy
    - Control of Haptic Devices
    - PID Control
- Chapter 4: Path Planning
    - Path Planning strategies and control
- Chapter 5: Teleoperation Introduction to Teleoperation
    - Teleoperation architectures
    - Active/Passive vs. Stable/unstable system
    - Communication channel passivation

The lecture has 2 practical works.

1. Practice 1: Kinematic Robot Model using Peter Corke/python (Forward kinematics, jacobian matrix and singularity analysis)
2. Practice 2: Collaborative Robot Programming

## ACTIVIDADES FORMATIVAS/ EDUCATIONAL ACTIVITIES

**Several methods are combined in the course:**

- Flipped lectures approach on the topics described in the program.
- Problems worked out in the classroom.
- Videos and other digital resources at this page
- 2 practical works at the laboratory.
- Personal study of the student.

**The student should:**

- Attend regularly to the lectures, taking part actively and making notes for the student's personal study.
- Attend the laboratory classes and write the reports concerning the practical works.
- Work the problems proposed in the classroom and give them when back required for their evaluation.
- Attend the final review class (a kind of flipped learning exam).

## EVALUACIÓN/ASSESSMENT

**FIRST SIT**

The assesment of the course is as it is described following:

- **Compulsory Practicals**: carry up to 4 points
    - Practice 1: Kinematic Robot Model (2.5 points)
    - Practice 2: Cobot Programming (2.5 points)
    - Lecturing (flipped class): Class lecturing (2.5 points)
    - Written examination (2.5 points)
- **Lectures attendance**: compulsory

**Note 1:** After the written exam, the lecturer may invite some students to explain their answers orally. Such an invitation may take place up to one week after the written exam has been completed. *[Spanish] Con posterioridad a la prueba escrita, el profesor podrá convocar a algunos estudiantes para que expliquen verbalmente sus respuestas. Esta convocatoria podrá tener lugar hasta una semana después de realizada la prueba escrita*.

**Note 2:** To successfully complete the course, students must pass the written exam by obtaining a minimum score of 1.25 out of 2.5 points. *[Spanish] Para poder superar la asignatura, el examen escrito debe aprobarse, es decir, se tiene que superar 1.25 puntos sobre 2.5*

**OTHER SITS**

There is not possibility of performing any supplementary practicals. The only valid way to pass the subject is a written examination (10 points).

**ECTS GRADE EQUIVALENCE**

(this table is only orientative, to make easier for Erasmus people to understand the Spanish grade system, not valid for certification purposes)

| Numerical Value | TECNUN Grade | ECTS Grade |
|---|---|---|
| Below 4 | Suspenso (SS) Fail | F |
| Equal of more than 4 and below 5 | Suspenso (SS) Fail | Fx |
| Equal of more than 5 and below 7 | Aprobado(AP) Sufficient | C,D,E |
| Equal of more than 7 and below 9 | Notable(NT) good | B |
| Equal of more than 9 and below 10 | Sobresaliente (SB) very good | A |
| 10 | Matrícula de Honor (MH) excellent | A+ |

**EXAMINATION LANGUAGE**

The written examination is delivered in English and the students will be able to choose to answer the questions in either Spanish or English. But, in the scope of every question, a language mixture is not admitted.

## HORARIOS DE ATENCIÓN/TUTORING

- Highly Recommended During the class
- Less recommended by email :
  - PhD Sánchez Tapia, Emilio José - Email: esanchez@ceit.es
- In case the students have any questions related to the subject, they are free to book tutoring sessions when they require.

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# BIBLIOGRAFÍA Y RECURSOS

# /BIBLIOGRAPHY ANAD RESOURCES


- Sánchez, E. , Díaz, I, Control of Biomechatronic devices. Class notes.
- Craig, J. J., Introduction to Robotics, Mechanics and Control, Addison Wesley, 2005 Localizalo en la biblioteca
- Biomedical Engineering Handbook, Joseph D. Bronzino Ed., CRC Press, IEEE Press, ISBN-10: 0849321247, ISBN-13: 978-0849321245 Localizalo en la biblioteca
- Burdea, G.C., Force and Touch Feedback for Virtual Reality. 1996, New York: John Wiley & Sons. Localizalo en la biblioteca (versión papel)
- Salisbury, J.K., F. Conti, and F. Barbagli, Haptic Rendering: Introductory Concepts. IEEE Computer Graphics and Applications, 2004. 24(2): p. 24-32. Localízalo en la biblioteca
- http://petercorke.com/Robotics_Toolbox.html