Universidad de Navarra

Biomecánica y biorobótica (Ing.Gr.)
Guía docente 2026-27

PRESENTACIÓN

Breve descripción:

En la parte de biorrobótica, este curso abarca los fundamentos de la cinemática directa e inversa, que son esenciales para determinar la posición y orientación de un robot en el espacio. En el ámbito médico, estas técnicas son utilizadas para lograr movimientos precisos en robots quirúrgicos, permitiendo una programación y coordinación efectiva entre el robot y el cirujano. Además, en terapia de rehabilitación, la cinemática directa e inversa se aplica en el diseño de robots y exoesqueletos que ayudan a los pacientes a recuperar habilidades motoras perdidas. En la parte de la biomecánica, se trabaja la captura y el análisis cinemático del movimiento del cuerpo humano combinando clases teóricas y un trabajo práctico en grupo.

Titulación (Módulo/Materia):

- Ingeniería Biomédica (Bioingeniería/Biomecánica y Biorrobótica)

Detalles:

- **ECTS**: 6 ECTS
- **Curso, semestre**: 4.º curso, 1.º semestre
- **Carácter**: Obligatorio
- **Idioma**: Castellano (3ECTS)/ Inglés (3ECTS)

Profesores de la asignatura:

- Gutiérrez Calderón, José Sebastián / Profesor titular
- Rodríguez Florez, Naiara / Profesora titular

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.

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

CE10 - Comprensión de los sistemas mecánicos y robóticos empleados en técnicas quirúrgicas y de rehabilitación.

PROGRAMA

Biomechanics (taught in English)

1. Introduction to Biomechanics.
2. Kinematics
    1. Basic concepts about human modelling

    2. Rotation matrix and coordinate systems
    3. Modelling with natural coordinates
    4. Human modelling examples
    5. Kinematic problems
3. Mocap experimental equipment
4. Anthropometry
5. Human motion reconstruction
6. Practical work: motion reconstruction of a limb (using Matlab)

Biorobotics (taught in Spanish)

1. Introduction to Robotics and Mechatronic Devices
    1. Classification
    2. Basic Terminology in Robotics
2. Robotic Applications in Medicine
    1. Surgical assistants: computer assisted surgery, minimally invasive surgery, telesurgey
    2. Rehabilitation robots, exoskeletons, robotic suits, prosthetic devices
    3. Surgical simulation and training
3. Robot Mathematical Modelling and Control
    1. Coordinate frames and homogeneous transformation
    2. Forward kinematics and Denavit-Hartenberg notation
    3. Inverse kinematics
    4. Jacobian matrix
4. Practical work using Matlab

PRE-REQUISITES: It is necessary to have done Mechanics and to have a basic knowledge of MATLAB.

ACTIVIDADES FORMATIVAS

The course is divided in two equal modules, Biorobotics and Biomechanics.

Biorobotics

Composed of: Theoretical part (35%) + Practical work (10%) + Laboratory (5%)

Theoretical part: Lectures in class in which the fundamental concepts of robotics are explained. This part is evaluated in the written exam, but the concepts are also used in the practical works.

Practical work: Complete modelling of a robot (direct and inverse kinematics) with a final report.

Laboratory: Use of a robot in the laboratoty, with a final test.

Biomechanics

Composed of: Theoretical part (30%) + Practical work (20%)

Theoretical part: Lectures in class (twice a week) making use of ppt presentations which have a combination of purely theoretical concepts together with exercises and videos of real life cases. This part is evaluated in the written exam.

Practical work: Human modelling based on a MoCap experiment in teams of 2-3 people. The experiment is carried out in the facilities in Igara, where students record some predetermined movements of the lower limb. Motion reconstruction and analysis are carried out in the computer rooms using Matlab with the guidance of the lecturers (once a week). Students have to hand in a written report.

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EVALUACIÓN

CONVOCATORIA ORDINARIA

DECEMBER

The final grade over 10 points will be calculated as follows (subject to slight changes) :

BIOROBOTICS: 5 points

- Final exam (mandatory): 3.5 points
  - Practical assignment (mandatory): 1 point.
  - Laboratory: 0.5 points. Attendance to practical is mandatory in order to pass

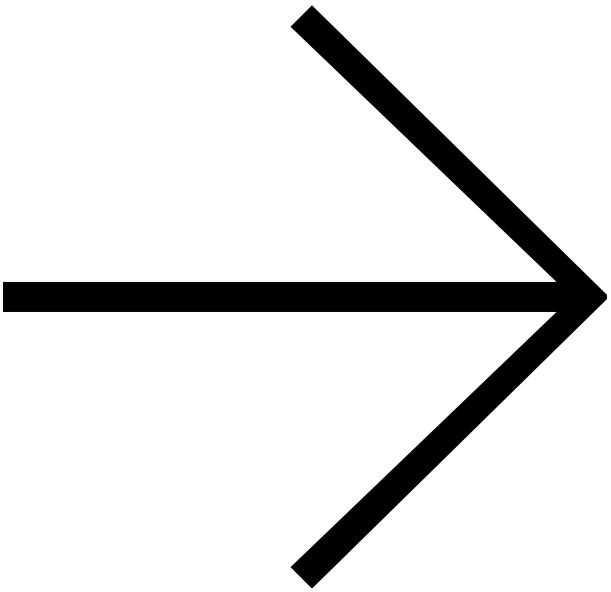
FINAL GRADE Biorob (FG_Biorob) = Biorob exam (35%) + Biorob practical assignment (15%)

BIOMECHANICS: 5 points

- Final exam (mandatory): 3 points
- Practical assignment, in teams (mandatory): 2 points
  - Attendance to practical sessions is mandatory (lab + computer)

FINAL GRADE Biomech (FG_Biomech) = Biomech exam (30%) + Biomech practical assignment (20%)

TOTAL



FINAL GRADE (FG) = FG_Biomech (50%) + FG_Biorob (50%)

A final grade of FG = 5.0 (over 10.0) is considered a PASS. If you fail (FG < 5.0), but you have passed Biomechanics (FG_Biomech >= 5.0) or Biorobotics (FG_Biorob >= 5.0) you only have to do the failed part in the retake exam. If you retake a part that you have already passed you keep the last grade.

CONVOCATORIA EXTRAORDINARIA

JANUARY

The final grade over 10 points will be calculated as follows:

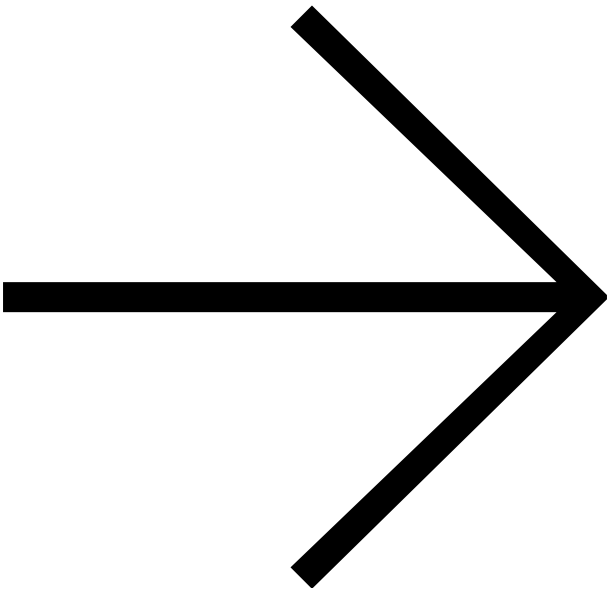
Biorobotics: 5 points

- Retake exam

Biomechanics: 5 points

- Retake exam

TOTAL



FINAL GRADE RETAKE: Biomech exam (50%) + Biorob exam (50%)

HORARIOS DE ATENCIÓN

El horario de atención se realizará con cita previa vía email:

- Dr Sebastián Gutiérrez (jsgutierrez@tecnun.es)
- Dr Naiara Rodriguez Florez (nrodriguezf@tecnun.es)

The office hours will be by appointment via email:

- Dr Sebastián Gutiérrez (jsgutierrez@tecnun.es)
- Dr Naiara Rodriguez Florez (nrodriguezf@tecnun.es)

BIBLIOGRAFÍA

Biomechanics: basic bibliography:

- Alejo Avello (2008) “Teoría de Máquinas” (10ª edición) ISBN 84-600-9359-X. Localizalo en la biblioteca (formato electrónico)
- Javier García de Jalón and Eduardo Bayo,“Kinematic and Dynamic Simulation of Multibody Systems: The Real-Time challenge “, Springer-Verlag, New-York, 1994. ISBN: 0-387-94096-0 Localizalo en la biblioteca
- ISB recommendation on definitions of joint coordinate system of various joints for the reporting of human joint motion:

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- Part I: ankle, hip, and spine. Wu et al., Journal of Biomechanics 35 (2002) 543-548 Localízalo en la biblioteca (formato electrónico)
- Part II: shoulder, elbow, wrist and hand. Wu et al., Journal of Biomechanics 38 (2005) 981-992 Localizalo en la biblioteca (formato electrónico)

Biorobotics: basic bibliography:

- Craig, J. J., Introduction to Robotics, Mechanics and Control, Addison Wesley, 2005 Localizalo en la biblioteca
- Sánchez, E., Biorobotics: class notes (available in the TECNUN photocopy-shop)
- Robotics Toolbox https://petercorke.com/toolboxes/robotics-toolbox/

Biorobotics: complementary bibliography

- Primer of Robotic and Telerobotic Surgery: A Basic Guide to Heart Disease, Garth H Ballantyne, Jacques Marescaux Lippincott Williams & Wilkins, ISBN-10: 0781748445, ISBN-13: 978-0781748445
- G. H. Ballantyne, "Robotic surgery, telerobotic surgery, telepresence, and telementoring: Review of early clinical results," *Surg. Endosc. Other Interv. Tech.*, vol. 16, no. 10, pp. 1389–1402, 2002. Localizalo en la biblioteca (formato electrónico)
- Burdea, G.C., Force and Touch Feedback for Virtual Reality. 1996, New York: John Wiley & Sons. Localízalo en la biblioteca
- Basdogan, C. and M.A. Srinivasan, Haptic Rendering in Virtual Environments, in Handbook of Virtual Environments: Design, Implementation, and Applications (Human Factors and Ergonomics), K.M. Stanney, Editor. 2002, Lawrence Earlbaum Inc.: London. p. 117-134. Localízalo en la biblioteca (formato papel)
- Salisbury, J.K., F. Conti, and F. Barbagli, Haptic Rendering: Introductory Concepts. IEEE Computer Graphics and Applications, 2004. 24(2): p. 24-32. Localizalo en la biblioteca (formato electrónico)