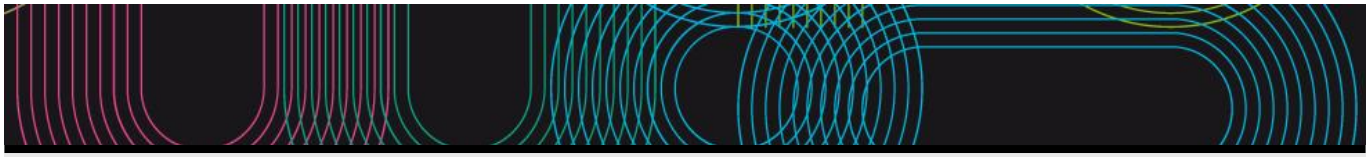

# (*)Escola de Enxeñaría Industrial

| Information |
| --- |
| For additional information about the centre and its degres visit the centre's website https://eei.uvigo.es/ |

# Máster Universitario en Ingeniería Biomédica

**Subjects**

**Year 1st**

| Code | Name | Quadmester | Total Cr. |
| --- | --- | --- | --- |
| V04M192V01101 | | 1st | 6 |
| V04M192V01102 | | 1st | 4.5 |
| V04M192V01103 | | 1st | 4.5 |
| V04M192V01104 | | 1st | 4.5 |
| V04M192V01105 | | 1st | 4.5 |
| V04M192V01106 | | 1st | 6 |
| V04M192V01201 | | 2nd | 4.5 |
| V04M192V01202 | | 2nd | 4.5 |
| V04M192V01203 | | 2nd | 4.5 |
| V04M192V01204 | | 2nd | 3 |
| V04M192V01205 | | 2nd | 4.5 |
| V04M192V01206 | | 2nd | 4.5 |
| V04M192V01207 | | 2nd | 4.5 |
| V04M192V01208 | | 2nd | 4.5 |
| V04M192V01209 | | 2nd | 4.5 |

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **(*)Estatística avanzada para a enxeñaría biomédica** | | | | |
| Subject | (*)Estatística avanzada para a enxeñaría biomédica | | | |
| Code | V04M192V01101 | | | |
| Study programme | Máster Universitario en Ingeniería Biomédica | | | |
| Descriptors | ECTS Credits | Choose | Year | Quadmester |
| | 6 | Mandatory | 1st | 1st |
| Teaching language | Spanish<br>Galician | | | |
| Department | | | | |
| Coordinator | de Uña Álvarez, Jacobo<br>Rodríguez Álvarez, María José | | | |
| Lecturers | de Uña Álvarez, Jacobo<br>Rodríguez Álvarez, María José | | | |
| E-mail | jacobo@uvigo.es<br>mxrodriguez@uvigo.es | | | |
| Web | | | | |
| General description | This course aims to be a useful tool in the training of a biomedical engineer. Its main objective is to train students in the knowledge and handling, both at a theoretical and practical level, of statistical techniques and the design of experiments applicable in the field of biomedical engineering. | | | |

| Training and Learning Results | |
|---|---|
| Code | |
| A2 | That the students can apply their knowledge and their ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study. |
| A4 | Students can communicate their conclusions, and the knowledge and rationale underpinning these, to specialist and non-specialist audiences clearly and unambiguously. |
| B1 | Ability to design, develop, implement, manage and improve products and processes in the different areas of the biomedical engineering, by means of appropriate analytical, computational or experimental techniques. |
| B2 | Ability to direct activities related to the CG1 competence |
| B5 | Knowledge to carry out measurements, calculations, assessments, appraisals, surveys, studies, reports, work plans and other similar works. |
| B8 | Ability to apply the principles and methods of quality. |
| C1 | Ability to design, implement and manage suitable experiments, analyze their results and draw conclusions in the field of biomedical engineering. |

| Expected results from this subject | Training and Learning Results |
|---|---|
| Know data analysis techniques and design of experiments applicable to biomedical engineering. | A2<br>B1<br>B5<br>C1 |
| Apply data analysis and experiment design techniques in the field of biomedical engineering. | A2<br>A4<br>B1<br>B2<br>B5<br>B8<br>C1 |

| Contents | |
|---|---|
| Topic | |
| Topic 1. Extension of experimental design and analysis | Basic principles and concepts of experimental design. Replicated designs. Blocking factor. Interaction. Factorial design with two factors: model, relevant hypothesis tests, ANOVA II table, main effects model. Factorial design with three factors. Fractional designs. One-half fraction of a 2^k design: main fraction and complementary fraction. Fractions of three-factor designs: Latin squares. |

| | |
|---|---|
| Topic 2. Introduction to quality control | Dimensions of quality and engineering. Basic principles of statistical quality control. Control by variables and control by attributes. Control charts: warning limits, action limits and decision rules. Characteristic operating function. Control by variables: x-bar chart, R chart, S chart, charts for individual measurements. Capability analysis. Control by attributes: p-chart, np-chart, c-chart and u-chart. |
| Topic 3. Industrial reliability and survival analysis | Concept of reliability and reliability measures. Reliability function and failure rate function. Mean residual life time. Notable probabilistic models: Exponential, Gamma, Weibull, Lognormal, Loglogistic. System reliability. Reliability studies: censored data and truncated data. Parametric methods of estimation and inference on reliability. Non-parametric methods: Kaplan-Meier and Nelson-Aalen curves. Goodness-of-fit plots. Accelerated life tests. Cox regression. Multiple types of failure. |
| Topic 4. Linear methods in regression and classification | Linear model and generalised linear model (logistic and Poisson). Estimation and inference. Model evaluation and selection (prediction error; information criteria; cross-validation and bootstrap). Variable selection and regularisation (variable subset selection; stepwise regression; LASSO and Ridge regression). Dimension reduction. |
| Topic 5. Non-linear methods in regression and classification | Modelling of non-linear effects: expansion in bases and penalised spline regression. Generalised additive model. Estimation and inference. Regression and classification methods based on trees: decision trees and random forests. Brief introduction to support vector machines and neural networks. |

## Planning

| | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Lecturing | 30 | 48 | 78 |
| Practices through ICT | 18 | 36 | 54 |
| Autonomous problem solving | 0 | 15 | 15 |
| Essay questions exam | 3 | 0 | 3 |

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

## Methodologies

| | Description |
|---|---|
| Lecturing | The contents of the subject will be presented in a lecture session. |
| Practices through ICT | Data processing through the use of free R software. |
| Autonomous problem solving | Autonomous resolution of practical exercises proposed during the theory classes. |

## Personalized assistance

| Methodologies | Description |
|---|---|
| Lecturing | In all the methodologies foreseen in this subject, personalized attention is contemplated, both in the classroom and through voluntary tutorials. |
| Practices through ICT | In all the methodologies foreseen in this subject, personalized attention is contemplated, both in the classroom and through voluntary tutorials. |
| Autonomous problem solving | In all the methodologies foreseen in this subject, personalized attention is contemplated, both in the classroom and through voluntary tutorials. |

## Assessment

| | Description | Qualification | Training and Learning Results | | |
|---|---|---|---|---|---|
| Practices through ICT | Attendance at practicals and resolution of six practical case studies throughout the course. Students will carry out practical cases of data analysis using R software. Each case study will account for 10% of the final grade | 60 | A2<br>A4 | B1<br>B2<br>B5<br>B8 | C1 |
| Essay questions exam | Final exam on the contents of the course. A minimum grade of 4 points (out of 10) will be required in the final exam. | 40 | A2<br>A4 | B1<br>B2<br>B5<br>B8 | C1 |

## Other comments on the Evaluation

Continuous evaluation: The student's work throughout the course will be evaluated. In the final qualification, the tests

carried out throughout the course (practical cases) will represent 60% and the final exam (to be made on the official date) 40%. To pass the subject, it will be compulsory to attend the final exam and to obtain qualification higher than 4 points (out of 10). In case of not obtaining in the final exam the minimum qualification to pass the subject, the grade to appear in the official record will be the minimum between 4.9 and the final qualification (weighted).

Second opportunity: In the second opportunity the same scale will be applied as in the continuous evaluation, with the practicals carried out throughout the course accounting for 60% and the final exam for 40%. In this case the qualifications of the practicals carried out throughout the course will be maintained and only the final exam will be repeated, in which a qualification higher than 4 points (out of 10) must be obtained in order to pass the subject. In case of not obtaining in the final test the minimum qualification to pass the subject, the grade to appear in the official record will be the minimum between 4.9 and the final qualification (weighted).

Global evaluation: As an alternative to the continuous evaluation system, students may choose, according to the mechanism established by the School, to be evaluated with a final exam that will represent 100% of the qualification. In this case, it will be necessary to obtain a qualification higher than 5 points (out of 10) in order to pass the subject.

Students are strongly requested to fulfill a honest and responsible behavior. It is considered completely unacceptable any alteration or fraud (i.e., copy or plagiarism) contributing to modify the level of knowledge and abilities acquired in exams, evaluations, reports or any kind of teacher□s proposed work. Fraudulent behavior may cause failing the course for a whole academic year. An internal dossier of these activities will be built and, when re-offending, the university rectorate will be asked to open a disciplinary record.

## Sources of information

### Basic Bibliography


James, G., Witten, D., Hastie, T., Tibshirani, R., **An Introduction to Statistical Learning: With Applications in R (https://www.statlearning.com)**, 2, Springer, 2021

Hastie, T., Tibshirani, R., Friedman, J., **The Elements of Statistical Learning: Data Mining, Inference, and Prediction (https://hastie.su.domains/ElemStatLearn/)**, 2, Springer, 2009

Montgomery, D.C., Runger, G.C., Hubele, N.F., **Engineering Statistics**, 5, Wiley, 2011


### Complementary Bibliography


Wood, S., **Generalized Additive Models: An introduction with R.**, 2, Chapman and Hall/CRC Texts in Statistical Science, 2017

Faraway, J.J., **Linear models with R**, 2, Chapman and Hall, 2015

Dean, A., Voss, D., **Design and Analysis of Experiments.**, Springer, 1999

Kuehl, R.O., **Diseño de experimentos. Principios Estadísticos para el Diseño y Análisis de Investigaciones**, 2, Thomson, 2001

Ryan, T.P., **Modern Experimental Design**, Wiley, 2007

Vilar Fernández, J.M., **Modelos Estadísticos Aplicados**, Universidade da Coruña, 2003

Montgomery, D.C., **Control Estadístico de la Calidad**, 3, Limusa Wiley, 2004

Montgomery, D.C., **Introduction to Statistical Quality Control**, Wiley, 2009

Kalbfleisch, J. D. y Prentice, R. L., **The Statistical Analysis of Failure Time Data**, 2, Wiley, 2011

Lawless, J. F., **Statistical Models and Methods for Lifetime Data**, 2, Wiley, 2003


## Recommendations

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **(*)Métodos matemáticos aplicados á enxeñaria biomédica** | | | | |
| Subject | (*)Métodos matemáticos aplicados á enxeñaria biomédica | | | |
| Code | V04M192V01102 | | | |
| Study programme | Máster Universitario en Ingeniería Biomédica | | | |
| Descriptors | ECTS Credits | Choose | Year | Quadmester |
| | 4.5 | Mandatory | 1st | 1st |
| Teaching language | | | | |
| Department | | | | |
| Coordinator | Fernández García, José Ramón | | | |
| Lecturers | Bazarra García, Noelia<br>Fernández García, José Ramón | | | |
| E-mail | jose.fernandez@uvigo.es | | | |
| Web | | | | |
| General description | | | | |

| Training and Learning Results | |
|---|---|
| Code | |
| A5 | Students must possess the learning skills that enable them to continue studying in a way that will be largely self-directed or autonomous. |
| B3 | Knowledge in basic and technological subjects that will enable students to learn new methods and theories, and provide them the versatility to adapt to new situations. |
| C2 | Ability to mathematically model Ability to mathematically model systems and processes complex in the field of biomedical engineering.systems and processes in the field of biomedical engineering. |

| Expected results from this subject | |
|---|---|
| Expected results from this subject | Training and Learning Results |
| To know mathematical methods of application in the field of biomedical engineering | B3<br>C2 |
| To apply mathematical methods in the field of biomedical engineering | A5<br>C2 |

| Contents | |
|---|---|
| Topic | |
| Fourier Analysis | Introduction to Fourier Analysis |
| Extensions of Fourier Analysis to Biomedical Engineering | Introduction to Fourier Analysis in the field of Biomedical Engineering |
| Introduction to Partial Differential Equations | Introduction to classical problems<br>Classification of the EDPs<br>Variational Approach |
| Numerical Methods for the resolution of EDP in Biomedical Engineering | Introduction to Finite Elements<br>Introduction to Finite Differences and Finite Volumes |

| Planning | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Lecturing | 14 | 16 | 30 |
| Problem solving | 8 | 16 | 24 |
| Practices through ICT | 14 | 20 | 34 |
| Objective questions exam | 2 | 0 | 2 |
| Report of practices, practicum and external practices | 0 | 20.5 | 20.5 |
| Essay questions exam | 2 | 0 | 2 |
| *The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. | | | |

| Methodologies | |
|---|---|
| | Description |
| Lecturing | In these sessions will develop those necessary theoretical concepts for the correct resolution of the problems of the Biomedical Engineering. They will carry out small exercises resolved that they allow to the student purchase the sufficient skills to be able to carry out<br>to resolution of a real problem. |
| Problem solving | Solve practical problems |
| Practices through ICT | In the practices of laboratory will put in practical all the theoretical knowledges tackled, as well as the resolution of real practical cases, with the support of a computer software. |

| Personalized assistance |
|---|

| Assessment | | | | | |
|---|---|---|---|---|---|
| | Description | Qualification | Training and Learning Results | | |
| Objective questions exam | Examination of the first corresponding block to the subjects 1 and 2 | 30 | A5 | B3 | C2 |
| Report of practices, practicum and external practices | Report of practices with the resolution of a practical case by part of the student that evaluates all the block of practices of computer with the computer support | 30 | A5 | B3 | C2 |
| Essay questions exam | Final examination where tackles all the content of the subject | 40 | A5 | B3 | C2 |

| Other comments on the Evaluation |
|---|

| Sources of information |
|---|
| **Basic Bibliography** |
| A. Cañada, **Series de Fourier y aplicaciones**, Ediciones Pirámide, 2002 |
| I. Peral, **Primer curso de Ecuaciones en Derivadas Parciales**, Addison-Wesley,, 1995 |
| D. G. Zill y M. R. Cullen, **Ecuaciones Diferenciales**, McGraw-Hill, 2008 |
| **Complementary Bibliography** |
| R. Churchil y J. Brown,, **Fourier series and boundary value problems**, McGraw Hill, 2008 |
| L. Evans, **Partial Differential Equations**, Amer Math Soc, 2010 |
| S. Larsson y V. Thomee, **Partial differential equations with numerical methods**, Springer, 2003 |

| Recommendations |
|---|

**Other comments**

It is recommended to make a review of the concepts tackled in Calculus subjects of first year of the Engineering degree, fundamentally the contents related with the Differential Equations.

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **(*)Modelado e simulación sistemas biomédicos** | | | | |
| Subject | (*)Modelado e simulación sistemas biomédicos | | | |
| Code | V04M192V01103 | | | |
| Study programme | Máster Universitario en Ingeniería Biomédica | | | |
| Descriptors | ECTS Credits | Choose | Year | Quadmester |
| | 4.5 | Mandatory | 1st | 1st |
| Teaching language | Galician | | | |
| Department | | | | |
| Coordinator | Fernández Villaverde, Alejandro | | | |
| Lecturers | Fernández Villaverde, Alejandro | | | |
| E-mail | afvillaverde@uvigo.gal | | | |
| Web | http://moovi.uvigo.gal/ | | | |
| General description | In this subject the students will gain the knowledge and skills required for building dynamic models of biosystems, with a focus on the processes and systems of interest in biomedical engineering. They will get acquainted with the techniques used in identification, simulation, and analysis of mathematical models, and they will learn to apply them to biomedical engineering problems. | | | |

| Training and Learning Results | |
|---|---|
| Code | |
| A5 | Students must possess the learning skills that enable them to continue studying in a way that will be largely self-directed or autonomous. |
| B3 | Knowledge in basic and technological subjects that will enable students to learn new methods and theories, and provide them the versatility to adapt to new situations. |
| C3 | Ability to select and apply advanced modeling methods to the design and simulation of biomedical systems. |

| Expected results from this subject | Training and Learning Results |
|---|---|
| To know the usefulness of mathematical modeling and apply it to biosystems of interest in medicine. | B3<br>C3 |
| To know model simulation methods and computational tools for modeling. | B3<br>C3 |
| Learn to build models from experimental data and existing biomedical knowledge. | A5<br>B3<br>C3 |
| To apply models to analyze the behavior of biosystems | A5<br>B3<br>C3 |

| Contents | |
|---|---|
| Topic | |
| 1. Introduction to mathematical modelling in biomedicine | 1.1. Motivation and history of biomedical modelling<br>1.2. Dynamic modelling: components and paradigms<br>1.3. Types of dynamic models<br>1.3.1. Graphs<br>1.3.2. Differential equations<br>1.4. Combinations of models<br>1.5. Examples |

| | |
|---|---|
| 2. Dynamical biomedical systems. Approaches to their modelling | 2.1. Types of biosistems of interest<br>2.2. Biochemical reaction kinetics<br>2.3. Cellular level<br>2.3.1. Metabolism<br>2.3.2. Cellular signalling<br>2.3.3. Gene expression<br>2.4. Organ level<br>2.4.1. Electrophysiology<br>2.4.2. Glucose regulation<br>2.4.3. Pharmacokinetics and pharmacodynamics<br>2.5. Population level<br>2.5.1. Epidemiology<br>2.5.2. Microbial communities |
| 3. Numerical simulation methods | 3.1. Integration of linear ordinary differential equations<br>3.1.1. Laplace transform<br>3.1.2. Transfer function<br>3.2. Integration of nonlinear ordinary differential equations<br>3.2.1. Fixed step methods<br>3.2.2. Variable step methods<br>3.3. Integration of stochastic equations<br>3.3.1. Gillespie algorithm<br>3.4. Simulation software<br>3.4.1. General purpose programming environments<br>3.4.2. Specialized simulation tools<br>3.5. Standards, formats, and repositories |
| 4. Model building and system identification | 4.0. STEP 0: obtain the equations of the model<br>4.1. STEP 1: analyse observability and structural identifiability<br>4.2. STEP 2: define the objective function<br>4.3. STEP 3: parameter optimization<br>4.3.1. Local methods<br>4.3.2. Global methods<br>4.3.3. Definition of the optimization problem<br>4.4. STEP 4: analysis of the goodness of fit<br>4.5. STEP 5: Parameter uncertainty quantification<br>4.6. STEP 6: Prediction uncertainty quantification<br>4.7. Experimental design<br>4.8. Model selection<br>4.9. Computational resources |
| 5. Dynamic behaviour | 5.1. Equilibrium and stability<br>5.1.1. Mathematical characterization of stability<br>5.2. Bifurcations<br>5.3. Oscillations<br>5.4. Robustness<br>5.4.1. Redundancy<br>5.4.2. Parametric insensitivity<br>5.4.3. Feedback<br>5.4.4. Feedforward loops<br>5.5. Model reduction |

**Planning**

| | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Lecturing | 15 | 16 | 31 |
| Problem solving | 5 | 7.5 | 12.5 |
| Practices through ICT | 12 | 24 | 36 |
| Seminars | 2 | 0 | 2 |
| Essay questions exam | 3 | 18 | 21 |
| Essay | 2 | 8 | 10 |

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

**Methodologies**

| | Description |
|---|---|
| Lecturing | Lectures given by the professor about the contents of the subject. |
| Problem solving | The professor will solve problems and exercises in the classroom. The students will solve similar exercises in order to purchase the necessary abilities. |
| Practices through ICT | In the practices the students will apply the theoretical knowledge about model building, calibration, simulation, and analysis, using computational tools (MATLAB). |

| | |
|---|---|
| Seminars | Presentation, given by an invited expert (active in biomedical research or practice), of contents related with the subject. Debate. |

**Personalized assistance**

| Methodologies | Description |
|---|---|
| Lecturing | Answering the students' questions and doubts. |
| Problem solving | Answering the students' questions and doubts. |
| Practices through ICT | Answering the students' questions and doubts. |
| Seminars | Answering the students' questions and doubts. |
| **Tests** | **Description** |
| Essay questions exam | Answering the students' questions and doubts. |
| Essay | Answering the students' questions and doubts. |

**Assessment**

| | Description | Qualification | Training and Learning Results | | |
|---|---|---|---|---|---|
| Lecturing | Evaluation criteria:<br>- Attendance to the sessions.<br>- Punctuality.<br>- Previous preparation of the session.<br>- Attitude and participation in the classroom discussions. | 5 | A5 | B3 | C3 |
| Practices through ICT | The practicals will be evaluated continuously (session to session), each one with a grade of 0 to 10.<br><br>Evaluation criteria:<br>- Minimum attendance to 80% of the sessions.<br>- Punctuality.<br>- Previous preparation of the practical session.<br>- Attitude and utilisation of the session.<br>- Achievement of the session goals. | 30 | A5 | B3 | C3 |
| Essay questions exam | The final examination will consist in a written test (questions and/or problems), graded between 0 and 10 points. It will be carried out individually and in person, and it will be held at the end of the semester, as scheduled by the direction of the school. | 40 | | B3 | C3 |
| Essay | A project (individual or in group) that will be carried out autonomously by the student, about research article(s) suggested by the instructor. Its evaluation will be based on the document written by the student, as well as by its presentation in the classroom. | 25 | A5 | B3 | C3 |

**Other comments on the Evaluation**

Each of the 3 tests (exam, ICT practices, and essay) will be graded between 0 and 10. It is necessary to obtain a minimum grade of 5 in each and every one of them in order to pass the subject, thus obtaining the total grade according to the percentage indicated above. If any one of the parts is not passed, the partial grades will be scaled so that the overall grade does not exceed 4.5. As for the attendance to the lectures, no minimum is required.

If a student does not pass the practicals in continuous evaluation throughout the semester, she/he will not be able to pass the subject in the first call of the course. In the second call, she/he will be able to take a single laboratory practical exam that would allow, if passed, to achieve a pass in the practices, and thus to have the possibility to pass the subject (as long as the final exam is also passed).

For the purpose of considering the student as "presented" or "not presented", only the participation in the final exam will be taken into account.

In the second call of the same course (i.e. within the same academic year), students must be examined for the parts not passed in the first call.

Ethical commitment: Students are expected to have an appropriate ethical behavior. In the case of detecting unethical behavior (such as copying, plagiarism, use of unauthorized electronic devices, among others) it will be considered that the student does not meet the necessary requirements to pass the subject. In this case, the overall grade in the current academic year will be a fail (0.0).

| Sources of information |
|---|
| **Basic Bibliography** |
| Joseph DiStefano III, **Dynamic systems biology modeling and simulation**, https://vdoc.pub/download/dynamic-systems-biology-modeling-and-simulation-4iqd7mrh3fv0, Elsevier Science, 2015 |
| **Complementary Bibliography** |
| Edda Klipp et al, **Systems biology: a textbook**, Wiley-Blackwell, 2016 |
| Brian Ingalls, **Mathematical Modelling in Systems Biology: An Introduction**, https://www.math.uwaterloo.ca/~bingalls/MMSB/MMSB_w_solutions.pdf, The MIT Press, 2018 |
| D. del Vecchio, R.M. Murray, **Biomolecular feedback systems**, http://www.cds.caltech.edu/~murray/BFSwiki/, Princeton University Press, 2014 |

| Recommendations |
|---|
| **Subjects that continue the syllabus** |
| (*)Control e regulación das funcións corporais/V04M192V01202 |

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **(*)Sistemas de diagnóstico e terapia** | | | | |
| Subject | (*)Sistemas de diagnóstico e terapia | | | |
| Code | V04M192V01104 | | | |
| Study programme | Máster Universitario en Ingeniería Biomédica | | | |
| Descriptors | ECTS Credits | Choose | Year | Quadmester |
| | 4.5 | Mandatory | 1st | 1st |
| Teaching language | Spanish<br>Galician | | | |
| Department | | | | |
| Coordinator | Quintáns Graña, Camilo<br>Pastoriza Santos, Vicente | | | |
| Lecturers | Aymerich López, María<br>Domínguez Prado, Inés<br>López Medina, Antonio<br>Otero García, María Milagros<br>Pastoriza Santos, Vicente<br>Quintáns Graña, Camilo | | | |
| E-mail | quintans@uvigo.es<br>vpastoriza@uvigo.es | | | |
| Web | http://moovi.uvigo.gal | | | |
| General description | The main purpose of this subject is that the student acquires the knowledge about the physical foundations and the technologies used in the medical equipment that integrate the systems of diagnosis and therapy used in the hospital setting. The subject matter is completed with an introduction to the protection, quality and applicable legislation. These contents are complemented and reinforced with the realization of practices oriented to the study of the operation and specifications of the equipment in the services existing in the hospitals participating in the Master's degree. | | | |

| Training and Learning Results | |
|---|---|
| Code | |
| A3 | That students are able to integrate knowledge and handle complexity and formulate judgments based on information that was incomplete or limited, include reflecting on social and ethical responsibilities linked to the application of their knowledge and judgments. |
| B3 | Knowledge in basic and technological subjects that will enable students to learn new methods and theories, and provide them the versatility to adapt to new situations. |
| B5 | Knowledge to carry out measurements, calculations, assessments, appraisals, surveys, studies, reports, work plans and other similar works. |
| B6 | Capacity for handling specifications, regulations and mandatory standards. |
| C4 | Knowledge and ability to design and analyze systems, sensors and techniques for diagnosis, therapy and monitoring. |

| Expected results from this subject | |
|---|---|
| Expected results from this subject | Training and Learning Results |
| To know and understand the physical principles of operation of the medical equipment that make up the diagnosis and therapy used in the hospital setting. | B3<br>B5<br>C4 |
| To know and understand the operating principles of the main medical equipment used in the hospital environment. | A3<br>B3<br>C4 |
| Knowledge to supervise the use and maintenance of medical equipment. | A3<br>B3<br>B5<br>B6<br>C4 |
| Capability to analyze the management of facilities associated with medical equipment and apply the knowledge acquired for its improvement. | A3<br>B5<br>B6<br>C4 |
| To know the fundamentals for working in multidisciplinary teams typical of biomedical engineering | B3<br>C4 |

| Contents | |
|---|---|
| Topic | |
| Topic 1: Introduction. | General description of the subject.<br>Introduction to diagnostic techniques and therapy. |
| Topic 2: Physical fundamentals of the diagnostic and therapy equipment. | Electromagnetic waves. Interaction of the electromagnetic radiation with matter.<br>Radioactive transitions.<br>Nuclear structure.<br>Nuclear processes. |
| Topic 3: Technologies for diagnostics with X-rays. | The X-ray apparatus. Generation of X-rays. Emission of X-rays.<br>X-ray interaction with matter. Detection and formation of image.<br>Intensifying screens, beam restrictor devices and grid. |
| Topic 4: Characterization and operation of computed tomography equipment. | Introduction. Tomographic image. Conventional, helical and multislice computed tomography. Components. Diagnostic and therapeutic uses. Safety. Representation of the image. Image quality. |
| Topic 5: Characterization and operation of magnetic resonance equipment | Introduction. Behavior of nuclear spin in a magnetic field.<br>Generation of the magnetic resonance signal. Examination room.<br>Open and closed resonance equipment. Emitters and receptors. Control console.<br>Diagnostic and therapeutic uses. Security.<br>Signal capture: Fourier transform, K-space and data matrix.<br>Repeat time, echo time, inversion time.<br>Classic acquisition sequences: spin-echo, and gradient echo.<br>Reconstruction in 2D and 3D. Artifacts in magnetic resonance. emerging techniques. |
| Topic 6: Technologies for Nuclear Medicine Diagnostics. | Introduction.<br>Radiopharmaceuticals for imaging diagnostics.<br>Techniques for the production of radiopharmaceuticals.<br>Particle accelerator.<br>Obtaining the flat image. The gamma camera.<br>Positron emission tomography (PET, SPECT). |
| Topic 7: Technologies for radiotherapy. | Introduction. Types of radiotherapies.<br>Brachytherapy.<br>External beam radiotherapy. Electron beam. X-ray photon beam. The linear accelerator.<br>Proton therapy. |
| Subject 8: Protection, quality and legislation. | Basic safety standards for protection against exposure to ionizing radiation.<br>Quality criteria in radiotherapy.<br>Safety concepts in nuclear installations.<br>Regulations on medical uses of X-rays.<br>Justification for the use of ionizing radiation in medicine.<br>Quality criteria in radiodiagnostics. |
| Practices. | Practice 1: Radiology.<br><br>Practice 2: Nuclear Medicine.<br><br>Practice 3: Radiotherapy. |

| Planning | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Introductory activities | 1 | 1 | 2 |
| Lecturing | 13 | 13 | 26 |
| Case studies | 4 | 8 | 12 |
| Seminars | 2 | 4 | 6 |
| Previous studies | 0 | 12 | 12 |
| Laboratory practical | 12 | 0 | 12 |
| Objective questions exam | 0.5 | 6.5 | 7 |
| Problem and/or exercise solving | 0.5 | 7 | 7.5 |
| Report of practices, practicum and external practices | 0 | 18 | 18 |
| Presentation | 2 | 6 | 8 |
| Systematic observation | 1 | 1 | 2 |
| *The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. | | | |

| Methodologies |
|---|

| | Description |
|---|---|
| Introductory activities | Activities directed to take contact and gather information on the students, as well as to present the matter. |
| Lecturing | Exposition by the lecturer of the contents on the matter object of study, theoretical bases and/or guidelines of a work, exercise that the/the student has to develop. The the skills to be worked on are: A3, B3, B5, B6 and C4. |
| Case studies | Analysis of a fact, problem or real event with the purpose to know it, interpret it, resolve it, generate hypothesis, contrast data, to reason, complete knowledge, diagnose it and train alternative procedures for solution. The skills to be worked on are: A3, B3, B5, B6 and C4. |
| Seminars | Activity focused on the work on a specific topic, that allows to deepen or complement the contents of the course. The skills to be worked on are: A3, B3, B5, B6 and C4. |
| Previous studies | Research, reading and work of documentation, previous to the classes or practical of laboratory, that makes the students of autonomous form. The skills to be worked on are: A3, B3, B5, B6 and C4. |
| Laboratory practical | Activities of application of the knowledge to concrete situations, and for acquisition of basic skills and procedures, related with the course. These practices will be developed at hospital facilities. The skills to be worked on are: A3, B3, B5, B6 and C4. |

**Personalized assistance**

| Methodologies | Description |
|---|---|
| Introductory activities | The students can attend tutoring sessions (individually or in a group). The timetable will be available on the subject's website on Moovi teleteaching portal (https://moovi.uvigo.gal/) at the beginning of the academic semester. Doubts and queries of the students on the organization of the course will be clarified. |
| Lecturing | The students can attend tutoring sessions (individually or in a group). The timetable will be available on the subject's website on Moovi teleteaching portal (https://moovi.uvigo.gal/) at the beginning of the academic semester. Doubts and queries of the students on the lecture contents of the course will be clarified. |
| Previous studies | The students can attend tutoring sessions (individually or in a group). The timetable will be available on the subject's website on Moovi teleteaching portal (https://moovi.uvigo.gal/) at the beginning of the academic semester. Doubts and queries of the students on the previous work to the classes or practical of laboratory will be clarified. |
| Seminars | The students can attend tutoring sessions (individually or in a group). The timetable will be available on the subject's website on Moovi teleteaching portal (https://moovi.uvigo.gal/) at the beginning of the academic semester. Doubts and queries of the students on the concrete topics will be clarified. |
| Case studies | The students can attend tutoring sessions (individually or in a group). The timetable will be available on the subject's website on Moovi teleteaching portal (https://moovi.uvigo.gal/) at the beginning of the academic semester. Doubts and queries of the students on previously presented cases will be clarified. |
| Laboratory practical | The students can attend tutoring sessions (individually or in a group). The timetable will be available on the subject's website on Moovi teleteaching portal (https://moovi.uvigo.gal/) at the beginning of the academic semester. Doubts and queries of the students on laboratory practices will be clarified. |
| **Tests** | **Description** |
| Report of practices, practicum and external practices | The students can attend tutoring sessions (individually or in a group). The timetable will be available on the subject's website on Moovi teleteaching portal (https://moovi.uvigo.gal/) at the beginning of the academic semester. Doubts and queries of the students on the practice reports will be clarified. |
| Presentation | The students can attend tutoring sessions (individually or in a group). The timetable will be available on the subject's website on Moovi teleteaching portal (https://moovi.uvigo.gal/) at the beginning of the academic semester. Doubts and queries of the students about the presentation preparation will be clarified. |

**Assessment**

| | Description | Qualification | Training and Learning Results |
|---|---|---|---|
| Objective questions exam | Exam that evaluate the knowledge that include enclosed questions with different alternative of answer (true/false, multiple election, pairing of elements, etc.) The students select an answer between a number limited of possibilities. | 20 | A3 B3 C4 B5 B6 |

| | | | | | |
|---|---|---|---|---|---|
| Problem and/or exercise solving | Test/exams in which the student has to solve a series of problems and/or exercises in a time/condition established by the lecturers. Of this way, the students has to apply the acquired knowledge. | 20 | A3 | B3<br>B5<br>B6 | C4 |
| Report of practices, practicum and external practices | Preparation of a report by part of the student in that they reflect the characteristics of the work carried out. The students have to describe the tasks and procedures developed, show the results obtained and/or observations made, as well as the analysis and treatment of data. | 35 | A3 | B3<br>B5<br>B6 | C4 |
| Presentation | Presentation by part of a group of students of a subject on contents of the subject or of the results of a work, exercise, project, etc. Can make of individual way or in group. | 15 | | | |
| Systematic observation | Attentive perception, rational, scheduled and systematic to describe and register the demonstrations of the behaviour of the students. It is possible to value learnings and actions, and as they carry out valuing the order, precision, the skill, efficiency, the active participation, etc. | 10 | A3 | B3<br>B5<br>B6 | C4 |

**Other comments on the Evaluation**

**1. Ordinary exam**

**1.1 Continuous assessment**

According to the guidelines of the degree and the agreements of the academic commission, a continuous assessment learning system will be offered.

The marks are valid only for the current academic year.

The schedule of the different assessment tests will be available at the beginning of each academic semester.

Continuous assessment consists of the following four parts:

1. Practices (35%), which are divided into:

- Development of the practices: realization of the practices of the matter. Missing is only allowed a session for justified reasons and must be recovered in another shift to the extent of the time possibilities. Your grade will be pass or fail.
- Laboratory practices report (35%).

2. Classroom exams (40%), which are roughly divided into:

- Objective tests (20%).
- Questions and exercises (20%).

3. Presentation (15%): The results of the work on a specific topic of the subject will be presented orally.

4. Systematic observation (10%). In addition, the student's participation in carrying out activities proposed for their autonomous work and participation in tutorials will be taken into account.

The final grade, which is scored out of a maximum of 10 points, is the sum of the grades for each part if the following conditions are met:

- Obtain a passing grade in laboratory practices (attendance at least two thirds of the practices).
- Obtain a minimum score of 40% in the practice report, and in the classroom exams.

If any of the above requirements is not met, the final grade will be the sum of the grades of each part, but limited to a maximum score of 4.9 points. Students who have not reached a minimum score of 40% in the evaluation of the report of the practices will have a term to make the appropriate improvements until the official date of the ordinary or extraordinary exam. Students who have not reached a minimum score of 40% in the classroom exams will be able to recover them in the official date of the ordinary or extraordinary exam maintaining the percentages of the continuous assessment.

To pass, students must obtain a total score equal to or greater than 50% of the maximum grade (5 points).

The exams of objective tests and exercises will be divided into two sessions distributed throughout the academic semester. The first exam will be performed in the middle of teaching period (during the hours of a theoretical class) and the second exam will take place on the date of the final exam.

**1.2 Global exam**

Students who do not opt for continuous assessment will have to take two exams similar to those of continuous assessment (objective test and exercises) and, they will have to make an oral presentation on one of the topics of the subject to choose between two options, if they have not previously requested the faculty to choose the topic. In addition, they must have obtained a pass grade in the laboratory practices.

It is understood that the completion of practices is mandatory regardless of the call to which they are presented.

To pass, you must obtain a minimum of 40% in each part and add a total of at least 5 points.

**2. Extraordinary exam**

In this call the evaluation will be as in the ordinary exam. It will be necessary to have passed the laboratory practices during the academic year.

**3. Ethical commitment**

The student is expected to exhibit appropriate ethical behavior. In the case of detecting unethical behavior (cheating, plagiarism, use of unauthorized electronic devices, or others) in any of the works or exams carried out, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

## Sources of information

### Basic Bibliography


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Stewart C. Bushong, **Manual de radiología para técnicos**, 978-84-1382-147-4, 12, Elsevier, 2022

Araceli Hernández Vitoria, María Cruz Lizuain Arroyo, Cristina Picón Olmos, **Fundamentos de Física Médica. Volumen 3: Radioterapia externa I. Bases físicas, equipos, determinación de la dosis absorbida y programa de garantía de calidad**, Aula Documendal de Investigación (A.D.I), 2012

Carlos Vallejo Carrascal, **Técnicas de imagen en medicina nuclear**, Editorial Síntesis, 2019

C. Álvarez, C. Escalada, P. Fernández, N. Ferrer, L. Carlos Martínez, M.C. Paredes, **Fundamentos de Física Médica. Volumen 7: Protección radiológica hospitalaria**, Aula Documendal de Investigación (A.D.I), 2016

Ignacio López Moranchel, **Protección radiológica**, 2ª, Editorial Síntesis, 2019

Ángel Alberich-Bayarri, Gracián García Martí, Eduardo Guibelalde del Castillo, Roberto Sanz Requena, **Fundamentos de Física Médica. Volumen 10: Radiaciones no ionizantes II. Resonancia magnética. Bases físicas, equipos y control de calidad.**, Aula Documendal de Investigación (A.D.I), 2018

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### Complementary Bibliography


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X. Pifarré, M. A. Rivas, J. Valverde, P. Ruiz, J. Molero, M.F. Rodríguez, **Fundamentos de Física Médica. Volumen 2: Radiodiagnóstico: bases físicas, equipos y control de calidad.**, Aula Documendal de Investigación (A.D.I), 2012

Patricia Irene Maurelos Castell, Ignacio López Moranchel, **Técnicas de radiología simple**, 2ª, Editorial Síntesis, 2020

Juan Montero Reyes, María Carmen Prieto, Daniela de Araujo, **Técnicas de radiología especial**, Editorial Síntesis, 2017

J.M. Delgado Rodríguez, A. García Romero, F. García Vicente, E. Millán Cebrián, **Fundamentos de Física Médica. Volumen 4: Radioterapia externa II. Dosimetría clínica, algoritmos de cálculo, sistemas de planificación y control de calidad.**, Aula Documendal de Investigación (A.D.I), 2013

F. Ballester, A. Brosed, V. Carmona, V. Crispín, et al, **Fundamentos de Física Médica. Volumen 5: Braquiterapia: bases físicas, equipos y control de calidad**, Aula Documendal de Investigación (A.D.I), 2014

R. Barquero, N. Ferrer, J.M. Martí, J. Pavía, R. Puchal, X. Setoain, **Fundamentos de Física Médica. Volumen 6: Medicina nuclear: bases físicas, equipos y control de calidad**, Aula Documendal de Investigación (A.D.I), 2014

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Álvaro Ruibal Morell, **La biología en la medicina nuclear e imagen molecular oncológica**, 2020

CONSEJO DE LA UNIÓN EUROPEA de 5 de diciembre de 2013, **DIRECTIVA 2013/59/EURATOM**, Diario Oficial de la Unión Europea, 2013

Centro de documentación: Normativa, **Consejo de Seguridad Nuclear (CSN)**,

González; Woods; Eddins, **Digital Image Processing using MATLAB**, 978-0-9820854-1-7, Third edition, Gatesmark Publishing, 2020


## Recommendations

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **(*)Análisis biomecánico de actividades e funcións humanas** | | | | |
| Subject | (*)Análisis biomecánico de actividades e funcións humanas | | | |
| Code | V04M192V01105 | | | |
| Study programme | Máster Universitario en Ingeniería Biomédica | | | |
| Descriptors | ECTS Credits | Choose | Year | Quadmester |
| | 4.5 | Mandatory | 1st | 1st |
| Teaching language | Spanish<br>Galician | | | |
| Department | | | | |
| Coordinator | López Campos, José Ángel | | | |
| Lecturers | López Campos, José Ángel | | | |
| E-mail | joseangellopezcampos@uvigo.es | | | |
| Web | | | | |
| General description | | | | |

| Training and Learning Results | |
|---|---|
| Code | |
| A5 | Students must possess the learning skills that enable them to continue studying in a way that will be largely self-directed or autonomous. |
| B3 | Knowledge in basic and technological subjects that will enable students to learn new methods and theories, and provide them the versatility to adapt to new situations. |
| C5 | Ability to develop biomechanical models of the musculoskeletal system based on the anthropometry of the human body and the mechanical laws of motion. |

| Expected results from this subject | |
|---|---|
| Expected results from this subject | Training and Learning Results |
| To know the principles of biomechanical analysis of human activities and functions | B3<br>C5 |
| To apply knowledge of the principles of biomechanical analysis of human activities and functions in the design within the field of biomedical engineering | A5<br>B3<br>C5 |

| Contents | |
|---|---|
| Topic | |
| 1.- Technical features related to the analysis of muscular activation using EMG. | 1.1. - Obtaining of raw signal. Protocols for data adcquisition.<br><br>1.2. - Signal processing. Filters, smoothing and normalisation.<br><br>1.3. - Implementation of signal processing tools. |
| 2.- Motion capture using optical devices. | 2.1. - Motion capture systems using cameras and markers.<br><br>2.2. - Calibration of optical systems.<br><br>2.3. - Capture, treatment and data export. |
| 3.- Computational simulation of biomechanic systems. | 3.1. - Multi-body models for the simulation of biomechanic systems.<br><br>3.2. - Scaling and inverse kinematics.<br><br>3.3. - Dynamic of biomechanic systems, muscular control and reverse dynamics. Systems for motion assistant. |

| Planning | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Lecturing | 15 | 0 | 15 |
| Practicum, External practices and clinical practices | 18 | 0 | 18 |

| | | | |
|---|---|---|---|
| Autonomous problem solving | 0 | 50 | 50 |
| Mentored work | 0 | 26.5 | 26.5 |
| Presentation | 2 | 0 | 2 |
| Systematic observation | 32 | 0 | 32 |
| Project | 0 | 26.5 | 26.5 |
| Report of practices, practicum and external practices | 0 | 30 | 30 |

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

## Methodologies

| | Description |
|---|---|
| Lecturing | Sessions in which the professor exposes the new theoretical concepts to the students, accompanied of brief practical examples. |
| Practicum, External practices and clinical practices | Sessions in which, the theoretical concepts developed during the lectures are carried to the practice by the student with the support of the educational. Furthermore, the student will receive training about the tools and methods applied in the resolution of practical problems. |
| Autonomous problem solving | Taking as starting point the concepts that were depeloved during lectures and the practical sessions, a set of problems are posed so that the student can apply the tools and skills adcquired in the resolution of problems. |
| Mentored work | Extensive study in which the student will apply all the tools developed in the matter to carry out a study with a wide scope to the whole of the topics that were covered by the subject. |
| Presentation | |

## Personalized assistance

| Methodologies | Description |
|---|---|
| Mentored work | Personalised sessions will be available for the student, in order to answer the doubts that can arise during the resolution of problems. |

| Tests | Description |
|---|---|
| Project | Personalised sessions will be available for the student, they will be oriented to give guidelines to the student for performing the work and in order to remember and apply theoretical concepts in the project developed. |

## Assessment

| | Description | Qualification | Training and Learning Results | | |
|---|---|---|---|---|---|
| Presentation | (*)Presentación, discusión e defensa dos resultados obtidos. | 10 | A5 | B3 | C5 |
| Systematic observation | The attitude of the student in the theoretical and practical lessons will be evaluated. Evaluation is performed by regarding participation, assistance and autonomous work. | 20 | A5 | B3 | |
| Project | The project delivered by the student will be evaluated. | 40 | A5 | B3 | C5 |
| Report of practices, practicum and external practices | Continuous evaluation will be performed based on the ability of resolution of problems proposed during the practice lessons. | 30 | A5 | B3 | C5 |

## Other comments on the Evaluation

## Sources of information

### Basic Bibliography

**Biomechanics of the musculo-skeletal system**, 2º, John Wiley and Sons, 1999

### Complementary Bibliography

H. Moore, **MATLAB for Engineers**, 4º, Financial Times Prentice Hall, 2014

## Recommendations

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **(*)Biomateriales avanzados e enxeñaría tisular** | | | | |
| Subject | (*)Biomateriales avanzados e enxeñaría tisular | | | |
| Code | V04M192V01106 | | | |
| Study programme | Máster Universitario en Ingeniería Biomédica | | | |
| Descriptors | ECTS Credits | Choose | Year | Quadmester |
| | 6 | Mandatory | 1st | 1st |
| Teaching language | Spanish<br>Galician | | | |
| Department | | | | |
| Coordinator | González Fernández, Pio Manuel<br>Serra Rodríguez, Julia Asunción | | | |
| Lecturers | Chiussi , Stefano<br>González Fernández, Pio Manuel<br>López Álvarez, Miriam<br>Serra Rodríguez, Julia Asunción | | | |
| E-mail | pglez@uvigo.es<br>jserra@uvigo.es | | | |
| Web | | | | |
| General description | | | | |

| Training and Learning Results | |
|---|---|
| Code | |
| A4 | Students can communicate their conclusions, and the knowledge and rationale underpinning these, to specialist and non-specialist audiences clearly and unambiguously. |
| B1 | Ability to design, develop, implement, manage and improve products and processes in the different areas of the biomedical engineering, by means of appropriate analytical, computational or experimental techniques. |
| B3 | Knowledge in basic and technological subjects that will enable students to learn new methods and theories, and provide them the versatility to adapt to new situations. |
| B4 | Ability to solve problems with initiative, decision making, creativity, critical reasoning and to communicate and transmit knowledge, abilities and skills in the field of biomedical engineering. |
| B5 | Knowledge to carry out measurements, calculations, assessments, appraisals, surveys, studies, reports, work plans and other similar works. |
| C6 | Knowledge of tissue engineering and ability to analyze, manage and design biomaterials with advanced properties and response to stimuli. |
| D1 | Ability to understand the meaning and application of the gender perspective in the different fields of knowledge and in professional practice with the aim of achieving a more just and equal society. |
| D3 | Sustainability and environmental commitment. Equitable, responsible and efficient use of resources. |

| Expected results from this subject | Training and Learning Results |
|---|---|
| Know the basic principles of tissue engineering and the ones of biomaterials with advanced properties, including response to stimuli | B3<br>C6<br>D1<br>D3 |
| Apply knowledge of the theoretical concepts of tissue engineering and the ones of biomaterials with advanced properties, including response to stimuli. | A4<br>B1<br>B4<br>B5<br>C6<br>D1<br>D3 |

| Contents | |
|---|---|
| Topic | |
| 1.- Introduction to advanced biomaterials and tissue engineering | 1.1. Basic concepts on advanced biomaterials<br>1.2. Basic concepts on tissue engineering |

| | |
|---|---|
| 2.- Design of advanced biomaterials | 2.1. Basic technical features and examples of bioinspired biomaterials<br>2.2. Basic 3D design tools<br>2.3. Scaffolds for tissue engineering<br>2.4. Biomaterials with osteoconductive and osteoinductive properties<br>2.5. Biomaterials with bactericidal properties<br>2.6. Biomaterials with antitumor properties |
| 3.- Smart biomaterials | 3.1. Basic technical features and examples of biosensors<br>3.2. Heat-transfer-based biomedical devices by laser-induced photothermy<br>3.3. Heat-transfer-based biomedical devices by electromagnetic induction<br>3.4. 4D Printing: 3D biomaterials shape/function modification over time in response to specific temperature, humidity or pressure conditions |
| 4.- Manufacture, characterization and sterilization of advanced biomaterials | 4.1. Techniques for the manufacture of advanced biomaterials<br>4.2. Techniques for the characterization of advanced biomaterials<br>4.3. Techniques for the sterilization of biomaterials |
| 5.- Biological evaluation of biomedical devices | 5.1. Nature of the substrate/support for culture and aseptic techniques<br>5.2. Physicochemical and physiological conditions of the cell growth medium<br>5.3. Incubation conditions: gas phase, humidity and temperature<br>5.4. Advantages and disadvantages of cell culture |
| 6.- Case reports | 6.1. Case study in Musculoskeletal System<br>6.2. Case study in Dentistry<br>6.3. Case study in Otorhinolaryngology<br>6.4. Case study in Tissue Engineering |
| 7.- Practical experiences | 7.1. Design and manufacture of advanced biomaterials<br>7.2. Design and 3D manufacture for tissue engineering<br>7.3. Hyperthermia testing<br>7.4. Analysis of advanced biomaterials<br>7.5. Manufacturing in Clean Room<br>7.6. Cytotoxicity assay |

**Planning**

| | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Lecturing | 10 | 25 | 35 |
| Presentation | 10 | 21 | 31 |
| Case studies | 4 | 5 | 9 |
| Research based methodologies | 4 | 5 | 9 |
| Laboratory practical | 16 | 30 | 46 |
| Essay questions exam | 1 | 0 | 1 |
| Presentation | 1 | 0 | 1 |
| Report of practices, practicum and external practices | 1 | 16 | 17 |
| Systematic observation | 1 | 0 | 1 |

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

**Methodologies**

| | Description |
|---|---|
| Lecturing | Content exposure by the lecturer on the subject matter of study, including theoretical bases, guidelines for reports and proposal of practical exercises that the student has to develop. |
| Presentation | Oral exposure by the students to the teacher and a group of students on a particular subject of interest within the contents or on the obtained results from a task, exercise, project... It will be carried out individually or in a group. |
| Case studies | Analysis of specific cases on the subject under study. The results of the search and analysis of the information will be presented to the teacher and group of students. |
| Research based methodologies | Activities developed in the laboratory practices and the preparation of reports based on the results of the scientific research carried out by following the scientific methodology. |
| Laboratory practical | Activities of application of knowledge to specific situations implying the acquisition of basic and procedural skills related to the subject matter of study. They will be performed in prepared spaces with specialized equipment (laboratories, computer rooms...) |

**Personalized assistance**

| Methodologies | Description |
|---|---|
| Presentation | Resolution of doubts and personalized help during one-on-one tutoring hours |
| Research based methodologies | Personalized guide on the experimental work taking into account the specific strengths and needs of each student |

| | |
|---|---|
| Laboratory practical | Personalized guide on the experimental work taking into account the specific strengths and needs of each student |

| Assessment | | | | | | |
|---|---|---|---|---|---|---|
| | Description | Qualification | Training and Learning Results | | | |
| Essay questions exam | Tests that include open questions on a developed topic as well as short answer questions. | 30 | | B1<br>B3<br>B4 | C6 | |
| Presentation | Content exposure by the students to the teacher and/or a group of students on a topic of relevance about the contents or the obtained results from a task, exercise, project... It can be carried out individually or in a group. | 30 | A4 | B3<br>B4 | C6 | |
| Report of practices, practicum and external practices | Preparation of a report by the students in which the characteristics of the assigned work will be reflected. Students must describe the tasks and developed protocol, show the obtained results or observations made, as well as the procedure followed for data analysis and treatment. | 30 | A4 | B1<br>B3<br>B4<br>B5 | C6 | |
| Systematic observation | Attentive, rational, planned and systematic perception to describe and record the attitude/aptitute of the student. | 10 | A4 | B4 | | D1<br>D3 |

**Other comments on the Evaluation**

The subject surpasses when obtaining a mark equal or upper to 5 points (on 10 points), obtained of the following form:

a) Continuous evaluation, practices of laboratory (30%) and oral expositions (30%), mandatory with minimum assistance of 80%;b) Global evaluation, proof of short answer (30%) and systematic observation (10%)c) Second opportunity, only reevaluation of methodoly/proofs considered non apt.

**Sources of information**

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R. Ian Freshney, **Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications**, 7th, Wiley Blackwell, 2016

William R. Wagner, Shelly E. Sakiyama-Elbert, Guigen Zhang, Michael J. Yaszemsk, **Biomaterials science : an introduction to materials in medicine**, 4, Elsevier, 2020

Clemens A. van Blitterswijk, Jan de Boer, **Tissue engineering**, 2, Academic Press, 2015

**Complementary Bibliography**

**Recommendations**

**Other comments**

EXCEPTIONAL MEASURES PLANNED
=== ADAPTATION OF METHODOLOGIES ===
* Teaching methodologies that are modified
* Remote-teaching
The Remote Campus tools will be used in synchronous mode for the presentation of contents, fundamentals, theory, general guidelines for carrying out activities and practical cases. All teaching material and resources will be available on the Faitic platform.
* Non-face-to-face mechanism for student assistance (tutoring)
Personalized attention. Communication via e-mail or other necessary telematic tool. Virtual Office Tutoring (Remote Campus).
=== ADAPTATION OF THE ASSESSMENT ===
On-line tests will be carried out (Remote Campus and Faitic) to expose topics, send papers and a multiple answer questionnaire.
The ratios indicated in the teaching guide of the subject will be maintained.

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **(*)Sinais biomédicas** | | | | |
| Subject | (*)Sinais biomédicas | | | |
| Code | V04M192V01201 | | | |
| Study programme | Máster Universitario en Ingeniería Biomédica | | | |
| Descriptors | ECTS Credits | Choose | Year | Quadmester |
| | 4.5 | Mandatory | 1st | 2nd |
| Teaching language | Spanish | | | |
| Department | | | | |
| Coordinator | Torres Guijarro, María Soledad | | | |
| Lecturers | Torres Guijarro, María Soledad | | | |
| E-mail | soledadtorres@uvigo.es | | | |
| Web | | | | |
| General description | In this course we will learn how to process encephalograms, electromyograms and electrocardiograms, extract their characteristics and classify them automatically using machine learning techniques. The learning methodology is "hands-on" using Matlab from the first day. Students must bring their laptop to all classroom sessions. | | | |

| Training and Learning Results | |
|---|---|
| Code | |
| A3 | That students are able to integrate knowledge and handle complexity and formulate judgments based on information that was incomplete or limited, include reflecting on social and ethical responsibilities linked to the application of their knowledge and judgments. |
| A5 | Students must possess the learning skills that enable them to continue studying in a way that will be largely self-directed or autonomous. |
| B3 | Knowledge in basic and technological subjects that will enable students to learn new methods and theories, and provide them the versatility to adapt to new situations. |
| B6 | Capacity for handling specifications, regulations and mandatory standards. |
| C11 | Ability to analyze and interpret signals and images from the biomedical field. |

| Expected results from this subject | Training and Learning Results |
|---|---|
| To know the signal processing techniques, and to apply them to biomedical signals. | A3<br>A5<br>B3<br>B6<br>C11 |
| To know the techniques of feature extraction and signal dimension reduction, and to apply them to biomedical signals | A3<br>A5<br>B3<br>B6<br>C11 |
| To know the methods<br>automatic classification systems, and to apply them to biomedical signals | A3<br>A5<br>B3<br>B6<br>C11 |

| Contents | |
|---|---|
| Topic | |
| Biomedical signal analysis techniques | Introduction to spectral analysis. Power spectral density. Model-based parametric methods. Subspace-based methods for spectral analysis. Time-frequency analysis |
| Feature extraction and dimension reduction | Feature extraction methods Dimension reduction/feature selection methods. |
| Biomedical signal classification methods | Performance evaluation metrics. Linear discriminant analysis. K-Nearest Neighbour. Artificial Neural Networks. Support Vector Machines. |

| Planning |
|---|

| | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Lecturing | 26 | 23 | 49 |
| Problem solving | 7.5 | 15 | 22.5 |
| Mentored work | 2 | 27 | 29 |
| Essay questions exam | 1 | 0 | 1 |
| Problem and/or exercise solving | 1 | 0 | 1 |
| Essay | 0 | 10 | 10 |

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

## Methodologies

| | Description |
|---|---|
| Lecturing | Presentation by the teacher of the contents of the subject, fostering the critical discussion of the concepts. The theoretical grounds of algorithms and procedures used to resolve problems are given.<br>With this methodology they work the competences CB3, CB5, CG3, CG6 and CE11. |
| Problem solving | Theoretical content is complemented by problem solving using the Matlab programme. With this methodology they work the competences CB3, CB5, CG3, CG6 and CE11, individually. |
| Mentored work | Students apply the contents to a specific case with real signals, consulting the bibliography and using the Matlab programme. This methodology is used to work on the competences CB3, CB5, CG3, CG6 and CE11, in pairs. |

## Personalized assistance

| Methodologies | Description |
|---|---|
| Lecturing | Doubts can be solved in the rests of the classes and in the teacher tutorial sesions. These tutorial sessions will be done individually or in short groups (with a maximum of 2-3 students). The tutorial sessions are typically agreed with the professor. The meetng requests can be done personally or by email. |
| Problem solving | Problems sessions are a good moment to consult doubts with the professor. The professor moves between the tables and some students take advantage of the proximity of the professor to consult doubts. |

## Assessment

| | Description | Qualification | Training and Learning Results | | |
|---|---|---|---|---|---|
| Essay questions exam | Written assessment tests, with long developmental questions. | 40 | A3<br>A5 | B3<br>B6 | C11 |
| Problem and/or exercise solving | Written evaluation tests, with brief questions and problems. | 20 | A3<br>A5 | B3<br>B6 | C11 |
| Essay | Assessment of the code and written reports describing the tutored work | 40 | A3<br>A5 | B3<br>B6 | C11 |

## Other comments on the Evaluation

CONTINUOUS ASSESSMENT

In continuous assessment, there will be two written assessment tests, one in the middle and the other at the end of the term.

In order to pass the course, it is necessary to obtain a score of 4 out of 10 or higher in each of the evaluable activities (two written tests, problems and tutored work).

GLOBAL ASSESSMENT

A written test will be given at the official date at the end of the term, and the problems and the tutored work will be handed in on the same date. In order to pass the course, it is necessary to obtain a score of 4 out of 10 or higher in each of the evaluable activities.

## Sources of information

### Basic Bibliography

John L. Semmlow, Benjamin Griffel, **Biosignal and medical image processing**, 978-1-4665-6738-8, 3, CRC Press, 2014

Londa Schiebinger, **Integrating Sex, Gender, and Intersectional Analysis into Bioengineering**, Elsevier, 2022

### Complementary Bibliography

Abdulhamit Subasi, **Practical Guide for Biomedical Signals Analysis Using Machine Learning Techniques - A MATLAB based approach**, 1, Academic Press, 2019
Rangaraj M. Rangayyan, **Biomedical signal analysis. A case-study approach**, 1, Wiley-IEEE Press, 2002

## Recommendations

### Subjects that continue the syllabus

(*)Análise cronobiolóxico de sinais biomédicas/V04M192V01306
(*)Bioinstrumentación. Sistemas de monitorización/V04M192V01305
(*)Tecnoloxías de imaxe médica/V04M192V01301

### Subjects that it is recommended to have taken before

(*)Estatística avanzada para a enxeñaría biomédica/V04M192V01101
(*)Métodos matemáticos aplicados á enxeñaria biomédica/V04M192V01102

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **(*)Control e regulación das funcións corporais** | | | | |
| Subject | (*)Control e regulación das funcións corporais | | | |
| Code | V04M192V01202 | | | |
| Study programme | Máster Universitario en Ingeniería Biomédica | | | |
| Descriptors | ECTS Credits | Choose | Year | Quadmester |
| | 4.5 | Mandatory | 1st | 2nd |
| Teaching language | | | | |
| Department | | | | |
| Coordinator | Delgado Romero, Mª Emma | | | |
| Lecturers | Barreiro Blas, Antonio<br>Delgado Romero, Mª Emma | | | |
| E-mail | emmad@uvigo.es | | | |
| Web | | | | |
| General description | (*)La asignatura centra su contenido en el análisis y desarrollo de técnicas de control automático clásico y avanzado aplicables en la regulación de las denominadas grandes funciones corporales. | | | |

| Training and Learning Results | |
|---|---|
| Code | |
| A5 | Students must possess the learning skills that enable them to continue studying in a way that will be largely self-directed or autonomous. |
| B3 | Knowledge in basic and technological subjects that will enable students to learn new methods and theories, and provide them the versatility to adapt to new situations. |
| C8 | Knowledge and ability to know methods of control and regulation and to apply advanced dynamic analysis techniques. |

| Expected results from this subject | |
|---|---|
| Expected results from this subject | Training and Learning Results |
| To know the control systems in biomedicine: Analysis and design in the time and frequency domain. | B3<br>C8 |
| To apply controllability and state estimation methods | A5<br>C8 |
| To know and to apply advanced techniques of dynamic analysis and control. | A5<br>B3<br>C8 |

| Contents | |
|---|---|
| Topic | |
| Subject 1. Control and regulation systems of corporal functions | Introduction, concepts, aims and applications. Modelling review of linear systems in continuous and discreet time. Stability concept, transitory and permanent. Diagram and computational tools for analysis and temporary design. |
| Subject 2. Frequency analysis and design | Frequency response function. Stability Criterion. Relative stability. Diagrams and computational tools for analysis and design in frequency. |
| Subject 3. Modelling, analysis and design in state variables | Controlability and observability. States feedbacks. Allocation of poles. Design of asymptotic observers. Principle of separation. |
| Subject 4. LQR regulator and Kalman filter | Optimum control: linear quadratic regulator (LQR) and optimum estimate Kalman filter. |
| Subject 5. Technicians advanced of dynamic analysis and control | Applications in physiological systems. |

| Planning | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Lecturing | 24 | 40 | 64 |
| Laboratory practical | 12 | 32.5 | 44.5 |
| Essay questions exam | 4 | 0 | 4 |
| *The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. | | | |

| Methodologies | |
|---|---|
| | Description |
| Lecturing | Theory classes with support of audiovisual means: cannon, portable computer and Internet connection |
| Laboratory practical | They will make six sessions of laboratory, each one of two hours, where the student will put in practice and will simulate the technicians and applications developed in the theory classes. In general, the student will develop a previous work to each session, the work of laboratory and a brief memory of results, as it indicate in each case. |

| Personalized assistance | |
|---|---|
| **Methodologies** | **Description** |
| Lecturing | Personalised attention during the sessions of the classroom and in schedule of tutorials to attend the doubts and queries to the didactic material proposed in the matter and its application to practical cases. |
| Laboratory practical | Personalised attention during the sessions of the laboratory and in schedule of tutorials to attend the doubts related with the practices to develop. |
| **Tests** | **Description** |
| Essay questions exam | Personalised attention during the realisation of the proofs to attend the doubts in the billed interpretation. |

| Assessment | | | | | |
|---|---|---|---|---|---|
| | Description | Qualification | Training and Learning Results | | |
| Laboratory practical | Continuous evaluation of the matter. The final mark is the average of the marks obtained in the sessions. It will correspond to 20% of the final note of the subject. | 20 | A5 | B3 | C8 |
| Essay questions exam | (1) Continuous evaluation of the matter. Proofs of long answer and/or development, and/or resolution of problems/exercises in each one of the subjects of theory and practical of laboratory. It will correspond to 40% of the final note of the subject.<br><br>(2) Examination/work. Proof of long answer and/or development, and/or resolution of problems/exercises. It will correspond to 40% of the final note of the subject. | 80 | | B3 | C8 |

**Other comments on the Evaluation**

To pass the matter the student has to obtain at least 5 points on 10 in the total mark of any call.

**Sources of information**

**Basic Bibliography**

L.Moreno, S.Garrido, C.Balaguer,, **Ingeniería de Control**, Ariel, 2003

J. Fernández de Cañete, C.Galindo, J. Barbancho, A. Luque, **Automatic control systems in biomedical engineering**, Springer, 2018

**Complementary Bibliography**

Astrom, Murray, **Feedback Systems**, Princeton University Press, 2008

**Recommendations**

**Subjects that it is recommended to have taken before**

(*)Modelado e simulación sistemas biomédicos/V04M192V01103

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **(*)Simulación de biofluídos en enxeñaría biomédica** | | | | |
| Subject | (*)Simulación de biofluídos en enxeñaría biomédica | | | |
| Code | V04M192V01203 | | | |
| Study programme | Máster Universitario en Ingeniería Biomédica | | | |
| Descriptors | ECTS Credits | Choose | Year | Quadmester |
| | 4.5 | Mandatory | 1st | 2nd |
| Teaching language | Spanish<br>Galician | | | |
| Department | | | | |
| Coordinator | Vence Fernández, Jesús | | | |
| Lecturers | Vence Fernández, Jesús | | | |
| E-mail | jvence@uvigo.es | | | |
| Web | | | | |
| General description | Application of numerical methods to solve problems applied to biofluid dynamics | | | |

| Training and Learning Results | |
|---|---|
| Code | |
| A1 | Knowledge and understanding that provide a basis or opportunity for originality in developing and / or applying ideas, often in a research context. |
| A4 | Students can communicate their conclusions, and the knowledge and rationale underpinning these, to specialist and non-specialist audiences clearly and unambiguously. |
| B3 | Knowledge in basic and technological subjects that will enable students to learn new methods and theories, and provide them the versatility to adapt to new situations. |
| B4 | Ability to solve problems with initiative, decision making, creativity, critical reasoning and to communicate and transmit knowledge, abilities and skills in the field of biomedical engineering. |
| B5 | Knowledge to carry out measurements, calculations, assessments, appraisals, surveys, studies, reports, work plans and other similar works. |
| C9 | Knowledge of the biophysical foundation, the theoretical analysis and modeling of the mechanical aspects of biological fluids. |

| Expected results from this subject | Training and Learning Results |
|---|---|
| To know the principles of biofluid analysis in biomedical engineering | A1<br>B3<br>B5<br>C9 |
| To apply knowledge of biofluid analysis in biomedical engineering. | A4<br>B3<br>B4<br>B5<br>C9 |
| To know the fundamentals of fluid dynamic simulation of biofluids | A1<br>B3<br>C9 |

| Contents | |
|---|---|
| Topic | |
| 1. Introduction to biofluids, properties and fundamentals. | Characteristics, equations and models used to solve biofluid dynamics problems. |
| 2. Computer tools for medical image processing | Visualization and treatment of medical images. Extraction of geometric models. Preparation of simulation domains |
| 3. Macrocirculation. Hemodynamic simulations. | Equations and models. Simulation of blood flow in aneurysms. |
| 4. Airway simulations. Microcirculation. | Study of airflows in the respiratory system. Aerosol dispersion simulation in the respiratory tract |
| 5. Fluid-structure interaction. Mass transport. | Simulation of systems with geometric deformation by adjusting the fluid-structure behavior in applications in the field of biofluids |

| | |
|---|---|
| 6. Modeling of medical devices. | Introduction to the analysis of fluid flows in machinery and devices of sanitary applications |

| Planning | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Lecturing | 16.7 | 33.3 | 50 |
| Practices through ICT | 13.3 | 26.7 | 40 |
| Problem solving | 4.5 | 9 | 13.5 |
| Objective questions exam | 3 | 0 | 3 |
| *The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. | | | |

| Methodologies | |
|---|---|
| | Description |
| Lecturing | Introduction and description of the different concepts and technical related with the subject |
| Practices through ICT | Resolution of problems of biofluids by means of the use of software of numerical simulation |
| Problem solving | Put in practice of the knowledge acquired in the subject by means of his application to the resolution of problems of biomedical engineering |

| Personalized assistance | |
|---|---|
| **Methodologies** | **Description** |
| Lecturing | In group or individual office hours, to reinforce knowledge and supervise the proposed activities |
| Practices through ICT | In group or individual office hours, to reinforce knowledge and supervise the proposed activities |
| Problem solving | In group or individual office hours, to reinforce knowledge and supervise the proposed activities |

| Assessment | | | | | |
|---|---|---|---|---|---|
| | Description | Qualification | Training and Learning Results | | |
| Practices through ICT | It will evaluate the quality of the solutions contributed in the reports of the activities proposed. | 35 | A4 | B4 | C9 |
| Problem solving | It will evaluate the quality of the solutions collected in the reports of the proposed activities and/or projects. | 35 | A4 | B4 | C9 |
| Objective questions exam | It will evaluate in a partial final/examination the concepts given in the sessions of classroom and laboratory | 30 | | B4<br>B5 | C9 |

**Other comments on the Evaluation**

The assessment of the subject is divided into the following sections:

- Multiple-choice exam: 30% of the total grade.
- Practical exercises with ICT support (submission of practice reports and other tasks proposed by the teaching staff): 35% of the total grade.
- Problem-solving (submission of reports or assignments on hypothetical scenarios proposed by the teaching staff): 35% of the total grade.

To pass the subject, students must obtain a minimum score of 20% in each assessment section.

By default, the assessment will be conducted through Continuous Assessment for all students. Any student who wishes to do so can opt out of this assessment method by requesting it within the specified time frame determined by the School.

For students who choose the Continuous Assessment method and fail the course in the First Opportunity exam (May), in order to pass the course in the Second Opportunity exam (July), the course instructors will provide them with the submissions or assignments they need to complete in order to be evaluated in that exam.

Students who opt out of the Continuous Assessment method will be evaluated based on a single test with 100% of the grade. In this case, the student must notify the course instructors with sufficient notice, who will then provide the evaluation methodology.

Ethical Commitment:

Students are expected to demonstrate appropriate ethical behavior. In the event of detecting unethical behavior (copying,

plagiarism, use of unauthorized electronic devices, among others), it will be considered that the student does not meet the necessary requirements to pass the course. In this case, the overall grade for the current academic year will be a failing grade (0.0).

| Sources of information |
| --- |
| **Basic Bibliography** |
| Jiri Blazek, **Computational Fluid Dynamics: Principles and Applications**, Elsevier, 2015 |
| T. Kajishima, K. Taira, **Computational fluid dynamics: Incompressible turbulent flows**, Springer, 2017 |
| **Complementary Bibliography** |
| Anderson et al., **Computational fluid dynamics: An introduction**, Springer, 2099 |
| Jesús Manuel Fernández Oro, **Técnicas numéricas en ingeniería de fluidos**, Reverté, 2012 |
| García Navarro et al., **Introducción a la mecánica de fluidos computacional**, Universidad de Zaragoza, 2021 |
| Y. A. Çengel and J. M. Cimbala, **Mecánica de fluidos: Fundamentos y aplicaciones**, McGraw-Hill, 2006 |

| Recommendations |
| --- |

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **(*)Biolectroquímica** | | | | |
| Subject | (*)Biolectroquímica | | | |
| Code | V04M192V01204 | | | |
| Study programme | Máster Universitario en Ingeniería Biomédica | | | |
| Descriptors | ECTS Credits | Choose | Year | Quadmester |
| | 3 | Mandatory | 1st | 2nd |
| Teaching language | Galician | | | |
| Department | | | | |
| Coordinator | Nóvoa Rodríguez, Ramón | | | |
| Lecturers | Nóvoa Rodríguez, Ramón | | | |
| E-mail | rnovoa@uvigo.gal | | | |
| Web | http://moovi.uvigo.gal/ | | | |
| General description | In this subject it is intended to introduce students to the discipline of Electrochemistry, its fundamentals and their applications, with special emphasis on biotechnological applications. | | | |

| Training and Learning Results | |
|---|---|
| Code | |
| A5 | Students must possess the learning skills that enable them to continue studying in a way that will be largely self-directed or autonomous. |
| B3 | Knowledge in basic and technological subjects that will enable students to learn new methods and theories, and provide them the versatility to adapt to new situations. |
| C10 | Knowledge and ability to apply the principles of the electrochemistry in the biomedical field. |
| D3 | Sustainability and environmental commitment. Equitable, responsible and efficient use of resources. |

| Expected results from this subject | |
|---|---|
| Expected results from this subject | Training and Learning Results |
| To apply knowledge of bioelectrochemistry in the field of biomedical engineering. | A5<br>B3<br>C10<br>D3 |

| Contents | |
|---|---|
| Topic | |
| 1. Introduction. | Nature and applications of electrochemistry.<br>Electrolytes in living beings. |
| 2. Electrochemical Cells. | Properties.<br>Electrode Potential.<br>Reference electrodes. |
| 3. Interfaces. | Double layer models.<br>Electrokinetic Phenomena |
| 4. Kinetics and transport in electrode reactions | Butler-Volmer Equation.<br>Fick's Laws |
| 5. Experimental techniques. | Potentiometry.<br>Amperometry.<br>Voltammetry.<br>Impedance.<br>Electrophoresis. |
| 6. Sensors (electrochemical and bioelectrochemical). | Potentiometric Sensors<br>Amperometric Sensors<br>Impedimetric Sensors<br>Macroelectrodes<br>Microelectrodes<br>Miniaturization (lab-on-chip). |
| 7. Biocompatibility and corrosion. | Corrosion basics<br>Corrosion in sensors and implants |

| Planning | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Lecturing | 15 | 30 | 45 |

| | | | |
|---|---|---|---|
| Laboratory practical | 6 | 9 | 15 |
| Problem solving | 3 | 4.5 | 7.5 |
| Report of practices, practicum and external practices | 0.5 | 4 | 4.5 |
| Essay questions exam | 3 | 0 | 3 |

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

## Methodologies

| | Description |
|---|---|
| Lecturing | Presentation of the subject contents with audiovisual support. |
| Laboratory practical | The practices will have individual support to the students |
| Problem solving | The resolution of exercises will have individual support to the students |

## Personalized assistance

| Methodologies | Description |
|---|---|
| Lecturing | Practical aspects with example exercises will be interspersed in the presentation of contents. |
| Laboratory practical | Exercises and practices will be carried out synchronized with theoretical teaching |
| Problem solving | The exercises, with individual support, will allow to fix the theoretical concepts. |

## Assessment

| | Description | Qualification | Training and Learning Results | | | |
|---|---|---|---|---|---|---|
| Lecturing | Classical exam of theory and exercises | 40 | | B3 | C10 | |
| Laboratory practical | The development in the laboratory, the previous preparation of the practice and the final report are graded | 30 | A5 | | | D3 |
| Problem solving | Autonomous work and presented memory are graded | 30 | A5 | B3 | C10 | D3 |

## Other comments on the Evaluation

## Sources of information

### Basic Bibliography

R. Navanietha Krishnaraj, Rajesh K. Sani, **Bioelectrochemical Interface Engineering**, 978-1-119-53842-4, Wiley, 2019

C. M. A. BRETT, **ELECTROCHEMISTRY**, 0 19 855388 9, Oxford University Press, 1993

### Complementary Bibliography

P. N. Bartlett, **Bioelectrochemistry**, 978-0-470-84364-2, Wiley, 2008

## Recommendations

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **(*)Enxeñaría de superficies para aplicacións biomédicas** | | | | |
| Subject | (*)Enxeñaría de superficies para aplicacións biomédicas | | | |
| Code | V04M192V01205 | | | |
| Study programme | Máster Universitario en Ingeniería Biomédica | | | |
| Descriptors | ECTS Credits | Choose | Year | Quadmester |
| | 4.5 | Optional | 1st | 2nd |
| Teaching language | Spanish | | | |
| Department | | | | |
| Coordinator | Cristóbal Ortega, María Julia | | | |
| Lecturers | Cristóbal Ortega, María Julia | | | |
| E-mail | mortega@uvigo.es | | | |
| Web | | | | |
| General description | The aim of this subject is to know the principles of surface engineering for biomedical applications. | | | |

| Training and Learning Results | |
|---|---|
| Code | |
| A1 | Knowledge and understanding that provide a basis or opportunity for originality in developing and / or applying ideas, often in a research context. |
| A3 | That students are able to integrate knowledge and handle complexity and formulate judgments based on information that was incomplete or limited, include reflecting on social and ethical responsibilities linked to the application of their knowledge and judgments. |
| A4 | Students can communicate their conclusions, and the knowledge and rationale underpinning these, to specialist and non-specialist audiences clearly and unambiguously. |
| B4 | Ability to solve problems with initiative, decision making, creativity, critical reasoning and to communicate and transmit knowledge, abilities and skills in the field of biomedical engineering. |
| B6 | Capacity for handling specifications, regulations and mandatory standards. |

| Expected results from this subject | Training and Learning Results |
|---|---|
| To know the principles of surface engineering for biomedical applications | A1 |
| Advanced knowledge of the various techniques that make it possible to modify the surface of different biomaterials for achieve adequate control over their behavior | A1 |
| To apply the knowledge of surface engineering for biomedical applications | A3<br>A4<br>B4<br>B6 |
| To know the main techniques currently used to characterize these surfaces from the chemical point of view, and microstructural structure that allows obtaining information on the modification carried out and analyzing its effect on the behavior of the biomaterial | A1<br>A3<br>B6 |

| Contents | |
|---|---|
| Topic | |
| 1. Introduction to the Engineering of Surfaces for applications *biomédicas | 1.1 Importance of the surface: superficial properties<br>1.2 Types of *biomateriales: Interaction of with the half biological<br>1.3 Concept of Engineering of Surfaces |

| | |
|---|---|
| 2.- Technical advanced of superficial modification | 2.1 Methods of *texturización<br>2.2 physical Methods and chemists of *funcionalización of surfaces<br>2.3 ionic Implantation<br>2.4 electrolytic Oxidation<br>2.5 thermal Projection<br>2.6 *PVD and CVD<br>2.7 electrochemical Technicians and *electroforéticas<br>2.8 Coatings by Sol-*gel |
| 3.- Technical of characterisation of the surface | 3.1 SEM/*EDS<br>3.2 *TEM/*EBSD/*FIB<br>3.3 *SIMS<br>3.4 *AFM<br>3.5 *XRD<br>3.6 Technicians of thermal analysis (*TG, *DSC and *ATD)<br>3.7 Measures of angle of contact |

**Planning**

| | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Lecturing | 20 | 35.5 | 55.5 |
| Autonomous problem solving | 0 | 6 | 6 |
| Laboratory practical | 9 | 9 | 18 |
| Mentored work | 2 | 20 | 22 |
| Seminars | 3 | 5 | 8 |
| Problem and/or exercise solving | 2 | 0 | 2 |
| Laboratory practice | 1 | 0 | 1 |

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

**Methodologies**

| | Description |
|---|---|
| Lecturing | Exhibition by part of the professor of the contents on the matter object of study, theoretical bases and/or guidelines of a work, exercise that the/the student has to develop |
| Autonomous problem solving | Activity in which they formulate problems and/or exercises related with the subject. The student/to has to develop the analysis and resolution of the problems and/or exercises of autonomous form. |
| Laboratory practical | Activities of application of the knowledges to concrete situations and of acquisition of basic skills and *procedimentales related with the matter object of study. They develop in special spaces with skilled equipment (laboratories, computer classrooms, etc). |
| Mentored work | The/The student, of individual way or in group, elaborates a document on the thematic of the matter or prepares seminars, investigations, memories, essays, summaries of readings, conferences, etc.<br>The work is presented at the end of the *cuatrimestre in front of the rest of students. |
| Seminars | Activity focused to the work on a specific subject, that allows to deepen or complement the contents of the matter. Can employ as I complement of the theoretical classes. |

**Personalized assistance**

| Methodologies | Description |
|---|---|
| Mentored work | The lecturer, during tutorial hours, will resolve any doubts that the student may have. |
| Lecturing | The teacher, during the development of the theoretical classes, will resolve any doubts that the student may have. |
| Seminars | The teacher, during the seminar, will resolve any doubts that the student may have. |
| Laboratory practical | The professor, during the development of the practical laboratory classes, will solve the doubts that the student has. |

**Assessment**

| | Description | Qualification | Training and Learning Results | |
|---|---|---|---|---|
| Mentored work | The student will make of way *individualizada two works *tutelados along the course.<br>One related with the Technicians of Superficial Characterisation, and another related with the Technicians of Superficial Modification.<br>Both works evaluated<br>by the reports presented, and the exhibition in class of the work made.<br>Each one of the works represents 35% of the global note of the matter. | 70 | A1<br>A3<br>A4 | B4<br>B6 |

| | | | | |
|---|---|---|---|---|
| Problem and/or exercise solving | It will make by means of a proof written in which they formulate problems and/or exercises related with the contents of the matter | 10 | A1<br>A3<br>A4 | B4<br>B6 |
| Laboratory practice | It will evaluate according to the criteria of assistance, degree of participation and reports of development of practices or of visits to companies (individual or by groups) | 20 | A1<br>A3<br>A4 | B4<br>B6 |

**Other comments on the Evaluation**

Global evaluation:&*nbsp;&*nbsp;in the two official editions the renunciation to the continuous evaluation and election of the system of global evaluation will make following the procedure and the term established by the centre. It will consist of an only examination written that will have a weight of 100% of the note and will evaluate all the theoretical and practical contents of the subject.1º EDITION OF THE RECORD: Modality of Continuous Evaluation.&*nbsp;Will consist of distinct proofs made during the teaching of the subject and a final proof in the official date&*nbsp;previously fixed by the centre. The note obtained will be the corresponding to the sum of the punctuations obtained in the diverse proofs.2º EDITION OF THE RECORD:&*nbsp;Modality of Global Evaluation.&*nbsp;It will make &*nbsp;a final proof in the official date&*nbsp;previously fixed by the centre that will cover the whole of the theoretical and practical contents that will suppose 100% of the note.Extraordinary announcement:&*nbsp;it will make in the previously fixed date by the centre. It will consider the system&of *nbsp;global evaluation&*nbsp;and the examination written will cover the whole of the theoretical and practical contents that will suppose 100% of the note.Ethical behaviour:&*nbsp;it expects that the present student a suitable ethical behaviour, attending especially to the indicated in the Articles 39, 40, 41 and 42 of the&*nbsp;Regulation on the evaluation, the qualification and the quality of the teaching and of the process of learning of the *estudiantado of the *Universidade of Vigo&*nbsp;(approved in the *claustro of 18 April 2023).WARNING: In case of discrepancies between the distinct versions&*nbsp;linguistic&*nbsp;of the guide will prevail the indicated in the version in Spanish

**Sources of information**

**Basic Bibliography**

M Jaffe, W. Hammond, P Tolias, T Arinzeh(Editores), **Characterization of Biomaterials**, 1, ELSEVIER, 2012

Bandyopadhyay, Amit; Bose, Susmita, **Characterization of Biomaterials**, 1, ELSEVIER, 2013

Saber Amin Yavari (Editor), **Surface Engineering of Biomaterials**, 1, Mdpi AG, 2020

**Complementary Bibliography**

Saber Amin Yavari, **Surface Engineering of Biomaterials**, Coatings, 2020

D. A. Skoog, F. J. Holler, S.R. Crouch, **Principios del análisis instrumental**, 978-607-526-664-0, 7, Cengage Learning, 2018

**Recommendations**

**Subjects that are recommended to be taken simultaneously**

(*)Técnicas avanzadas no invasivas en enxeñaría biomédica: Aplicación do láser en medicina/V04M192V01208

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **(*)Robótica médica** | | | | |
| Subject | (*)Robótica médica | | | |
| Code | V04M192V01206 | | | |
| Study programme | Máster Universitario en Ingeniería Biomédica | | | |
| Descriptors | ECTS Credits | Choose | Year | Quadmester |
| | 4.5 | Optional | 1st | 2nd |
| Teaching language | Spanish | | | |
| Department | | | | |
| Coordinator | Paz Domonte, Enrique | | | |
| Lecturers | Armesto Quiroga, José Ignacio<br>López Fernández, Joaquín<br>Paz Domonte, Enrique | | | |
| E-mail | epaz@uvigo.es | | | |
| Web | | | | |
| General description | The main elements of robotic systems in the field of biomedical engineering are presented. Concepts related to the architecture, modeling, programming and operation of robots, both manipulator arms and mobile robots, in the field of medicine, healthcare and hospital environments. | | | |

| Training and Learning Results | |
|---|---|
| Code | |
| A5 | Students must possess the learning skills that enable them to continue studying in a way that will be largely self-directed or autonomous. |
| B3 | Knowledge in basic and technological subjects that will enable students to learn new methods and theories, and provide them the versatility to adapt to new situations. |

| Expected results from this subject | |
|---|---|
| Expected results from this subject | Training and Learning Results |
| Knowledge of the principles of medical robotics and its main systems | B3 |
| Ability to apply techniques for the representation of spatial location: position and orientation | A5<br>B3 |
| Ability to analyze kinematically and dynamically robotic equipment | A5<br>B3 |
| Applied knowledge of robotics programming and control techniques. | B3 |
| Knowledge of the principles of human-machine interaction, healthcare robotics, robotic applications in surgery and auxiliary techniques (augmented-virtual reality, image-guided simulators-trainers) | B3 |

| Contents | |
|---|---|
| Topic | |
| 1. Introduction to medical robotics | (*)Introdución á robótica médica<br>Robótica asistencial. Próteses e órtesis. Asistencia muscular. Rehabilitación. Exoesqueletos. *obótica en cirurxía. Cirurxía guiada por imaxe. Endoscopios |
| 2. Morphology of robots | (*)Morfoloxía do robot |
| 3. Representation of spatial localization: position and orientation | (*)Representación de la localización espacial: posición y orientación |
| 4. Robot kinematics: direct, reverse, and differential | (*)Cinemática: directa, inversa, modelo diferencial |
| 5. Introduction to robot dynamics | (*)Introducción a la dinámica |
| 6. Robot programming and control techniques | (*)Control e programación de robots.<br>Interacción home-máquina.<br>Teleoperación. Sistemas hápticos.<br>Percepción háptica en cirurxía.<br>Simuladores/adestradores<br>Realidade virtual e aumentada. |
| 7. Mobile and service robotics | (*)Robótica móvil y de servicios |
| Practices 1 to 3. Simulation in CoppeliaSim | Introduction to the simulation with CoppeliaSim<br>Modelling and simulation of a medical robot.<br>Simulation of a robotics surgery environment. |

| | |
|---|---|
| Practice 4. Robot programming | Programming of industrial robots.<br>Security aspects. |
| Practice 5 and 6. Mobile and service robotics | Modelling and simulation.<br>Localization and mapping.<br>Route planning. |

**Planning**

| | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Lecturing | 20 | 40 | 60 |
| Problem solving | 4 | 8 | 12 |
| Laboratory practical | 12 | 18 | 30 |
| Objective questions exam | 3 | 0 | 3 |
| Essay | 0 | 7.5 | 7.5 |

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

**Methodologies**

| | Description |
|---|---|
| Lecturing | Lectures in classroom with the help of technical means: blackboard, computer and projector |
| Problem solving | Resolution of problems in classroom with the help of technical means: blackboard, computer and projector. |
| Laboratory practical | Laboratory practices in the technological laboratories of the Department of Systems Engineering and Automation or in the computer laboratories of the School of Industrial Engineering |

**Personalized assistance**

| Methodologies | Description |
|---|---|
| Lecturing | Attention to queries and answers to doubts and questions asked while teaching lecture lessons |
| Problem solving | Attention to queries and answers to doubts and questions asked while solvign problems in classroom |
| Laboratory practical | Attention to the queries and answer to the questions made during the practices in laboratory |

**Assessment**

| | Description | Qualification | Training and Learning Results | |
|---|---|---|---|---|
| Problem solving | The resolution of problems in the classroom can serve for the continuous evaluation of the students.<br>Maximum 1 point out of 10. | 10 | A5 | B3 |
| Laboratory practical | Laboratory practices are considered mandatory.<br>The work done in the laboratory practices, as well as the previous work or the subsequent deliverables (when requested), constitute the fundamental part of the continuous evaluation. | 20 | A5 | B3 |
| Objective questions exam | Written exam on the date established by the official exam calendar.<br>It may consist of multiple choice questions, short answer questions, development questions, and problem solving questions.<br><br>It will be necessary to achieve a minimum in each part (typically 40%), in order to pass the exam. | 40 | A5 | B3 |
| Essay | Voluntary work to improve grades.<br>Maximum 3 point out of 10 | 30 | A5 | B3 |

**Other comments on the Evaluation**

Laboratory practices are considered mandatory.

To pass the subject in the first call, it is necessary to have attended at least 80% of the laboratory practices, and to have obtained an average grade of practices (including deliverables) greater than or equal to 5.

In case of not passing the practices in continuous evaluation, and for the students who renounce the continuous evaluation, it will be necessary to submit to an additional laboratory exam, once the official exam has been passed.

**Sources of information**

**Basic Bibliography**

Barrientos, Peñin, Balaguer, Aracil, **Fundamentos de Robótica**, Mc-Graw-Hill, 2007

Achim Schweikard, Floris Ernst, **Medical Robotics**, Springer, 2015

**Complementary Bibliography**

Varios, **Latest Developments in Medical Robotics Systems**, Colección de artículos, Intechopen, September 15, 2021

## Recommendations

### Subjects that are recommended to be taken simultaneously

(*)Control e regulación das funcións corporais/V04M192V01202

### Subjects that it is recommended to have taken before

(*)Modelado e simulación sistemas biomédicos/V04M192V01103
(*)Simulación biomecánica/V04M192V01308

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **(*)Mecánica de materiais e tecidos blandos** | | | | |
| Subject | (*)Mecánica de materiais e tecidos blandos | | | |
| Code | V04M192V01207 | | | |
| Study programme | Máster Universitario en Ingeniería Biomédica | | | |
| Descriptors | ECTS Credits | Choose | Year | Quadmester |
| | 4.5 | Optional | 1st | 2nd |
| Teaching language | Spanish | | | |
| Department | | | | |
| Coordinator | Riveiro Rodríguez, Antonio | | | |
| Lecturers | Comesaña Piñeiro, Rafael<br>Riveiro Rodríguez, Antonio | | | |
| E-mail | ariveiro@uvigo.es | | | |
| Web | | | | |
| General description | (*)Nesta materia presentarase a teoría da mecánica de medios continuos a materiais e tecidos brandos e hiperelásticos. Introduciranse os conceptos fundamentais detrás do comportamento mecánico da materia branda. Así mesmo, daranse a coñecer os diferentes métodos experimentais de caracterización de materiais brandos, así como métodos de simulación numérica de problemas mecánicos que inclúan materiais brandos. | | | |

| Training and Learning Results | |
|---|---|
| Code | |
| A5 | Students must possess the learning skills that enable them to continue studying in a way that will be largely self-directed or autonomous. |
| B3 | Knowledge in basic and technological subjects that will enable students to learn new methods and theories, and provide them the versatility to adapt to new situations. |

| Expected results from this subject | |
|---|---|
| Expected results from this subject | Training and Learning Results |
| To know the theory of elasticity and resistance of materials applied to soft and hyperelastic materials and tissues. | B3 |
| To apply knowledge of the mechanics of continuous media to soft and hyperelastic materials and tissues. | A5<br>B3 |

| Contents | |
|---|---|
| Topic | |
| 1. Introduction to soft solids | Rubber-like materials, gels, soft biological tissues, etc. |
| 2. Mechanical characterization | Research, experiments, interpretation |
| 3. Continuous non-linear mechanics | Stresses, deformations, laws of equilibrium. |
| 4. Constitutive modeling of soft materials | Constitutive models, simulation. |
| 5. Elasticity under large deformations | Hyperelastic materials |
| 6. Dissipative behavior | Description and characterization of the dynamic response |
| 7. Composite materials | Mechanics of composite materials, anisotropic and heterogeneous, obtained biomimetically, through additive manufacturing, etc. |

| Planning | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Lecturing | 18 | 18 | 36 |
| Problem solving | 6 | 6 | 12 |
| Laboratory practical | 12 | 0 | 12 |
| Mentored work | 0 | 40 | 40 |
| Autonomous problem solving | 0 | 12.5 | 12.5 |
| *The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. | | | |

| Methodologies | |
|---|---|
| | Description |

| | |
|---|---|
| Lecturing | Exposition of the general aspects and contents of the subject under study by the teacher in a structured way, with special emphasis on the foundations and most important aspects or aspects that are most difficult to understand for the student |
| Problem solving | Activity in which problems and/or exercises related to the subject are formulated. The teacher will indicate the appropriate or correct solutions through the exposition of routines, formulas or algorithms, transformation procedures of the available information and will help the students with the interpretation of the results. It will be used as a complement to the lecture. |
| Laboratory practical | Laboratory practices carried out cooperatively and in which the theoretical concepts seen in the classroom will be put into practice. They take place in special spaces with specialized equipment (laboratories, computer rooms, etc.). |
| Mentored work | Students, individually or in groups, will prepare a document on the subject matter or will prepare seminars, research, reports, essays, summaries of readings, conferences, etc. |
| Autonomous problem solving | Activity in which problems and/or exercises related to the subject (theoretical part and practical part) will be formulated. The student must develop the analysis and resolution of the problems and/or exercises autonomously. |

**Personalized assistance**

| Methodologies | Description |
|---|---|
| Lecturing | It will be carried out fundamentally in the office hours. |
| Problem solving | It will be carried out fundamentally in the office hours. |
| Laboratory practical | It will be carried out fundamentally in the office hours. |
| Mentored work | It will be carried out fundamentally in the office hours. |
| Autonomous problem solving | It will be carried out fundamentally in the office hours. |

**Assessment**

| | Description | Qualification | Training and Learning Results | |
|---|---|---|---|---|
| Problem solving | One or several tests consisting of exercises and/or conceptual tests will be proposed, ensuring that no test exceeds 40% of the overall grade for the subject. These tests will be conducted during class hours throughout the course on dates/times approved by the institution. They will be graded on a scale of 0 to 10 points. | 40 | A5 | B3 |
| Mentored work | The work will be done in teams but evaluated individually (integrating the development of questions and the resolution of corresponding problems/exercises). Each team of students will work on a problem proposed by the professor, which will encompass both theoretical and practical aspects related to the subject. | 40 | A5 | B3 |
| Autonomous problem solving | The students will independently solve problem sets regularly presented at the end of each theoretical and/or laboratory unit. Students will be required to describe the procedures used, as well as the results obtained or observations made in relation to the questions posed by the lecturer. | 20 | A5 | |

**Other comments on the Evaluation**

The subject will be considered passed when the student's final grade exceeds 5.0.

**First Call or Edition**

1. Continuous Assessment Mode: The final mark for the subject will combine the grades from the problem sets/questions proposed for independent solving (20%), the continuous assessment tests corresponding to conceptual exercises/tests (40%), and the proposed supervised work (40%) developed throughout the course. In any case, it is necessary to obtain a minimum grade of 4 out of 10 in each of the problem sets/questions, as well as in the continuous assessment tests, or in the proposed supervised work.
2. Non-Continuous Assessment Mode: A period of two weeks from the beginning of the course is established for students to document their inability to follow the continuous assessment process. The student who waives continuous assessment will take a final exam that will cover the totality of the contents of the subject, both theoretical and practical, and which may include multiple choice questions, reasoning or development questions, problem solving or the development of a practical case. The exam grade will be 100% of the final grade. A minimum grade of 5.0 points out of a possible 10.0 is required to pass the subject. This exam will be held on the dates established by the School management for the final exam.

**Second Call or Edition:**

1. Students who wish to improve their grade or who did not pass the subject in the First Call may take the Second Call, where they will take a final exam that will cover all the contents of the subject, both theoretical and practical. The second call will be held on the date established by the School's management.

## Sources of information

### Basic Bibliography


L Ortiz Berrocal, **Elasticidad**, 3ª, McGraw-Hill, 1998

GA Holzapfel, **Nonlinear Solid Mechanics: A Continuum Approach for Enineering: A Continuum Approach for Engineering**, Wiley, 2000

Stephen C. Cowin; Stephen B. Doty, **Tissue Mechanics**, Springer, 2007


### Complementary Bibliography


Masao Doi, **Soft Matter Physics**, Oxford University Press, 2013

Javier Bonet; Richard D. Wood, **Nonlinear Continuum Mechanics for Finite Element Analysis**, 2ª, Cambridge University Press, 2010

Stephen C. Cowin; Jay D. Humphrey, **Cardiovascular Soft Tissue Mechanics**, Kluwer Academic Publishers, 2004


## Recommendations

### Other comments

Continuous assessment is not contemplated if students cannot attend theoretical classes or laboratory practices due to overlapping with other activities.

The sending of electronic messages or the use of the mobile phone during the development of the teaching classes supposes the expulsion of the classroom. Likewise, you will lose your status of continuous evaluation

The original teaching guide is written in Spanish. In case of discrepancies, the Spanish version of this guide will prevail.

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **(*)Técnicas avanzadas no invasivas en enxeñaría biomédica: Aplicación do láser en medicina** | | | | |
| Subject | (*)Técnicas avanzadas no invasivas en enxeñaría biomédica: Aplicación do láser en medicina | | | |
| Code | V04M192V01208 | | | |
| Study programme | Máster Universitario en Ingeniería Biomédica | | | |
| Descriptors | ECTS Credits | Choose | Year | Quadmester |
| | 4.5 | Optional | 1st | 2nd |
| Teaching language | Spanish | | | |
| Department | | | | |
| Coordinator | Pou Saracho, Juan María | | | |
| Lecturers | Pou Saracho, Juan María | | | |
| E-mail | jpou@uvigo.es | | | |
| Web | | | | |
| General description | This matter offers to the future biomedcial engineers a vision of the paper of the non-invasive techniques and the laser in modern medicine. | | | |

| Training and Learning Results | |
|---|---|
| Code | |
| A3 | That students are able to integrate knowledge and handle complexity and formulate judgments based on information that was incomplete or limited, include reflecting on social and ethical responsibilities linked to the application of their knowledge and judgments. |
| B6 | Capacity for handling specifications, regulations and mandatory standards. |

| Expected results from this subject | |
|---|---|
| Expected results from this subject | Training and Learning Results |
| To know advanced non-invasive techniques in the field of biomedical engineering | B6 |
| To know applications of lasers in medicine | B6 |
| To apply knowledge of non-invasive techniques and laser techniques in the field of biomedical engineering | A3<br>B6 |

| Contents | |
|---|---|
| Topic | |
| SUBJECT 1.- INTRODUCTION | Introduction to advanced non-invasive techniques in biomedical engineering<br><br>Analysis of advanced non-invasive techniques<br><br>Introduction to the laser |
| SUBJECT 2.- BASIC PRINCIPLES | Functioning of a laser source<br><br>Main parts of a laser source<br><br>Guiding and focalizing a laser beam |
| SUBJECT 3.- TYPES OF LASERS USED IN MEDICINE | Gas lasers<br><br>Solid state lasers<br><br>Diode lasers<br><br>Other lasers |

| | |
|---|---|
| SUBJECT 4.- SAFETY | Security in the utilisation of laser sources laser in medicine<br>Potential ocular damages<br>Potential damages in the skin<br>Safety regulations<br>Measures of control and prevention |
| SUBJECT 5.- MAIN APPLICATIONS OF THE LASER IN MEDICINE | Applications of the laser in ophthalmology<br>Applications of the laser in dermatology<br>Applications of the laser in otorhinolaryngology<br>Applications of the laser in urology |

**Planning**

| | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Lecturing | 24 | 48 | 72 |
| Laboratory practical | 12 | 24 | 36 |
| Objective questions exam | 1.5 | 0 | 1.5 |
| Report of practices, practicum and external practices | 3 | 0 | 3 |

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

**Methodologies**

| | Description |
|---|---|
| Lecturing | Presentation of the contents on the matter object of study by the professors of the subject. Presentation of real cases of application of the laser technology in medicine. |
| Laboratory practical | Activities of application of the knowledge to specific situations and of acquisition of basic and practical skills related to the matter object of study. They will be developped in the premises of the University Hospital Complex of Vigo. |

**Personalized assistance**

| Methodologies | Description |
|---|---|
| Lecturing | The professor, during the exhibition of the theoretical classes, will clarify in individual form and/or collectively all the doubts that can have the student on the matter object of study. |
| Laboratory practical | The professor, during the development of the practical class of laboratory, will solve the doubts that the student may have realted to the matter under study. |

**Assessment**

| | Description | Qualification | Training and Learning Results | |
|---|---|---|---|---|
| Objective questions exam | The exam will consist in an individual examination. | 60 | A3 | B6 |
| Report of practices, practicum and external practices | Work made in team but evaluated individually. | 40 | | |

**Other comments on the Evaluation**

To pass the subject, a minimum note of 2 points out of 10 must be achieved. This applies in the individual exams as well as in the team work report.

In the second opportunity, only the students that fail to pass the subject will be evaluated.

Ethical commitment

It is expected that the students conduct theirselves in a suitable ethical manner. In the case to detect a non ethioal behaviour (copy, plagiarism, utilisation of unauthorised electronic devices, and others) it will be considered that the student does not achieve the necessary requirements to pass the subject. In this case the global qualification in the present academic year will be of fail (0.0). During the evaluation exam any electronic device will be allowed, with the exception that explicit permission is given by the professor in charge. The fact to enter an unauthorised electronic device in the classroom of examination will be considered reason of failing the subject in the present academic course and the global qualification will be fail (0.0).

## Sources of information

### Basic Bibliography

Jeff Hecht, **Understanding Lasers: An Entry-Level Guide, 4th Edition**, Wiley, 2018

Markolf H. Niemz, **Laser-Tissue Interactions Fundamentals and Applications**, Springer, 2007

### Complementary Bibliography

Helena Jelínková, **Lasers for Medical Applications Diagnostics, Therapy and Surgery**, Woodhead Publishing, 2013

## Recommendations

### Other comments

To enrol in this subject it is suggested to compare the schedules of this subject with others, with the objectiv to avoid lecturing overlap. The continuos evaluation will not be applied if the students can not follow the lectures due to overlapping with other subjects.

Likewise the sending of electronic messages or the utilisation of the mobile telephone during the development of the lectures implies the expulsion from the classroom.

The student that does not abide with that established in the previous paragraph not only will be expulsed from the classroom, but he/she will lose his/her posibility to follow the continuous evaluation.

The original learning guide is that written in Spanish. In case of discrepancies, the spanish version of this learning guide will prevail.

## IDENTIFYING DATA

**(*)Deseño de produtos e servizos intelixentes no sector biomédico**

| | | | | |
|---|---|---|---|---|
| Subject | (*)Deseño de produtos e servizos intelixentes no sector biomédico | | | |
| Code | V04M192V01209 | | | |
| Study programme | Máster Universitario en Ingeniería Biomédica | | | |
| Descriptors | ECTS Credits | Choose | Year | Quadmester |
| | 4.5 | Optional | 1st | 2nd |
| Teaching language | Spanish<br>Galician | | | |
| Department | | | | |
| Coordinator | Comesaña Campos, Alberto | | | |
| Lecturers | Comesaña Campos, Alberto | | | |
| E-mail | acomesana@uvigo.es | | | |
| Web | http://moovi.uvigo.gal/ | | | |
| General description | This subject, developed within the framework of the advanced studies in Biomedical Engineering, aims to train its students in the field of Artificial Intelligence applied to the conceptualization, design, and implementation of intelligent clinical decision support systems, understood and applied to both healthcare products and diagnostic services.<br>To this end, the teaching approach will prioritise, on the one hand, the understanding of the fundamental theoretical concepts underlying models of artificial intelligence, both those based on symbolic reasoning and those based on statistical learning, and, on the other hand, the practical realisation of these articulated models through the design and programming of the information flows of the corresponding algorithms.<br>The content will cover essential knowledge related to the concept of intelligent systems, exploring its meaning and variants, which will involve a methodological exploration of the inherent logics and guiding principles of the different inference processes, in order to subsequently comment on and develop the implementation of intelligent systems through different approaches, covering symbolic and statistical inference processes.<br>Due to the specific nature of the theoretical content of the subject, a gradual and progressive understanding, supported by hermeneutic debate, of the interpretation of propositional and first-order logic, of the concept of uncertainty and risk, of the bases of inference in learning techniques, of the distinction and applicability of the different paradigms of reasoning, of the importance in clinical decision-making of the predictive techniques of artificial intelligence and, in general, of the conceptual design of coherent, robust and reliable intelligent systems will be promoted.<br>All this is aimed at acquiring, understanding and applying the knowledge and cognitive resources necessary to develop the ability to create intelligent system schemes that can be translated into products and services in the biomedical sector, with a proven predictive and preventive capacity, and endowed with reasoning and decision-making abilities. At the end of the course, the student will be able to demonstrate the necessary theoretical and practical competence to create an intelligent product or service that solves a real complex problem in the field of biomedical engineering, which implies facing a problematic issue with a multiplicity of influencing variables, the permanent presence of uncertainty in its traditional variants, a relevant associated risk and, above all, the absence of a valid analytical, experimental or numerical model for its solution.<br>Finally, in addition to the skills and abilities already mentioned, the subject will include transversal training in data processing, programming fundamentals, the collection, analysis and presentation of clinical results and the development of proofs of concept, as well as other knowledge implicit in the study of intelligent systems. | | | |

## Training and Learning Results

| Code | |
|---|---|
| A2 | That the students can apply their knowledge and their ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study. |
| A4 | Students can communicate their conclusions, and the knowledge and rationale underpinning these, to specialist and non-specialist audiences clearly and unambiguously. |
| A5 | Students must possess the learning skills that enable them to continue studying in a way that will be largely self-directed or autonomous. |
| B3 | Knowledge in basic and technological subjects that will enable students to learn new methods and theories, and provide them the versatility to adapt to new situations. |
| B5 | Knowledge to carry out measurements, calculations, assessments, appraisals, surveys, studies, reports, work plans and other similar works. |

## Expected results from this subject

| Expected results from this subject | Training and Learning Results |
|---|---|

| | |
|---|---|
| Design intelligent products and services applied in the field of biomedical engineering. | A2<br>A4<br>B5 |
| Ability to represent human intelligence and experience in order to help solve complex problems and as decision support in biomedicine | A2<br>A4<br>A5<br>B3<br>B5 |

| **Contents** | |
|---|---|
| Topic | |
| 1. Intelligent Systems | 1.1. Definition of Intelligent System within the field of Artificial Intelligence.<br>1.2. Intelligent products and services in the biomedical sector.<br>1.3. Evolution of intelligent systems: from symbolic reasoning to statistical learning methods. |
| 2. Knowledge Representation | 2.1. Knowledge-based systems.<br>2.2. Logical representation of knowledge.<br>2.3. Principles of propositional and first-order logic.<br>2.4. Inference mechanisms.<br>2.5. Applications in products and services for biomedical engineering. |
| 3. Uncertainty and Risk | 3.1. Definition in the context of biomedical engineering of engineering decisions.<br>3.2. Classification and types of uncertainty.<br>3.3. Decisions with uncertainty.<br>3.4. Uncertainty management.<br>3.5. Empirical definition of risk associated with uncertainty.<br>3.6. Uncertainty and risk in the biomedical sector. |
| 4. Expert Systems | 4.1. Definition and theoretical contextualization.<br>4.2. Types and components of expert systems.<br>4.3. Development of expert systems.<br>4.4. Deterministic models and stochastic models.<br>4.5. Inferential approaches.<br>4.6. Applications in products and services for biomedical engineering. |
| 5. Machine Learning algorithms. Regression, classification, and clustering algorithms. | 5.1. Machine learning: Definition applied to non-connectionist approaches.<br>5.2. Regression models.<br>5.3. Classification models.<br>5.4. Clustering models.<br>5.5. Data pretreatment.<br>5.6. Training methods.<br>5.7. Controlled data augmentation techniques.<br>5.8. Applications in products and services for biomedical engineering. |
| 6. Neural Networks | 6.1. Definition and theoretical contextualization.<br>6.2. The connectionist paradigm versus the symbolic one.<br>6.3. Usual types and architectures.<br>6.4. Training methods.<br>6.5. Types of learning: supervised, unsupervised, reinforced.<br>6.6. Applications in products and services for biomedical engineering. |
| 7. Evolutionary Algorithms | 7.1. Definition and theoretical contextualization.<br>7.2. Programming and evolutionary strategies.<br>7.3. Programming and genetic algorithms.<br>7.4. Genetic algorithm operators.<br>7.5. Applications in products and services for biomedical engineering. |
| 8. Decision Support Systems | 8.1. Definition and theoretical contextualization.<br>8.2. Components and development.<br>8.3. Relationship with intelligent systems. Complementary operation.<br>8.4. Verification, validation and contrast of results.<br>8.5. Search for the best hypothesis.<br>8.6. Applications of biomedical decision systems. |

| | |
|---|---|
| Assignments<br>Practical implementation of an intelligent system on products and services in the field of biomedical engineering.<br>Throughout the assignments, students will be required to design, develop, and conceptually test a new intelligent system that incorporates, at a minimum, a symbolic or statistical inference model. Afterwards, they must apply it as a tool to support clinical decision-making. | 1. Definition of the problem within the biomedical engineering sector.<br>2. Evaluation of its relevance and integration with an intelligent product or service.<br>3. Search for solutions in the field of artificial intelligence.<br>4. Identification of criteria, variables, descriptors and any other relevant information.<br>5. Proposal of conceptual diagram of solution and evaluation of data flow.<br>6. Implementation of the solution.<br>7. Validation of results.<br>8. Dissemination, communication and presentation of the proposed solution. |

**Planning**

| | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Lecturing | 18 | 15 | 33 |
| Problem solving | 2 | 0 | 2 |
| Laboratory practical | 8 | 2 | 10 |
| Practices through ICT | 4 | 1 | 5 |
| Objective questions exam | 1.5 | 4 | 5.5 |
| Essay questions exam | 2.5 | 6 | 8.5 |
| Problem and/or exercise solving | 0 | 4.5 | 4.5 |
| Laboratory practice | 0 | 24 | 24 |
| Report of practices, practicum and external practices | 0 | 20 | 20 |
| *The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. | | | |

**Methodologies**

| | Description |
|---|---|
| Lecturing | The theoretical content will be presented by the lecturer during the classes, complemented by discussion and interpretation of the same. They will be coordinated with the planned practical activities. |
| Problem solving | In a complementary way to the presentation of the theoretical contents, different application exercises will be proposed and developed, which the students will have to solve in a comprehensive and reasoned way. |
| Laboratory practical | In groups, the students of the course, under the supervision and control of the lecturer, must develop and implement an intelligent system applied to a product or service within biomedical engineering. |
| Practices through ICT | In the development of the practices of the subject, the students must actively use different information and communication technologies, even implementing some of them. |

**Personalized assistance**

| Methodologies | Description |
|---|---|
| Laboratory practical | Proposition and review of the outcomes of the course activities, aiming to support individually the learning process in small groups of students. An appropriate follow-up will be performed on student's work to verify that the best practices shown in theory classes are applied, and that the procedimental recommendations provided by the lecturer are followed. The tutorial sessions can be carried out using IT tools (email, video-call, Moovi forums, etc.) according to the modality of prior concertation of the virtual place, date and time. |

**Assessment**

| | Description | Qualification | Training and Learning Results | |
|---|---|---|---|---|
| Objective questions exam | During the course, a series of objective and short-answer evaluation questionnaires will be carried out on the theoretical topics, either considering all the topics as a whole or individualizing each of them. | 20 | A2<br>A5 | B3 |
| Essay questions exam | At the end of the course there is an examination which includes development questions relating to the theoretical and practical content of the course. | 25 | A2<br>A5 | B3<br>B5 |
| Problem and/or exercise solving | The problems solved in class, after being checked and corrected, can be collected and supplemented with new ones. All of them will have to be commented on and justified before they are finally handed in. Their understanding, explanation and detailed justification will be assessed. | 5 | A2<br>A5 | B3<br>B5 |

| | | | | |
|---|---|---|---|---|
| Laboratory practice | In the practices of the subject, an intelligent system must be designed, developed and implemented that responds to a real problem existing in the biomedical engineering sector. Said system will be exemplified and merged with a usual biomedical product or service. Among other issues, the correct definition of the problem, its relevance and degree of complexity, the requirement in the acquisition of knowledge, the identification of variables and criteria, the evolution in the approach to the solution, as well as the degree of autonomy of the student will be assessed and their work in identifying the solution. During the practices, mandatory periodic deliveries and individual and/or group meetings could be considered. | 15 | A4<br>A5 | B3<br>B5 |
| Report of practices, practicum and external practices | At the end of the course, a complete technical report of the results obtained during the practical sessions of the subject must be prepared. In this report the solution (intelligent service or product) obtained must be described, justifying it appropriately. It will include, at least, an introduction to the problem, a detailed conceptual and methodological description, an application example, a comparative discussion and some general conclusions. In addition, the commented source code must be submitted in an added file, as well as any other necessary mathematical development. Among other issues, the theoretical justification, the architecture of the solution, its management of uncertainty and the degree to which it solves the problem initially posed will be assessed. Other aspects that will be considered will be the writing, technical presentation, student involvement in classes and work, adjustment to delivery times and the possible presentation and defense of the solution obtained, which is compulsory. | 35 | A4<br>A5 | B5 |

**Other comments on the Evaluation**

The assessment of the subject will include the lecturer's assessment of the student's work, both individual and group, whether face-to-face or remote, weighted as indicated in the Assessment section.

To determine the grade for all the assessment tests, a numerical grading system will be used, with values ranging from 0.0 to 10.0 points, in accordance with current legislation (R.D. 1125/2003, of 5 September, BOE. No. 224, of 18 September). In any case, the subject is considered passed if the grade obtained is at least 5.0 out of 10.

**The subject offers two different evaluation modalities in its first evaluation period: continuous evaluation and non-continuous or global evaluation.** In the second period, the evaluation is carried out exclusively by means of the corresponding global examination.

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**Comments for the First Assessment Period / Ordinary Exam Period**

The student may follow the above modalities:

***- Continuous evaluation modality***

In this modality, the student will pass the subject if he/she obtains a minimum of five points (5.0) out of 10 without having to take the corresponding ordinary period examination. Each assessment test is worth 10 points. It is necessary to obtain a minimum of 5.0 points out of 10 in each of the assessment tests and in each part or subpart of those tests in order to pass the subject. Students who do not pass the continuous assessment, i.e. who do not pass each and every one of the assessment tests set, will be required to take the corresponding additional tests and, if applicable, to take the second period examination. This is subject to the considerations and clarifications deemed appropriate by the teacher.

***- Non-continuous or global evaluation modality***

At the beginning of the course, enrolled students have a deadline set by the School of Industrial Engineering to explicitly opt out of continuous evaluation. In this case, the enrolled student must inform the professor as soon as this has been requested and confirmed.

A student who opts out of continuous evaluation in order to pass the subject must take a single final examination on the date set by the School for the first assessment period, covering all the theoretical and practical content of the subject, including short answer questions, long answer questions, problem solving and the development of practical scenarios. Additionally, it will be necessary to design and justify the functioning of an intelligent system implemented in a product or service within biomedical engineering. In order to pass the subject, students must achieve an overall mark of at least 5.0 out of 10 in each of these tests.

**Comments for the Second Assessment Period / Extraordinary Exam Period**

Students who have not passed the subject in the ordinary period by any of the above modalities will have a second opportunity to pass the subject by taking the second period examination on the date set by the School of Industrial Engineering.

The second period examination will cover all the theoretical and practical content of the subject, including short answer questions, long answer questions, problem solving and the development of practical cases. Additionally, it will be necessary to design and justify the functioning of an intelligent system implemented in a product or service within biomedical engineering. In order to pass the subject, students must achieve an overall mark of at least 5.0 out of 10 in each of these tests.

**Ethical Behavior**

Students are expected to demonstrate appropriate ethical behaviour. In the event of unethical behaviour (cheating, plagiarism, use of unauthorized electronic devices, etc...) it will be assumed that the student does not meet the necessary requirements to pass the subject. In this case, the overall grade for the current academic year will be a fail (0.0). The use of teaching aids or electronic devices during examinations is not permitted unless specifically authorized. Bringing unauthorized materials or electronic devices into the examination room will be considered grounds for failing the subject for the current academic year and the overall grade will be a fail (0.0).

## Sources of information

### Basic Bibliography


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Fakhreddine O. Karray y Clarence de Silva, **Soft computing and intelligent systems design : theory, tools, and applications**, Pearson-Addison Wesley, 2004

Enrique Castillo , José Manuel Gutiérrez y Ali S. Hadi, **Expert systems and probabilistic network mode**, Springer Science & Business Media, 2012

George J. Klir y Bo Yuan, **Fuzzy sets and fuzzy logic**, Prentice Hall, 1995

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Andrés Rodríguez, **Deep Learning Systems: Algorithms, Compilers, and Processors for Large-Scale Production. Synthesis Lectures on Computer Architecture**, Morgan & Claypool Publishers, 2020

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### Complementary Bibliography


Timothy J. Ross, **Fuzzy logic with engineering applications**, John Wiley & Sons, 2009

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Mehmed Kantardzic, **Data mining: concepts, models, methods, and algorithms**, IEEE Press; Wiley, 2020

Kenji Suzuki, **Computational Intelligence in Biomedical Imaging**, Springer, 2014

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Sachi Nandan Mohanty, **Machine learning for healthcare applications**, Wiley-Scrivener, 2021

Donna L. Hudson y Maurice E. Cohen, **Neural networks and artificial intelligence for biomedical engineering**, Institute of Electrical and Electronics Engineers, 2000


## Recommendations

**Subjects that it is recommended to have taken before**

(*)Estatística avanzada para a enxeñaría biomédica/V04M192V01101

**Other comments**

It is strongly recommended that students taking this course have prior knowledge of programming, especially in numerical calculation environments.

Likewise, it is recommended that they be able to read, interpret and understand texts written in English.