ENGLISH FRIENDLY COURSES (EFC) 2024-2025
CAMPUS OF GIPUZKOA

https://www.ehu.eus/es/web/informatika-fakultatea/incoming_students
Coordinator: informatica.internacional@ehu.eus

In addition to the general offer of courses taught in English, some Centers offer for incoming students English Friendly Courses (EFC): subjects taught in Spanish or Basque, in which the syllabus summary; lecturer tutoring, examinations and/or papers are available in English.

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<th>COURSE</th>
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1 SEMESTER: 1st: September 2024 to January 2025
2nd: January 2025 to May 2025
2 SCHEDULE: Morning (M)/ Afternoon (A): begins at 13.30.
### English Friendly Courses taught in BASQUE:

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3 SEMESTER: 1st: September 2024 to January 2025  
2nd: January 2025 to May 2025  

4 SCHEDULE: Morning (M)/ Afternoon (A): begins at 13.30.
In the subject Computer Structure (first year of the Informatics Engineering Degree) the students learnt the basic architecture of a Von Neuman computer. Computer Architecture starts from the learnt concepts and summarizes the main techniques used to achieve higher performance in computers.

In the first part we will analyse the cache memory as an element to improve the performance of the access to the information (instructions and data) stored in the memory system. In the second part we will analyse pipelined architectures, studying the hardware as well as the most commonly used compiler techniques to execute programs in an efficient way. Finally, the third part will concentrate on the analysis of the basic characteristics of parallel systems conformed with many computers, particularly we will concentrate on the shared memory systems: performance of parallel systems, synchronisation, task scheduling and parallel programming (OpenMP).

A further step from the acquired knowledge will be given in future year subjects (High Performance Processors and Parallel Computation Systems of the Computer Engineering speciality): on the one hand, advanced techniques to improve the performance of the processors (superscalar processors, multi-core architectures, vector machines and GPUs) and, on the other hand, distributed memory systems for parallel processing. These systems make use of massive parallelism using thousands of processors to diminish the execution time of complex problems.

Thereby the subject is an essential in the knowledge area. It is basic to be able to understand the next subjects of the speciality and it gives a general idea of the topic to students going to other specialities that will be very useful for their career.

Focusing on professional competencies, this subject gives to the students indispensable skills in computer system organization.

The expected learning outcomes are:
1. To identify and analyze the design parameters of cache memories.
2. To analyze the influence of cache memory in the efficiency of the programs' execution.
3. To understand how the pipelined processors work
4. To analyze code optimisations to improve the performance of the processor.
5. To formulate and apply the concepts of parallelism in shared memory multiprocessors.
6. To program simple parallel applications facing some problems such as data hazards, synchronisation and load balancing.

Theoretical and Practical Contents

1.-CACHE MEMORY.
   1.1.-Introduction: memory hierarchy.
   1.2.-Main characteristics: size, content, way.
   1.3.-Design parameters: mapping, replacement policy, write strategy.
   1.4.-Assignments. Optional practical work.

2.-INSTRUCTION LEVEL PARALLELISM (ILP).
   2.1.-Motivation: increasing the processors' performance.
   2.2.-Design of a pipelined processor: DLX.
   2.3.-Data and control hazards.
   2.4.-Introduction to multi-cycle and superscalar processors.
   2.5.-Compiler techniques for pipelined processors.
   2.6.-Assignments.
3.- INTRODUCTION TO PARALLEL COMPUTING SYSTEMS.
3.2.- Shared memory machines: synchronization and load balancing.
3.3.- Programming multiprocessors: OpenMP.
3.4.- Development of a parallel application.

BASIC CONCEPTS OF C PROGRAMMING LANGUAGE

TEACHING METHODS

The first two topics of the subject will be taught using two types of classroom activities: master classes and exercise (practical) classes. Both of them will be performed in an active and collaborative way.

The third topic will combine master classes and exercise (practical) classes with laboratory sessions. A practical work, a functional software module and a report about the work carried out in groups will be compulsory in this topic to pass the subject.

TYPES OF TEACHING

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<th>Types of teaching</th>
<th>M S GA GL GO GCL TA TI GCA</th>
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Legend:
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- TA: Workshop
- TI: Industrial workshop
- GCA: Applied fieldwork groups

Evaluation methods
- Continuous evaluation
- End-of-course evaluation

Evaluation tools and percentages of final mark
- Percentages and assessed parts are specified in next section 100%

ORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT

The subject has two assessment options: the final assessment and the continuous assessment.

a) Continuous assessment. This is the predetermined option and can only be used in the ordinary call. Active and continuous participation of the students is required: coming to contact lessons and laboratories, assignment and class work delivery, participating in assessment activities, practical works and presentations. When these conditions are not fulfilled the students will be assessed in final assessment.

The continuous assessment will be: written exams (72.5%), assignments (5%) and practical work (22.5%). In both the written exams and the practical work, the minimum mark required is 4 points.

In order to resign to the call, it is enough not to take the exam of the last topic.

b) Final assessment. This will be the option when the student is not in continuous assessment: written exam (80%) and practical work (20%). To pass the subject it is necessary to obtain at least 4 points in both the written exam and the practical work.

In order to resign to the call, it is enough not to take the final exam.

Students who, having fulfilled the conditions for being in the continuous assessment system, decide to opt for the global assessment, must inform via e-mail the lecturers responsible for the subject at the latest after the assessment of the second continuous assessment exam.

EXTRAORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT

The only option for the extraordinary call will be final assessment.

MANDATORY MATERIALS
## BIBLIOGRAPHY

### Basic bibliography

1. Hennessy J.L., Patterson D.A. 
   On-line information (slides, appendices...) in the following address: https://www.elsevier.com/books-and-journals/book-companion/9780128119051

2. Patterson D.A., Hennessy J.L. 


4. Stalling W. 
   http://williamstallings.com/COA/COA7e.html


### Detailed bibliography


### Journals

Journals of the area: IEEE Computer, IEEE Micro, ACM...

### Web sites of interest

Web pages of the manufacturers: INTEL, AMD, IBM, etc. 
Other web pages: www.top500.org, www.openmp.org...

### OBSERVATIONS

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COURSE GUIDE 2024/25

Faculty 226 - Faculty of Informatics
Degree GINFOR20 - Bachelor's Degree in Informatics Engineering
COURSE 26210 - Network Services & Applications
Credits, ECTS: 6

COURSE DESCRIPTION
This subject is taken in the third year, when the student must opt for one of the specialties. Anyway, this subject is compulsory for all students. Due to the importance that computer networks - especially the Internet - have nowadays, it is considered that all students should acquire basic knowledge about this area.

COMPETENCIES/LEARNING RESULTS FOR THE SUBJECT
In this subject, the basic requirements for developing applications in which the network plays a key role are studied. Besides, the most relevant network applications are also studied. The subject focuses on the part of application development that is linked to the existence of the Internet, giving special importance to the study of developments in TCP/IP. Models for the creation of network applications and interfaces for their development are studied.

Theoretical and Practical Contents
1. Network application design
2. Network application development
3. Network applications
4. Network application's security
5. Advanced tools for the development of network applications.

TEACHING METHODS
Being basically a practical subject, in the theoretical classes the main concepts are explained and the student then goes into greater depth following the references provided by the professor. Theoretical concepts are put into practice in the practical classes.

Students have to carry out two types of practical work in groups. 1) They do the practical work proposed in the laboratory classes, always supported by the professor. This practical component uses to be short (one session) and highly directed, without much margin for moving away from the objective.
2) Students have to carry out (mainly out of classroom) other more general practical work, using the main concepts taught in class in a wider and more realistic way. The goal of the practical work is to design a network application and the nature of the designed application must be agreed with the professor beforehand.

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Evaluation methods
- Continuous evaluation
- End-of-course evaluation

Evaluation tools and percentages of final mark
- Percentages and evaluation methods are detailed in the following sections. 100%

ORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT
Students have to choose between two types of evaluation: continuous or overall. Initially, any student attending to classes is considered as enrolled in continuous evaluation, so attending to classes is a necessary condition in continuous evaluation.

Continuous evaluation is divided into three parts. In the first part, the students do a practical work in groups, mainly outside class hours, consisting on the design of a network application design. This represents 15% of the mark. Secondly, in the last theme the practical work done in the laboratory is evaluated. It represents 5% in the final mark. Finally, the remaining contents, both theoretical and practical, are evaluated by 3 written exams. In exams taken while it is possible to move on to global evaluation, it will be necessary to obtain a minimum grade of 3 points to remain in continuous evaluation.

The students that don't meet the conditions to remain in continuous evaluation will automatically go to overall evaluation. The ones that do meet the conditions will definitively be evaluated in continuous evaluation unless otherwise requested through eGela within the period indicated by the teacher. In continuous evaluation waiving the call is not
possible, so students aiming to waive the call must go to global evaluation as explained before. In the case of overall evaluation, the student has to take a written exam that represents 100% of the final mark. To waive the call it is enough not to take the exam.

EXTRAORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT

In this case the student must be evaluated by the overall evaluation. Its conditions are those described for the ordinary call.

MANDATORY MATERIALS

https://egela.ehu.eus/

BIBLIOGRAPHY

Basic bibliography
- 7th, 6th, 5th and 4th editions are also valid.
- TCP/IP Sareak, 3. argitaldia. JM Rivadeneyra. UEU 2009

Detailed bibliography

Journals

Web sites of interest
Sockets:
- Python: https://docs.python.org/3/library/socket.html
- C: https://beej.us/guide/bgnet/
- RFC reports: https://www.rfc-editor.org/
- W3 Consortium: http://www.w3.org/
- Twisted: https://twistedmatrix.com/trac/wiki/Documentation

OBSERVATIONS
COURSE GUIDE 2024/25

**Faculty** 226 - Faculty of Informatics  
**Degree** GINFOR20 - Bachelor's Degree in Informatics Engineering

**COURSE**

26213 - Abstract Computational Models  
**Credits, ECTS:** 6

**COURSE DESCRIPTION**

The main objective of "Abstract Computation Models" subject is to determine the computational difficulty of those problems that can be solved by a computer. This subject presents theoretical contents to distinguish whether a given problem is very difficult to compute or not. Moreover, we will see that there exist problems that cannot be solved by any computer. "Abstract computation models" subject complements the knowledge of the previous "Languages, Computation and Intelligent Systems" subject.

**COMPETENCIES/LEARNING RESULTS FOR THE SUBJECT**

Competences:
1) Know basic Computability Theory concepts  
2) Be able to formalize Computability Theory concepts  
3) Realize that there are limits beyond which algorithmic methods do not work  
5) Develop intuition about non computable and intractable problems  
6) Know some Complexity classes and the relationship among them  
7) Learn techniques for determining the computational difficulty of problems

**Theoretical and Practical Contents**

2) SAT problem. NP-complete problems. polynomial-time reductions. P versus NP question.  
3) Techniques to deal with intractable problems. Aproximations. Randomness.  
4) Limits of computation. More about undecidable problems.

**TEACHING METHODS**

Support material will be available in the eGela virtual classroom.  
We will work with Python programming language in the laboratories.

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**Evaluation methods**

- Continuous evaluation  
- End-of-course evaluation

**Evaluation tools and percentages of final mark**

- Véase la explicación en el apartado inferior 100%

**ORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT**

The subject has two different kinds of assessments: final (or overall) assessment and continuous assessment.

Continuous assessment

The student will voluntarily decide whether to take part or not in it, since it is offered exclusively for those students who can carry out continuous monitoring of the subject within the established dedication framework and can attend to presentational activities.

Pre-enrolment in the continuous assessment mode will take place during the first week of the course. Pre-enrolment will become definitive after confirmation of the application by the student on established dates (around the 12th week of the
course, with approximately 70% of the continuous assessment already completed) and after partial performance verification by the teaching staff. If the student does not confirm his or her definitive enrolment in the continuous assessment on the abovementioned dates, it will be understood that he or she dismisses the enrolment.

The course is mainly focused on continuous assessment.

Continuous assessment will be evaluated by means of three written exams, with a weight of 30, 40 and 20% of the overall grade of the subject. Besides, a 10% of the grade will be determined by laboratory work.

Additionally, a minimum of a 30% grade must be achieved in each written exam and a minimum of 5 over 10 is required to pass the subject.

Final Assessment

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This kind of assessment will be applicable to students who do not wish to take part in continuous assessment or those who do not meet the criteria continuous assessment.

In this case, a single written exam about the 100% of the subject must be performed. It will be carried out according to the official examination schedule of the Faculty. The minimum grade required in the final exam will be 5 out of 10.

**EXTRAORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT**

One single written exam about 100% of the subject in which the minimum grade is 5 out of 10.

**MANDATORY MATERIALS**

**BIBLIOGRAPHY**

Basic bibliography


Detailed bibliography

- J. IBAÑEZ; A. IRASTORZA; A. SANCHEZ. "LOS PROGRAMAS WHILE. Bases para una teoría de la Computabilidad". Informe interno. UPV/EHU / LSI / TR 5-96.

**Journals**

**Web sites of interest**

- http://www.jflap.org/
- https://eu.udacity.com/course/intro-to-theoretical-computer-science--cs313
- http://computational.complexity.googlepages.com/
**COURSE GUIDE**  2024/25

**Faculty**  226 - Faculty of Informatics  
**Degree**  GINFOR20 - Bachelor's Degree in Informatics Engineering  

**COURSE**  
26218 - Data Mining  
Credits, ECTS: 6

**COURSE DESCRIPTION**  
This subject focuses on a field known as data mining or machine learning. It includes a series of techniques which, being based on artificial intelligence and classic statistics, have emerged strongly in the last decade for solving problems using large volumes of data. Its applications range from bioinformatics or finance to marketing-advertising, and also natural language.

Although the technological giants have been in the vanguard of this discipline for years, over the last few years more and more small- and medium-sized companies and institutions are becoming aware of the need to store data on their activities, and to analyse them to draw useful conclusions for their day-to-day operations. In the case of Euskadi, the machine tool sector and the term 'Industry 4.0' have increased the profile of our discipline.

The subject is closely linked to other computing subjects such as "Artificial Intelligence" and "Algorithm Design"; optional subjects include "Machine Learning and Neural Networks" and "Heuristic Search", plus others from other specialities related to database and computing systems.

Students will study the main data mining techniques and will become familiar with real programs.

**COMPETENCIES/LEARNING RESULTS FOR THE SUBJECT**  
Main results of the learning process:
- knowledge acquisition on principal supervised classification techniques
- knowledge acquisition on principal non-supervised classification (clustering) techniques
- knowledge acquisition on principal techniques for classification models' evaluation
- skills on the use of principal software tools for learning and evaluation supervised and non-supervised classification models

Main data mining techniques will be studied, and the student will acquire skills in the use of free software which implements those techniques. The student will also show real data mining applications. Skills on the basic, international machine learning vocabulary will be acquired by the student.

**Theoretical and Practical Contents**  
1. Introduction to data mining  
Applications and success stories. Everything related to data mining as a discipline within the field of artificial intelligence

2. Distance-based classifiers: k-nearest neighbour  
The intuitive nature of this classic method of data mining makes it ideal as the first technique of supervised classification. Its basic functioning will be studied, together with its main variants and parameters for use.

3. Techniques to evaluate and validate classifiers  
Study of the main techniques for evaluating classifiers, with special emphasis on supervised classification methods and the estimation of success rates. Introduction to the main statistical tests for comparison between different classifiers.

4. Classification trees and decision rules  
Study of these two algorithms, inspired by the philosophy of 'divide and rule', with special emphasis on the transparency and simplicity of its final models. Different growth and pruning options will be explained.

5. Classifiers based on Bayesian networks  
Study of the basic theory underlying Bayes' theorem. Classification models of different complexity will be explained. We will examine the following applications of this type of classifiers: models for diagnosis and prognosis in medicine (evidence-based medicine, computational medicine).

6. Combination of classifiers  
Study of the different techniques used to combine classifiers. The virtues of the consensus reached by classifiers will be highlighted.
7. Techniques for selecting variables
Study of basic concepts and techniques, both from the univariate and the multivariate points of view. Applications of this type of techniques: most important genes in an illness (a new area of bioinformatics).

8. Non-supervised classification (clustering)
Main clustering techniques. Describing the characteristics of this type of problem, differentiating them from the supervised ones. Practical examples: image segmentation, groups of foodstuffs based on their nutritional characteristics, segmentation of customers and targeted marketing and advertising.

9. Introduction to heuristic searches and genetic algorithms

10. Introduction to neural networks
Basic mechanisms of a neural network classification structure. Main neural network architectures. The subject is a motivation for a further course in the Faculty: "Machine Learning and Neural Networks"

**TEACHING METHODS**
Three lessons per week. One practical laboratory with computers (personal laptop, or provided by the Faculty), and two theoretical lessons.

**TYPES OF TEACHING**

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**Evaluation methods**
- Continuous evaluation
- End-of-course evaluation

**Evaluation tools and percentages of final mark**
- Written test, open questions  60%
- Exercises, cases or problem sets  40%

**ORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT**
A mid-exam, consisting of the 35% of the theoretical material (2'5 points of a total of 6), will be realized by mid-October. In case of having a sufficient mark in this exam, the final theoretical exam on January will only cover the 65% of the theory material (3'5 points of a total of 6). In this last January exam a minimum mark is needed to be able to pass the entire subject (1'5 points of a total of 3'5).

At least two deadlines will be announced to collect the practical laboratories developed by the student.

In order to pass the subject, it is needed to pass both parts: theory and practice.

**EXTRAORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT**
A final exam in January consisting in the 100% theoretical material. If the student has not delivered the practical laboratories during the weeks of the course, those must be delivered to the teacher one week before the final theoretical exam.

In order to pass the subject, it is needed to pass both parts: theory and practice.

**MANDATORY MATERIALS**
"egela" system is used to guide the "day-per-day" of the course: material of the theoretical lessons, as well as the
formulation of the practica-laboratory sessions.

**BIBLIOGRAPHY**

**Basic bibliography**
- J. Han, M. Kamber (2006). Data Mining: concept and techniques. Morgan Kaufmann. (Second edition)


**Detailed bibliography**

**Journals**
- Data Mining and Knowledge Discovery. Springer.

**Web sites of interest**
- WEKA software: http://www.cs.waikato.ac.nz/ml/weka/
- caret-R package for classification and regression: https://topepo.github.io/caret/
- Datasets' benchmark repository (University of California Irvine): http://archive.ics.uci.edu/ml/
- A list of intuitive data mining applications, described in a divulagative style (updated by the teacher): http://www.sc.ehu.es/ccwbayes/members/inaki/DM-applications.htm
- LiO software for heuristic optimization: http://www.dsi.uclm.es/simd/SOFTWARE/LIO/
Formal methods make software development acquire a more scientific character and similar to other disciplines related to engineering, as well as promote the use of tools with solid foundations, as occurs in other well-established disciplines. These methods are called formal because they are based on mathematics, mainly on mathematical logic. Some years ago the industrial development of system using formal techniques was considered a complex theoretical exercise and unfeasible in real problems. However, the increasing complexity and importance of the computer systems ended up making patent the importance of construct reliable and safe systems, i.e. systems that lack errors or failures. Not only because of the terrible repercussions these failures can have in areas where security is critical, but also because of the economic and quality repercussions that affect companies. This, together with the fact that computer systems play an increasingly essential role in society (in particular, they are more and more present in the devices that we use every day) made the industrial world change its attitude. Thus, in the last decades, formal methods have gained a notable advance and their use in the industrial field has ceased to be the utopia that their detractors claimed. Currently there are large companies, such as Intel, IBM, Sony, Siemens, Amazon or Microsoft, which collaborate very actively both in the creation of tools to help formal software development, and in the application of these tools to obtain reliable industrial applications.

In fact, this course uses a software development tool created by Microsoft: Dafny. Although the usefulness of formal methods, and their efficiency, in industrial developments are already proved, more work is still needed for most engineers to know and apply them. This work must be carried out by the universities that must include them in their academic content; by the teachers, who must be trained and researched in this area of knowledge; and by the students, who must have a more solid formation in mathematics and logic. This course contributes to this task of ensuring that the software engineer's work is true engineering, so that the end user receives reliable and safe products.

COMPETENCIES/LEARNING RESULTS FOR THE SUBJECT

The specific objectives of this subject are:

- Understand the importance of programming being a more scientific than craft activity.
- Know the history and motivation of formal methods of software development.
- Know the state of the art in the area of formal software development.
- Know the languages, methods and concrete tools of formal software development.
- Ability to handle languages and concrete tools of formal software development.

Theoretical and Practical Contents

Topic 1.- Introduction
Topic 2.- Mathematical Induction
Topic 3.- Introduction to the Dafny System
Topic 4.- Value Types
Topic 5.- Structural Induction and Datatypes
Topic 6.- Arrays and Framing
Topic 7.- Modules and Objects

TEACHING METHODS

We use different teaching methodologies. In classes, the conceptual contents of the subject will be presented and in the laboratories, practical problems will be solved using the Dafny tool, in an interactive way, in which the students use the tool at the same time as the teacher. Problems and exercises will be provided that students must develop individually, so that they can be aware of their learning level throughout the semester.

TYPES OF TEACHING

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Legend:

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Evaluation methods

- Continuous evaluation
- End-of-course evaluation

Evaluation tools and percentages of final mark
In order to pass the subject in continuous assessment, students must carry out three individual practical assignments in the laboratory that test their knowledge of the tools and techniques addressed in class. The percentage of the grade for each practical work is 30% for the first, 40% for the second and 30% for the third.

ORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT

In order to pass the subject in continuous assessment, students must carry out three individual practical assignments in the laboratory that test their knowledge of the tools and techniques addressed in class. The percentage of the grade for each practical work is 30% for the first, 40% for the second and 30% for the third.

EXTRAORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT

The global evaluation consists of carrying out individual practical work in the laboratory that is equivalent to the set of works carried out during the course for continuous evaluation.

MANDATORY MATERIALS

- Lectures slides.
- The on-line tutorial and the documentation of the Web page: https://dafny.org/

BIBLIOGRAPHY

Basic bibliography
- Documentación de la página Web:
  https://dafny.org/

Detailed bibliography

Journals
- ACM Transactions on Computational Logic
- ACM Transactions on Software Engineering and Methodology
- Applicable Algebra in Engineering, Communication and Computing
- Formal Aspects of Computing
- Formal Methods in System Design
- Journal of Automated Reasoning
- Software Testing Verification & Reliability

Web sites of interest
- Dafny: a language and program verifier for functional correctness https://dafny.org/
- Formal Methods and Software Technology - Interesting Conferences http://user.it.uu.se/~bengt/Info/conferences.shtml

OBSERVATIONS
COURSE GUIDE 2024/25

<table>
<thead>
<tr>
<th>Faculty</th>
<th>226 - Faculty of Informatics</th>
<th>Cycle</th>
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<tr>
<td>Degree</td>
<td>GINFOR20 - Bachelor's Degree in Informatics Engineering</td>
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COURSE

26238 - Human Computer Interaction

Credits, ECTS: 6

COURSE DESCRIPTION

The "Human-Computer Interaction" subject is compulsory for students in the Software Engineering speciality in the Computer Science degree course, and optional for students of other specialities. You will need to have basic knowledge of Software Engineering, for example what a three-level architecture is or a software development cycle. During the term, the front end of a three-level web application will be developed.

COMPETENCIES/LEARNING RESULTS FOR THE SUBJECT

The subject aims at the student learning to: (1) analyse (apprehend/understand), discuss, evaluate and analyse user requirements in order to (2) analyse, design and evaluation systems that are usable, accessible and ergonomic in different environments and places in a structured and methodical way, (3) paying special attention to the different needs of different types of users with varying cognitive and psycho-motor (dis)abilities, (4) transmit and weigh up, in a collaborative manner with users, ideas, designs and applications for these systems.

In addition, we will work on other generic competences envisaged in the profile of the degree, in the document List_of_competences.pdf at http://www.ehu.es/documents/340468/516505/Lista_de_competencias.pdf, in particular the general competences: C3, C4, C5, C9 and C10 of the degree, as well as the specific competences IS1, IS2 and IS4 of the specialty of Software Ingeneering.

Theoretical and Practical Contents

Theme 1 Introduction. Basic concepts.
Theme 2 The human factor.
Theme 3 Devices for, and styles of, interaction.
Theme 6 Design techniques. New trends.
Theme 7 Interface evaluation techniques. Carry out a usability study. Measurements and analysis.

TEACHING METHODS

The subject involves three main types of activities, all based on presence-based classes (one-off and regular) and student participation: theory classes, practical sessions in the laboratory and other sessions for work and discussion in groups.

Based on active teaching methodologies, both in the theory classes and in the practical sessions, and with the aim of encouraging students to participate actively and gain satisfaction, activities based on teamwork and the presentation of solutions will be organised, followed by debates and the discussion of problems encountered in the practical work sessions.

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Evaluation methods

- Continuous evaluation
- End-of-course evaluation

Evaluation tools and percentages of final mark

- Se especifican a continuación en función del tipo de evaluación 100%

ORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT

The assessment system for the subject offers two options: continuous assessment or exam and practical work -based assessment (final assessment).
1. Continuous assessment: based on one-off and regular attendance in class, presenting results, taking tests on the knowledge acquired and the performance of practical work (both individually and in groups). The grade is obtained from the following assessment results:
   a. Development project (75% of the grade, compulsory): a project on the construction of a usable interface, throughout the term. Individual tests on the knowledge acquired will be set, and the mark will help towards the end-of-project grade.
   b. Complementary work (25% of the grade): An evaluation of the summaries made from the course reading list and presentation of solutions, as well as participation in related debates.

2. Exam and practical work based assessment (final assessment). Based on the established periods and procedures, with voluntary attendance in class. The final exam consists of two phases: one to assess the competences obtained in the course of the usable interface project (compulsory and done before the exam), and the other to assesses the level of knowledge shown in the subject. Both the practical work and the exam are individual and compulsory, and must be passed (with a mark of 5 for each one).

**EXTRAORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT**

The same requirements and assessment criteria as for the final assessment are applied. Pass grades are not carried over to the next year.

**MANDATORY MATERIALS**

Materials provided by the professor (notes, slides, definitions, articles, studies....).

**BIBLIOGRAPHY**

**Basic bibliography**
- Usability Engineering. Jakob Nielsen, AP Professional, 1993

**Detailed bibliography**
- Designing the User Interface 4th edition ¿ Ben Shneiderman, Addison Wesley 2005

**Journals**

**Web sites of interest**
- http://hcibib.org/
- http://www.useit.com/
- http://www.uie.com/articles/
- http://www.usernomics.com/

**OBSERVATIONS**
### COURSE DESCRIPTION

PLEASE NOTE THAT THIS SUBJECT IS TAUGHT ONLY IN SPANISH, ALTHOUGH IT IS ENGLISH FRIENDLY

This subject is an elective course of the 4th year of the Informatics Engineering Degree in the speciality Computer Engineering (taught during the first four-month period).

The subject is intended to introduce the student of Computer Science to both the theoretical and practical aspects of Digital Signal Processing. Therefore, the subject uses concepts learned in previous subjects in the areas of mathematics (complex numbers, sinusoidal, etc.) and programming.

In the professional field, the subject enables students to process digitally any type of signal (sound, image, information from sensors, time series, etc.) in multiple fields (audio-visual, industry, medicine, meteorology, etc.). In this way, it serves as a link to other areas such as Data Science, Big Data, Industry 4.0, Robotics, Physiological Computing, etc.

The fundamental objectives are:

- To introduce the student to the basic concepts related to Digital Processing: signals, systems, time and frequency analysis, filters.
- To deepen these concepts in the case of sound and image, and to show the methods used in digital systems to capture, process and produce this type of signals.
- To present practical applications of these techniques and alternatives for their implementation.
- To put into practice the concepts studied, applying them in the laboratory to real cases of sound (voice and music) and image processing, using MATLAB platform (other alternatives could be: SCILAB, Octave, Python&®).

### COMPETENCIES/LEARNING RESULTS FOR THE SUBJECT

[LEARNING OUTCOMES]

The learning outcomes provided by the subject are the following:

- Knowing how to use digital signal processing software and critically interpret the results obtained.
- Being able to apply the mechanisms of transformation of continuous signals to digital signals: sampling and quantification.
- Know the main methods of calculating the Fourier transform and know how to apply them to digital signals.
- Knowing the main parameters of FIR and IIR digital filters, and knowing how to design and apply them to digital signals.
- Develop a specific task with autonomy using self-management and self-regulation techniques.
- Communicate their ideas and arguments in an understandable way and according to the established formal criteria.
- Value teamwork, accepting the potential of diversity as a learning opportunity.
- Carry out their tasks responsibly in order to achieve the objectives and the collective result.

### Theoretical and Practical Contents

Theme 1
1.1 Introduction
1.2 Signals and systems Why digital processing?

Theme 2
2.1 Digital signals
2.2 Definitions and properties. Digitization. Basic signals and operations. Sound and image

2.3 Project. Introduction to a specific software for digital signal processing: Sound and Image

Theme 3
3.1 Time domain analysis
3.2 Usual operations. Windowing and short-term operations. Correlation
3.3 Projects. Time-domain analysis of sound and image signals

Theme 4
4.1 Frequency domain analysis
4.2 Starting idea. Fourier series and transform. Application to two-dimensional systems
4.3 Projects: Frequency analysis of sound and image signals

Theme 5
5.1 Filters.
5.3 Projects: Linear systems (FIR, IIR) and filter design.

Theme 6
6.1 Applications of digital signal processing.
6.2 Areas of application and examples.
6.3 Final projects: medium/high complexity projects in which acquired competencies in the subject are applied.

TEACHING METHODS
There are four types of activities:

- Autonomous study by the students of the material available in the virtual classroom for each subject in which the theoretical/practical concepts to be used are presented, as well as a proposal of exercises associated with them. In addition to directly accessible information, students can use bibliographic references as support material.

- Presentation and exercise classes in which, in a participative way, the theoretical/practical concepts of each topic are shared and the doubts associated with them are clarified, always emphasizing their usefulness and practical aspects. In these sessions, the initially proposed exercises (“on paper”) will be shared in order to deepen the theoretical foundations. Exercises will also be proposed on each topic that the students will have to solve and that will be evaluated with the corresponding feedback.

- Development of specific projects in which the students (preferably in groups of 2) apply the theoretical/practical concepts learned to real cases of sound (voice and music) and image processing, using MATLAB, SCILAB, Octave, etc. For each of these sessions, a technical report of results must be submitted that will be evaluated with the corresponding feedback.

- Development of a final project (medium/high complexity level) in which the students (preferably in groups of 2) will apply the theoretical/practical knowledge previously learned in the course. In order to facilitate student learning, specific projects will be monitored by providing feedback based on previously established and shared evaluation criteria. In this way, students are aware of their level of learning and take steps to improve it if necessary.

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Evaluation methods
- Continuous evaluation
- End-of-course evaluation

Evaluation tools and percentages of final mark
- The percentages and types of assessment are specified in the following sections 100%
The assessment systems considered are the continuous assessment system and the final assessment system. In the ordinary call, the continuous assessment system is the one that will be used in preference, as indicated in the current regulations of the UPV/EHU. The mark is calculated as follows:

- Theory: classroom exercises and written tests 50%.
- Practice: specific projects 35% and final project 15%. There will be individual written evaluations that will weigh the marks of the practical part.

For the final assessment mode, the students will have to submit the reports corresponding to the specific projects and the final project at least two weeks before the date of the ordinary call (date of the final theory test). In this case, the examination will weigh 60% and the practical part 40%. There will be an individual written evaluation that will weigh the overall mark of the practical part.

In order to pass the subject, in any modality, it is necessary to pass both the practical and theoretical parts of the subject separately.

Students who, fulfilling the conditions to continue in the continuous assessment system, decide to opt for the final or global assessment, must inform the teacher responsible for the subject by email before the beginning of the second week of the grouped timetable of the four-month period established in the centre's calendar.

In the case of the extraordinary call, the final mark is calculated based on two parts:

- Theory (60%): Assessed by a knowledge test.
- Practical (40%): This is assessed on the basis of the technical reports corresponding to the specific and final projects, which must be submitted before the date of the theory test. There will be an individual written evaluation that will weigh the overall mark of the practical part.

In order to pass the course it is necessary to pass both parts (theoretical and practical).

For the correct development of the subject it is required:

- a PC type personal computer.
- and specific software for signal processing (MATLAB, etc.), for the laboratory practices.

The centre provides both resources. In addition, students have the possibility of carrying out the practical projects on their own computers using the UPV/EHU's MATLAB corporate licence and free software (SCILAB, Octave, Python, etc.).

Basic bibliography


Detailed bibliography


Journals
Digital Signal Processing (Elsevier)
Signal Processing (Elsevier)
IEEE Signal Processing Letters

Web sites of interest
www.mathworks.com
www.sciab.org
www.dsprelated.com
www.gnu.org/software/octave
www.scipy.org

OBSERVATIONS
The subject "Introduction to Operating Systems" focuses on the functional description of operating systems, through its system calls interface, which presents it to the (systems) programmer as a virtual machine that largely hides the complexity of the underlying hardware. This training is complemented by other subjects in the Computer Engineering specialty of the Degree in Informatics Engineering: "Operating Systems" focuses on fundamental techniques and models in the design of operating systems, aimed at managing the different system resources, in order to understand the need for compromises in the design and configuration of the operating system; "Administration of Systems and Networks" focuses on presenting and developing the main aspects associated with the administration of computer systems, in an approach oriented towards the functions of the administrator and also regarding the user who makes use of this type of system; finally "Design of Operating Systems and Real Time", which is currently not taught, deals with the implementation of the system.

The skills and knowledge acquired in this course prepare students to work in system software/application development, code library design, and high-level programs that interact with the operating system. These skills can also be valuable in software design, development, and maintenance, and in understanding best practices and techniques for producing high-quality software. It gives the option to work in the field of software development for embedded systems, such as medical devices, automotive and consumer electronics. Finally, it is worth to say that this subject is the base of other advanced subjects in operating systems through which students can prepare to work in computer security and software development of operating systems.

The subject "Introduction to Operating Systems" is a compulsory subject included in the curriculum of the Degree in Informatics Engineering and is taught in the second year. For the good use of this subject, it is highly recommended to have passed "Computer Structure" and "Basic Programming", both taught in first year.

### COMPETENCIES/LEARNING RESULTS FOR THE SUBJECT

At the end of the course, the students should be able to:
- Know the characteristics of the different types of operating systems such as time-sharing systems, distributed systems, real time, etc.
- Identify the interfaces provided by an operating system
- Develop Linux utilities for applications from its system call interface
- Manage the fundamental concepts of operating systems (files, access protection, processes, threads, communication and synchronization elements)
- Manage the functionality of its components (manage the process, memory, and input-output subsystems)

Other important aspects that are going to be promoted are the ability to find the information and tools necessary to solve the problems that arise, and the ability to accurately describe the functionality of the developed utilities, so that they can be used by other users or developers.

### Theoretical and Practical Contents

**Unit 1: Introduction**
- Functional vision of an Operating System (OS)
- Functions and Interfaces of an OS
- Types of OSs according to their functionality (Evolution and Classification)
- Current market for OSs
- Lab: Basic Shell Tasks as User and Administration Interface

**Unit 2: System call mechanism**
- Operating System's Support architecture (I/O)
- I/O routine call mechanism
- Resident routines
- OS access mechanism: system calls

**Unit 3: Input-output and files**
- Introduction to the concepts of Device Independence and redirection
- Operation modes on devices and files
- Organization of the file system. Namespaces, directories
- I/O "Buffering": libraries functions vs. system calls
- Advanced access to device properties
- System calls for I/O and C standard library functions
- Exercises on I/O and lab work

Unit 4: User management and security
- Multi-user systems
- Protection mechanisms
- Security-related system calls
- Exercises on user management and security and lab work

Unit 5: Memory management
- Loading and placement of programs in systems with one or more programs in memory
- Support for virtual memory systems: physical and virtual addressing
- Static and dynamic relocation. Reentrant code
- Static and Dynamic link libraries
- Calls to the operating system related to program loading and memory management
- Compilation practices, memory management, static and dynamic link libraries, and program loading

Unit 6: Process control
- Concept of execution flow and context. Context switching
- Multiprogrammed and multithreaded systems
- Concept of process (Unix model), states and transition graph
- Processes’ scheduling and basic scheduling policies
- System calls and library functions related to process and thread control
- Practical work: process execution in background from the Shell, process monitoring, simple and multprogrammed shell, multithreaded examples

Unit 7: Communication and synchronization between processes and threads
- Concepts of concurrency, shared resource, race condition and exclusive access
- Critical sections of code. Basic mechanisms for exclusive access to critical sections
- Communication with message passing through mailboxes. Communication and synchronization via threads
- System calls related to communication and synchronization between processes and threads
- Resource management model based on the client-server scheme. Examples of resource managers (drivers)
- Practical work: communication and synchronization between processes (using pipes) and threads

TEACHING METHODS
This course is based on the functional vision of operating systems and the application programming interface (API). Therefore, although always based on the theoretical concepts that support it, it will have a large practical component. For this, various teaching methodologies will be used, from master classes to more active methodologies such as PBL (Project Based Learning) or pBL (Problem Based Learning) and laboratory activities.

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Evaluation methods
- Continuous evaluation
- End-of-course evaluation

Evaluation tools and percentages of final mark
- The percentages and types of evaluation are specified in the following sections. 100%

ORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT

CONTINUOUS ASSESSMENT
The evaluation systems that are contemplated are the continuous evaluation system and the final evaluation system. The continuous assessment system is the one that will be used preferably, as indicated in the current regulations of the UPV/EHU. The student who decides to opt for the final evaluation, must inform the teacher(s) within the terms and manner indicated in the current regulations of the UPV/EHU.
The continuous evaluation mode is based on the following three evaluation tests:
- Individual evaluation questionnaires: 60%
- Practical Works: report with the developed code, specifications, verification results of the practice proposals and interview: 30%
- (Others) Specific individual assessment questionnaires on the work carried out: 10%

To pass the subject it is necessary that the student:
- Completes and submits all assessment tests
- Gets at least 40% of the evaluation of each of the tests
- The final average mark with all the evaluation tests is at least 5 out of 10

FINAL EVALUATION

For those who do not follow the continuous evaluation, the following evaluation mechanism is foreseen:
- Final individual written test (theoretical questions, practical exercises, code analysis, design/programming of utilities...): 80%
- The realization and delivery of a practical work and an interview about it: 20%

To pass the subject it is necessary that each student:
- Completes and submits all assessment tests
- Gets at least 40% of the evaluation of each of the tests
- The final average grade with all the tests is at least 5 out of 10

EXTRAORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT

In the extraordinary call evaluation will be similar to the final evaluation of the ordinary call:
- Final individual written test (theoretical questions, practical exercises, code analysis, design/programming of utilities...): 80%
- The realization and delivery of a practical work and an interview about it: 20%

To pass the subject it is necessary that each student:
- Completes and submits all assessment tests
- Gets at least 40% of the evaluation of each of the tests
- The final average grade with all the tests is at least 5 out of 10

MANDATORY MATERIALS

Subject eGela online classroom, Linux operating system (there will be access to Linux through a server), manuals, tools and C programs that will be provided through eGela (Moodle service from UPV/EHU).

BIBLIOGRAPHY

Basic bibliography
Remzi H. & Andrea C. Arpaci-Dusseau:

Abraham Silberschatz, Peter B. Galvin, Greg Gagne:

Francisco Manuel Márquez García:

Brian W. Kernighan, Rob Pike:

Detailed bibliography
Andrew S. Tanenbaum:

Mark Rochkind:

William Stallings:

Journals
Web sites of interest
www.linux.org: forums, tutorials and many other stuff about Linux
www.gnu.org: all about the gnu operating system
www.die.net: the Linux manual online

OBSERVATIONS
"Advanced Information Management" is a compulsory subject within the Specialty of Software Engineering. This subject rests on aspects taught in "Web Systems" and "Databases". On the one hand, the knowledge on XML technologies seen in "Web Systems" is broadened. On the other hand, the new data management needs that go beyond the relational model are addressed.

The management of data has been and is, increasingly important in any organization. From the systems of files and databases, the current organizations have had to face new challenges as the volume, diversity and the means in which these data were transported, managed and produced increase. This subject familiarizes the student with these new information technologies.

**COMPETENCIES/LEARNING RESULTS FOR THE SUBJECT**

The topics to be discussed are outlined below.

Document exchange between organizations: the XML world and description standards
* See the options offered by the XML language for the organization of unstructured data as well as some available standards
* Understand the use of XML for exchange in companies and do it through a prototype

Impact of object orientation on DBMS: the object-relational model
* Through the new versions of Oracle, understand and manage how the concepts of object orientation have permeated the definition and manipulation of databases.

Impact of "datafication", that is, the transformation of everyday objects into data that add to the sea of massive data that the Internet already houses, the product of our fingerprints through social networks or smartphones.
* Understand the concepts and opportunities of the BigData world
* Become familiar with noSQL databases.

Learning results will be worked on
- general: C1, C2, C3, C4, C5, C6, C7, C8, C9, C10 and C12
- more specific to Ing. Soft: SI1, SI2, SI3, SI4, SI5, and SI6

**Theoretical and Practical Contents**

1. Standards and XML technology for document interchange (XPath, XML Schema, Schematron, XQuery, xSQL)
2. Modelo Objeto-relacional (Oracle 10)
3. noSQL (MongoDB, Neo4j)

**TEACHING METHODS**

According to the eminently practical content of the subject, lectures are accompanied by weekly laboratories where students will check their understanding of the concepts taught through solving practical exercises. Student groups will be set to jointly develop a project that will involve the intensive use of XML technologies.

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**Evaluation methods**

- Continuous evaluation
Evaluation tools and percentages of final mark

- Written test, open questions  90%
- Teamwork assignments (problem solving, Project design)  10%

ORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT

The course has two modes of assessment: final (or overall) assessment and continuous assessment.

CONTINUOUS ASSESSMENT
 Continuous assessment, to which students may take advantage of voluntarily, is offered exclusively to students who can carry out continuous monitoring of the subject within the established framework of dedication and attendance to face-to-face activities. Pre-registration in the continuous assessment mode will be carried out on the established dates. The pre-registration will become final after confirmation of the application by the student on the dates established (between 60% and 80% of the course) and after verification of partial performance by the teaching staff. If on the aforementioned dates the student does not confirm their final registration in continuous assessment, it will be understood that they renounce it.

Weight of each topic in the final note:
- XML: 65%
- Object-Relational: 15%
- noSQL: 20%

ASSESSMENT OF THE WHOLE
- Final exam: 90% The exam will consist of a part of basic concepts and practical written exercises.
- Practical work: 10%. To take the final exam of the overall assessment (in the ordinary or extraordinary call), the work of the XML project must have been submitted. A deadline for delivery will be set prior to the exam. To pass the course it will be necessary to pass each part (exam, practical work) separately.

NOTE: In case of return to confinement, the evaluation tests (both continuous and final) will be adapted to the new situation.

EXTRAORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT

Final exam: 100% The exam will consist of a part of basic concepts and practical written exercises.

NOTE: In case of return to confinement, the evaluation tests (both continuous and final) will be adapted to the new situation.

MANDATORY MATERIALS

Software to be used throughout:
- OXYGEN XML Editor
- ORACLE DBMS
- MongoDB DBMS noSQL
- Neo4J DBMS noSQL

BIBLIOGRAPHY

Basic bibliography
XQuery. P. Walmsley. 2007, O&#8217;Reilly.

Detailed bibliography
Journals

Web sites of interest
http://www.w3schools.com/

http://infolab.stanford.edu/~ullman/fcdb/oracle/or-objects.html

OBSERVATIONS
The objective of this subject is to study the structure and functioning of the electronic elements that allow communicating digital systems, in particular a computer, with the outside world. It begins studying the elements that capture and condition the signals of the real world. Next, the basic circuits for processing these signals are studied: analog, digital, analogue digital conversion, data acquisition cards and signal processing (DSP). This subject is completed with some practical simulation and design exercises using widely used programs in the field of electronic circuit design. All this will be very useful when dealing with topics such as: the design of integrated circuits, design of applications based on microprocessors, the study of signal processing or robotics, etc., object of other subjects of the degree.

COMPETENCIES/LEARNING RESULTS FOR THE SUBJECT

The expected learning outcomes are:

- Be able to handle with the basic instrumentation of an electronic laboratory.
- Be able to identify the appropriate sensor for the capture of a certain physical signal.
- Be able to design a basic signal conditioning device (amplification and filtering).
- Be able to simulate the operation of analog electronic circuits.
- Be able to design an analog to digital and digital to analog conversion circuit.
- Be able to process information received from sensors with data acquisition systems.

Theoretical and Practical Contents

UNIT 0. Introduction: Interface with the real world.
UNIT 1. Acquisition of signals: sensors.
UNIT 2. Conditioning of signals: the operational amplifier and its applications.
UNIT 3. A / D and D / A converter circuits.
UNIT 4. Cards and data acquisition systems (DAQ).

TEACHING METHODS

Active methodologies of cooperative learning will be used, looking for the active participation of the students and the work in-group, something fundamental for the achievement of the desired competences in this specialty. In addition to theory classes, practical laboratory sessions based on cooperative learning are proposed. The content of the practical topics is developed in the laboratory, in-group.

TYPES OF TEACHING

<table>
<thead>
<tr>
<th>Types of teaching</th>
<th>M</th>
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Legend: M: Lecture-based S: Seminar GA: Applied classroom-based groups
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Evaluation methods

- Continuous evaluation
- End-of-course evaluation

Evaluation tools and percentages of final mark

- Written test, open questions 20%
- Multiple choice test 20%
- Exercises, cases or problem sets 35%
- Individual assignments 10%
- Teamwork assignments (problem solving, Project design) 15%

ORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT

In the first call, each student will be able to choose between two options: traditional evaluation by taking a final exam, or...
continuous evaluation during the course. In principle, the preferred evaluation method is continuous evaluation. To continue in continuous evaluation, it is essential to obtain a grade greater than 4 out of 10 in each section evaluated, the student who, fulfilling the conditions to continue in the continuous evaluation system, decides to opt for the global evaluation, must inform the teacher responsible for the subject by email within 9 weeks before the date of the final evaluation. The student who does not meet the requirements to remain in continuous evaluation will automatically go to final evaluation.

Percentages and types of evaluation:

<table>
<thead>
<tr>
<th>Type</th>
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<tr>
<td>Exercises</td>
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<tr>
<td>Questions</td>
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<tr>
<td>Laboratory</td>
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<td>Attendance</td>
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<tr>
<td>Tests</td>
<td>20%</td>
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<tr>
<td>Total</td>
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</table>

EXTRAORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT

The final exam consists on a written test in which the degree of knowledge of the subject, both theoretical and practical, treated in the subject will be evaluated.

MANDATORY MATERIALS

Documentation provided by the teacher in egela.

BIBLIOGRAPHY

Basic bibliography

- BOLTON W., 2001. Mecatrónica: Sistemas de control electrónico en la ingeniería mecánica y eléctrica. (Marcombo)

Detailed bibliography

- BISHOP R., 1999. Learning with LabVIEW. Addison-Wesley
- NORTON H.N., 1982. Sensores y analizadores. (Gustavo Gili)

Journals

- IEEE Instrumentation and measurement magazine
- IEEE transactions on instrumentation and measurement
- IEEE Robotics and automation magazine
- IEEE sensors Journal
- IEEE signal processing magazine
IEEE transactions on circuit and systems II. Analog and digital signal processing

IEEE transactions on industrial electronics and control instrumentation

Revista española de electrónica (http://www.redeweb.com/index.php?option=com_frontpage&Itemid=1)

Electronic Design (http://electronicdesign.com/index.cfm?AD=1&)

**Web sites of interest**


**OBSERVATIONS**
### COURSE GUIDE 2024/25

<table>
<thead>
<tr>
<th>Faculty</th>
<th>226 - Faculty of Informatics</th>
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<tbody>
<tr>
<td>Degree</td>
<td>GIARTI20 - Bachelor's Degree in Artificial Intelligence</td>
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<td>Cycle</td>
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### COURSE

<table>
<thead>
<tr>
<th>Course Code</th>
<th>28268 - Advanced Statistical Methods</th>
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<tr>
<td>Credits, ECTS</td>
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### COURSE DESCRIPTION

The subject Advanced Statistical Methods is a second year subject of the Degree in Artificial Intelligence. It is an extension of the statistical methods covered in the first year of the degree. The previously introduced concepts are developed in more detail and the Bayesian paradigm is introduced. Moreover, the knowledge and skills obtained through this subject establish the basis for the understanding of the paradigms introduced in further years, in particular in the data analysis area.

An expert in Artificial Intelligence should be able to conduct a statistical analysis and to understand the underlying models, with the goal of proposing solutions in the domain of Artificial Intelligence.

### COMPETENCIES/LEARNING RESULTS FOR THE SUBJECT

- Understand the Bayesian paradigm in statistical inference
- Build statistical models that solve real-life problems
- Draw conclusions justifying them by interpreting the data and evidences.
- Learn to develop simple programs for the visualization and analysis of data in R

### Theoretical and Practical Contents

1. Review of some probability concepts
   1.1 Random variables
   1.2 Joint, marginal and conditional distributions
2. Estimation
   2.1 Properties of the estimators
   2.2 Method of moments
   2.3 Maximum likelihood
   2.4 Non-parametric bootstrap
3. Introduction to Bayesian estimation
   3.1 Conjugate distributions
   3.2 Monte Carlo approximation
   3.3 Normal model
   3.4 Gibbs sampling
   3.5 Group comparison and linear regression
4. Statistical tests
   4.1 Parametric, non-parametric and permutation tests
   4.2 Multiple testing correction

### TEACHING METHODS

In this subject we will promote the autonomous work of the student using computer and bibliographic resources that will help understanding the topic. Lectures with the conceptual contents of the subject will be complemented with exercises. The computation part will be covered with weekly computer sessions using R programming language.

### TYPES OF TEACHING

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<th>Types of teaching</th>
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### Evaluation methods

- Continuous evaluation
- End-of-course evaluation

### Evaluation tools and percentages of final mark

- The assessment types and conditions are indicated below: 100%
ORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT

The student can be evaluated under two types of assessments: continuous or final. The continuous assessment system is prioritized, as indicated in the regulation of the UPV/EHU.

If a student who meets the requirements of continuous assessment wishes to opt for the final assessment, he or she must inform the lecturers responsible for the subject in the following manner and within the following deadlines: via email once the written test of the 2nd fixed week has been graded.

Continuous assessment:
The continuous assessment involves practical individual and group works (15%), theory and exercises partial exams in the laboratory (85%).
The final mark will be the mean of the results obtained in all the evaluation items, provided that a minimum of 4 has been obtained in each one. The subject will be passed with an average mark of 5 or more.

Global assessment:
The global assessment involves a theory and exercises exam in the laboratory (100%). Not taking part in any of these exams will be considered a withdraw. The subject will be passed with an average mark of 5 or more.

EXTRAORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT

The assessment in extraordinary examination will be the same as the global assessment:

The global assessment involves a theory and exercises exam that will take place in the laboratory (100%). Not taking part in any of these exams will be considered a withdraw. The subject will be passed with an average mark of 5 or more.

MANDATORY MATERIALS

There is no required material. The student will complete his/her material by following the classes.

BIBLIOGRAPHY

Basic bibliography
Peter D. Hoff (2009) A First Course in Bayesian Statistical Methods. Springer

Detailed bibliography

Journals

Web sites of interest

OBSERVATIONS
"Automated Reasoning" is a second-year mandatory course of the Bachelor's Degree in Artificial Intelligence, taught in the second term.

In this course, we introduce the formal basis of:
A) Logical reasoning: reasoning is the ability to make inferences about some given knowledge, and automated reasoning is concerned with the building and use of computing systems that automate this process.
B) Knowledge representation: we consider the two most widely used logical formalisms, propositional logic and first-order logic.

Additionally, we use state-of-the-art software in a practical way and analyze some of the most important applications in Artificial Intelligence.

In this manner, we enhance and complete the knowledge introduced in some first-year subjects. More specifically:
1) "Discrete Mathematics", where some deductive reasoning systems for propositional and first-order logics are presented.
2) "Programming Methodology", where first-order logic is used as formal specification language.

Along with this subject, the problem of knowledge representation is also addressed in two other second-year courses of the second term, although from different viewpoints: "Databases" and "Artificial Intelligence". Further, some other reasoning methods are studied in the course "Artificial Intelligence", such as rule-based systems.

The knowledge presented in this course serves as a basis or is completed in higher courses of the degree, like "Database Design" (third year), "Development of Big Data Applications" (third year), "Knowledge-Based Systems" (fourth year) and "Advanced Techniques in Artificial Intelligence" (fourth year).

COMPETENCIES/LEARNING RESULTS FOR THE SUBJECT

* Knowledge representation using formal logic languages.
* Proving a conclusion from the given assumptions by the application of mechanical formal system.
* Model and counter-model generation for logical statements.
* Understanding some algorithms and strategies involved for automated deduction.
* Using automated reasoning tools and understanding their outcomes.

Theoretical and Practical Contents

1. Mathematical representation of knowledge.
2. Deductive methods and tools for propositional logic.
3. Deductive methods and tools for first-order logic.

TEACHING METHODS

In the master classes, we describe the theoretical subjects of the course and resolve some practical exercises.

Likewise, in the practical group classes, we resolve some additional exercises by means of using state-of-the-art automated tools.

In both cases, we use active methodologies that encourage students to acquire skills by working, both autonomously and in teams, in order to solve the different proposed objectives. In addition, we encourage the formulation of questions and their discussion, so that students acquire skills related to oral communication, synthesis capacity and teamwork.

In order to facilitate and ensure learning, we monitor and provide feedback on the basis of previously established evaluation criteria, providing students with the opportunity to become aware of their progress.
**TYPES OF TEACHING**

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Evaluation tools and percentages of final mark

- Continuous evaluation
- End-of-course evaluation

**Evaluation methods**

- Continuous evaluation
- End-of-course evaluation

**Evaluation tools and percentages of final mark**

- Written test, open questions 70%
- Exercises, cases or problem sets 30%

**ORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT**

The criteria established in the current regulations are applied for the choice of assessment system (continuous or final), and also for changes to the assessment system (from continuous to final). The default assessment mode is continuous. Actually, the subject is oriented to the continuous assessment modality.

### Continuous evaluation

The assessment of the acquired knowledge and skills consists in mid-course exams (70%) and practical exercises (30%).

More concretely, there are 3 mid-course exams. Next, we state the subjects and percentages of the final grade that respectively correspond to each exam:

* First mid-course exam: Propositional logic, 20%.
* Second mid-course exam: First-order logic, 25%.
* Third mid-course exam: Practical applications - Prolog, 25%.

All the tests are marked out of 10 points.

The final grade is obtained by calculating the weighted average of the marks in the mid-course exams and practical exercises.

In any case, in order to pass the course it is compulsory to satisfy the following conditions:

a) Exceed the minimum mark (3 of 10 points) in all the mid-course exams
b) Exceed the minimum mark (5 of 10 points) in the final grade.

### End-of-course evaluation

Changes from continuous assessment to final assessment can be requested as long as a percentage equal to or higher than 80% of the final grade has not been assessed.

Final assessment is made through a written exam, which is marked out of 10 points and gives the final grade of the course.

It is compulsory to exceed the minimum mark (5 of 10 points) in the final grade in order to pass the course.

In order to resign from the evaluation, it is necessary not to take the final written exam.

**EXTRAORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT**

We apply the criteria established for the end-of-course evaluation method of the ordinary examination period.

That is, the assessment is made through a final written exam, which is marked out of 10 points and gives the final grade of the course.

It is compulsory to exceed the minimum mark (5 of 10 points) in the final grade in order to pass the course.

In order to resign from the evaluation, it is necessary not to take the final written exam.

**MANDATORY MATERIALS**

All the resources that are available at the virtual classroom in eGela.
BIBLIOGRAPHY

Basic bibliography


Detailed bibliography


Journals

* Journal of Automated Reasoning (https://www.springer.com/journal/10817/)
* Journal of Logic and Computation (https://academic.oup.com/logcom)
* ACM Transactions on Computational Logic (https://dl.acm.org/journal/tocl)

Web sites of interest

The TPTP Problem Library for Automated Theorem Proving: https://tptp.org/
System on TPTP: https://www.tptp.org/cgi-bin/SystemOnTPTP
The CADE ATP System Competition: https://tptp.org/CASC/
Logic Tools: https://logictools.org/

OBSERVATIONS
PLEASE NOTE THAT THIS SUBJECT IS TAUGHT ONLY IN SPANISH/BASQUE, ALTHOUGH IT IS ENGLISH FRIENDLY.

This course is a compulsory course in the 2nd year of the Engineering Degree in Artificial Intelligence (taught during the first term).

The subject is designed to introduce students to both the theoretical and practical aspects of Digital Signal Processing. For this reason, the subject uses concepts previously learned in first-year subjects of the degree in the area of mathematics (Mathematical Analysis, Algebra), statistics (Statistical Methods in Engineering) and programming (Basic Programming, Programming Methodology, Modular Programming and Object Oriented).

Within the context of the degree in Artificial Intelligence, the course provides students with the necessary tools to process signals of various kinds and transform them so that they can be used as input to intelligent information processing systems that are presented in multiple subjects of the degree (Data Mining, Artificial Intelligence, Machine Learning and Neural Networks, Biomedical and Physiological Data Analysis, Speech Processing, among others).

In the professional field, the subject enables students to digitally process any type of signal (sound, image, information from sensors, time series, etc.) in multiple fields (audiovisual, industry, medicine, meteorology, etc.). In this way, it serves as a link to other areas such as Data Science, Big Data, Industry 4.0, Robotics, Physiological Computing, etc.

COMPETENCIES/LEARNING RESULTS FOR THE SUBJECT

According to the verified report of the degree in Artificial Intelligence, the competences (specific, transversal) and learning outcomes are presented.

The specific competences acquired by taking the subject are:
M07CE1 - Knowledge of the representation of signals and systems in the time and frequency domains, both in continuous and discrete time.
M07CE2 - Ability to understand, analyse, evaluate and apply the most appropriate digital signal processing strategies to deal with a given physical process.

The transversal competences acquired by taking this subject are:
CT1 - Autonomy and Self-regulation
Ability to use self-management and self-regulation techniques.
CT3 - Communication and Multilingualism
Ability to communicate ideas and arguments in a comprehensible way and according to established formal criteria.
CT8 - Teamwork
Value teamwork, accepting the potential of diversity as a learning opportunity. Carry out with responsibility the tasks that correspond to them in order to achieve the objectives and the collective result.

The specific learning outcomes provided by the subject are the following:
RA1 - Know how to use digital signal processing software and critically interpret the results obtained.
RA2 - Master and be able to apply the mechanisms of transformation of continuous signals to digital: sampling and quantification.
RA3 - Know the main methods of calculating the Fourier transform and know how to apply them to digital signals.
RA4 - Know the main parameters of FIR and IIR digital filters, and know how to design and apply them to digital signals.

Based on these competences and learning outcomes, the following objectives are contemplated in the subject:
O1 - To introduce students to the basic concepts related to Digital Processing: signals, systems, time and frequency analysis, filters.
O2 - To deepen in these concepts for signals of different nature, and to show the methods used in digital systems to capture, process and produce this type of signals.
O3 - To show different practical applications of these techniques and alternatives for their implementation.
O4 - To put into practice the concepts studied, applying them in the laboratory to real cases of signal processing using the
MATLAB platform (other alternatives such as SCILAB, Octave, Python, etc. may also be used).

**Theoretical and Practical Contents**

PLEASE NOTE THAT THIS SUBJECT IS TAUGHT ONLY IN SPANISH/BASQUE, ALTHOUGH IT IS ENGLISH FRIENDLY.

Theme 1

1. Introduction to digital signal processing
2. Signals and systems Why digital processing? Introduction to the subject in which the basic definitions of the PDS are shown.

Theme 2

1. Digital signals
2. Definitions and properties. Digitization. Basic signals and operations
3. Analysis of different types of signals (sound, image, physiological, etc.)
   Practical part: Specific Project 1 (PE1) - Introduction to Matlab
After introducing the main types of signals, a specific project will be carried out in order to learn the functionalities of the Matlab platform.

Theme 3

1. Time domain analysis
2. Usual operations. Windowing and short-term operations. Correlation
   Practical part: Specific Project 2 (SP2) - Time Domain Analysis
This chapter presents the treatment of signals in the time domain. It introduces short-time analysis of signals and the possible features to be extracted, e.g. correlation. It ends with a project in which a sound signal is analysed to automatically extract the frequencies present by means of correlation.

Theme 4

1. Frequency domain analysis
2. Starting idea. Fourier series and transform. Application to two-dimensional systems
3. Projects: Analysis of digital signals in the frequency domain
   Practical part: Specific Project 3 (SP3) - Frequency domain analysis
This chapter presents the treatment of signals in the frequency domain after applying the Fourier transform. Window analysis is again used in order to extract features in the frequency domain. It ends with a project in which several sound signals (DTFM, melodies) are analysed in order to extract the frequencies present in them by analysing the spectra.

Theme 5

1. Filters
2. LTI systems. FIR filters. Z transform. IIR filters. Non-linear filters
   Practical Part: Specific Project 4 (SP4) - LTI Filters: FIR
   Practical Part: Specific Project 5 (SP5) - LTI Filters: IIR
This topic introduces the two types of LTI filters, FIR and IIR, together with the Z-transform. In this topic, two specific projects with FIR and IIR filters respectively are developed in practical applications, e.g. removal of unwanted noise in signals.

Theme 6

1. Applications of digital signal processing.
2. Areas of application and examples.
   The last topic of the course explores the concept of sampling, quantification and aliasing. In addition, applications of PDS are considered that point towards possible final projects.
   Practical part: Final Project (FP) - Application of PDS in a given context.
   This is a project of medium/high complexity in which what has been learnt in the course is applied.

**TEACHING METHODS**

PLEASE NOTE THAT THIS SUBJECT IS TAUGHT ONLY IN SPANISH/BASQUE, ALTHOUGH IT IS ENGLISH FRIENDLY.

There are four types of activities:

- Autonomous study by the students of the material available in the virtual classroom for each subject in which the theoretical/practical concepts to be used are presented, as well as a proposal of exercises associated with them. In addition to directly accessible information, students can use bibliographic references as support material.
- Presentation and exercise classes in which, in a participative way, the theoretical/practical concepts of each topic are shared and the doubts associated with them are clarified, always emphasizing their usefulness and practical aspects. In these sessions, the initially proposed exercises ("on paper") will be shared in order to deepen the theoretical foundations. Exercises will also be proposed on each topic that the students will have to solve and that will be evaluated with the corresponding feedback.

- Development of specific projects in which students in groups (preferably in groups of 2 or 3) apply the theoretical/practical concepts learnt to real problems, using specific signal processing software. For each of these sessions, a technical report of the results must be submitted that will be evaluated with the corresponding feedback.

- Development of a final project (medium/high complexity level) in which the students (preferably in groups of 2 or 3) will apply the theoretical/practical knowledge previously learned in the course.

In order to facilitate student learning, specific projects will be monitored by providing feedback based on previously established and shared evaluation criteria. In this way, students are aware of their level of learning and take steps to improve it if necessary.

### TYPES OF TEACHING

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### Evaluation methods

- Continuous evaluation
- End-of-course evaluation

### Evaluation tools and percentages of final mark

- The percentages and types of assessment are specified in the following sections 100%

### ORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT

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The assessment systems considered are the continuous assessment system and the final assessment system. In the ordinary call, the continuous assessment system is the one that will be used in preference, as indicated in the current regulations of the UPV/EHU. The mark is calculated as follows:

- Theory: classroom exercises and written tests 50% (5 points: 2 points for topics 1-2-3, 2.5 points for topics 4-5, and 0.5 points for topic 5).
- Practical: specific projects 35% and final project 15%. This part of the course uses a PBL type methodology and involves the autonomous completion of the proposed projects, with the delivery of the corresponding technical reports (transversal communication skills) by each group of two or three people (collaborative learning). In addition, there will be individual written evaluations that will weigh the marks of the practical part in the following way:

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<thead>
<tr>
<th>Minimum mark</th>
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For the final assessment mode, the students will have to submit the reports corresponding to the specific projects and the final project at least two weeks before the date of the ordinary call (date of the final theory test). In this case, the examination will weigh 60% and the practical part 40% (based on previously submitted projects). There will be an individual written evaluation that will weigh the overall mark of the practical part (see the weighting in the continuous assessment).

In order to pass the subject, in any modality, it is necessary to pass both the practical and theoretical parts of the subject separately.
Students who, fulfilling the conditions to continue in the continuous assessment system, decide to opt for the final or global assessment, must inform the teacher responsible for the subject by email before the beginning of the second week of the grouped timetable of the four-month period established in the centre's calendar.

**EXTRAORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT**

**PLEASE NOTE THAT THIS SUBJECT IS TAUGHT ONLY IN SPANISH/BASQUE, ALTHOUGH IT IS ENGLISH FRIENDLY.**

In the case of the extraordinary call, the final mark is calculated based on two parts:

- **Theory (60%)**: It is assessed by means of a knowledge test on the date of the extraordinary call.
- **Practical (40%)**: This is assessed on the basis of the technical reports corresponding to the specific and final projects, which must be submitted before the date of the theory test. There will be an individual written evaluation that will weigh the overall mark of the practical part.

In order to pass the course it is necessary to pass both parts (theoretical and practical).

**MANDATORY MATERIALS**

**PLEASE NOTE THAT THIS SUBJECT IS TAUGHT ONLY IN SPANISH/BASQUE, ALTHOUGH IT IS ENGLISH FRIENDLY.**

For the correct development of the subject it is required:

- a PC type personal computer.
- and specific software for signal processing (MATLAB, etc.), for the laboratory practices.

The centre provides both resources. In addition, students have the possibility of carrying out the practical projects on their own computers using the UPV/EHU's MATLAB corporate licence and free software (SCILAB, Octave, Python, etc.).

**BIBLIOGRAPHY**

**Basic bibliography**

**PLEASE NOTE THAT THIS SUBJECT IS TAUGHT ONLY IN SPANISH/BASQUE, ALTHOUGH IT IS ENGLISH FRIENDLY.**


**Detailed bibliography**

**PLEASE NOTE THAT THIS SUBJECT IS TAUGHT ONLY IN SPANISH/BASQUE, ALTHOUGH IT IS ENGLISH FRIENDLY.**


**Journals**

**PLEASE NOTE THAT THIS SUBJECT IS TAUGHT ONLY IN SPANISH/BASQUE, ALTHOUGH IT IS ENGLISH FRIENDLY.**

Digital Signal Processing (Elsevier)
Signal Processing (Elsevier)
IEEE Signal Processing Letters
COURSE GUIDE 2024/25

Faculty 226 - Faculty of Informatics
Degree GIARTI20 - Bachelor's Degree in Artificial Intelligence

COURSE
28271 - Advanced Machine Learning Credits, ECTS: 6

COURSE DESCRIPTION

The subject is taught in the second semester of the 3rd year of the Artificial Intelligence degree. It is a natural continuation of the Data Mining subject (2nd year). It is also tightly linked to other subjects of the first semester, such as Machine Learning and Neural Networks, and Natural Language Processing.

The subject has a dual perspective. First, the theoretical roots of the machine learning paradigm are studied, and introduced a classifiers which naturally raises from these roots. Second, non-standard classification problems are studied and solved: that’s, going beyond the "comfort area" of supervised and unsupervised classification.

All these problems are crucial for the subjects in the 4th year of the degree.

In order to study this subject, the student needs to use the knowledge previously learned in the Data Mining subject, and other basic subjects such as Advanced Statistical Methods and Operation Research.

COMPETENCIES/LEARNING RESULTS FOR THE SUBJECT

Output of the learning process:
- Knowledge on the theoretical-practical roots of the machine learning paradigm

Theoretical and Practical Contents

1. Machine Learning fundamentals
   - PAC learning, VC
   - Loss functions
   - Empirical Risk Minimization

2. Methods based on kernels
   - Linear methods for classification - Support Vector Machines (SVMs)

3. Weakly supervised classification
   - Semi-supervised classification
   - Positive unlabeled learning
   - Learning with label proportions
   - Crowd learning
   - Miscelanea: other types of weakly supervised problems

4. Non-standard supervised classification
   - Multi-label learning
   - Multi-dimensional classification
   - Hierarchical classification
   - Structured output prediction

TEACHING METHODS

Different teaching methodologies are used. Some of them, teaching classes with slides, presenting the theoretical parts and case studies of the subject. Some of these problems will be solved by the students.

On the other class, computer laboratories are used. Coding practices will be used to solve the exposed problems.

The student will receive feedback from the teacher, based on the output of these theoretical and laboratory classes. These works will be graded.

TYPES OF TEACHING

<table>
<thead>
<tr>
<th>Types of teaching</th>
<th>M</th>
<th>S</th>
<th>GA</th>
<th>GL</th>
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<tbody>
<tr>
<td>Hours of face-to-face teaching</td>
<td>40</td>
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<td>Horas de Actividad No Presencial del Alumno/a</td>
<td>60</td>
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Legend:
- M: Lecture-based
- S: Seminar
- GA: Applied classroom-based groups
- GL: Applied laboratory-based groups
- GO: Applied computer-based groups
- GCL: Applied clinical-based groups
- TA: Workshop
- TI: Industrial workshop
- GCA: Applied fieldwork groups
Evaluation methods

- Continuous evaluation
- End-of-course evaluation

Evaluation tools and percentages of final mark

- Written test, open questions 40%
- Exercises, cases or problem sets 60%

**ORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT**

While continual and global evaluation systems are allowed, the first one, continual evaluation, is hardly recommended and will be the default system, as exposed in the UPV/EHU rules.

The student who, fulfilling the requirements to complete the continual evaluation, decides the global evaluation, needs to inform the teachers during the first 9 months of the course (in writing form).

The evaluation of the subject is continual, and composed of the following tests-exams:
1- Tests during the course: 60% of the final mark. This will be done by:
   - Individual works to evaluate the concepts exposed during the classes.
   - Group and individual works to evaluate how the students solve the problems exposed during the classes and practical sessions.

2- Writing exam in the official date fixed by the Faculty in the official exam-period: 40% of the final mark. It is a writing-exam, where the theoretical-practical concepts exposed in the subject will be evaluated.

The final mark is a sum of both, previous (sub)marks: but it is needed to obtain a minimum of 4 points (over 10) in each of the both tests-exams.

The student has the right to be evaluated by the "global evaluation system". To proceed with this, the student needs to present, in writing form, his/her election of the global system: during the first 9 weeks of the course. If the student does not present any work during the first 9 weeks of the course, it is understood that he/she opt for the global evaluation type.

In both types of evaluation, if the student is not present in the final writing exam, it is understood that he/she gives up, and will be qualified as "non-present".

**EXTRAORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT**

The rules of the ordinary call will be applied.

The students who opted for the continual evaluation form can "save" for this extraordinary call the partial marks obtained in the tests and works done during the course. When these are completed, he/she only needs to perform the extraordinary exam of the subject, which covers the 40% of the final mark. It is also needed to obtain, at least, a 4 over 10, in each of the tests-exam, to be considered to pass the subject.

**MANDATORY MATERIALS**

None.

**BIBLIOGRAPHY**

**Basic bibliography**


Detailed bibliography
None

Journals

Web sites of interest
Web sites of interest
PLEASE NOTE THAT THIS SUBJECT IS TAUGHT ONLY IN SPANISH/BASQUE, ALTHOUGH IT IS ENGLISH FRIENDLY.

www.mathworks.com
www.scilab.org
www.dsprelated.com
www.gnu.org/software/octave
www.scipy.org

OBSERVATIONS
COURSE GUIDE

<table>
<thead>
<tr>
<th>Faculty</th>
<th>226 - Faculty of Informatics</th>
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</thead>
<tbody>
<tr>
<td>Degree</td>
<td>GIARTI20 - Bachelor's Degree in Artificial Intelligence</td>
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<tr>
<td>Cycle</td>
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<td>Year</td>
<td>Third year</td>
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COURSE DESCRIPTION

The study of this subject is the solution of optimization problems. Finding the best solution to a problem is one of the most important elements of decision making. Optimal planning of processes, optimization of finding the shortest route in a transport company or allocation of resources are examples of optimization problems that appear so often in real life.

In the Operative Research subject, classic techniques for solving optimization problems are explained, such as Simplex, Branch & Bound or the Hungarian method. To apply these algorithms, the problems must have specific characteristics (usually they are simple problems). However, many of the problems presented in reality are very complex (NP-hard) and therefore it is impossible to use the algorithms we have mentioned. The algorithms that we will learn in the Heuristic Searches subject will, in a short time, try to obtain the best possible solutions. Of course, no guarantee of optimal results. They are known as heuristic algorithms, and they are based on intuition. During the subject, we will study combinatorial optimization problems, and learn how to formalize them, and design and implement algorithms to solve them. Not only that, we will learn how to choose the most effective among the proposed algorithms.

"Please note that this subject is taught only in Spanish/Basque”

COMPETENCIES/LEARNING RESULTS FOR THE SUBJECT

- Acquiring the ability to formalize combinatorial optimization problems, represent their solutions appropriately, and define the search space.

- Knowing how to design and apply constructive algorithms, algorithms based on a single solution, and population algorithms.

- To acquire the ability to grasp multiple objectives or problems in dynamic contexts, and to have the ability to apply appropriate algorithms by analyzing the scientific bibliography.

- Knowing how to define and apply an experimental design to compare stochastic algorithms. Mastering techniques for visualizing results, and having the ability to apply statistical analysis methods to draw strong conclusions.

Theoretical and Practical Contents

* Unit 1 - Introduction to heuristic searches.
  1.1. Combinatorial optimization problems.
  1.2. Coding and search space for solutions.
  1.3. The complexity
  1.4. A review of classical methods.
  1.5. Constructive algorithms.

* Unit 2 - Local search heuristic algorithms.
  2.1. Environmental function
  2.2. Local search algorithms
  2.3. Selection criteria.
  2.4. Local maxima and minima and their estimation
  2.5. Bases of attraction

* Unit 3 - Advanced local searches.
  3.1. Multi-start methods (MLS, GRASP, ILS,...)
  3.2. Environment function modification methods (VNS, VND...)
  3.3. Methods for accepting bad solutions (SA, TS,...)

* Unit 4 - Algorithms based on populations
  4.1. Introduction
  4.2. Genetic algorithms
  4.3. Estimation of Distribution Algorithms
  4.4. Swarm Intelligence algorithms (ACO, PSO)

* Unit 5. Variations of optimization problems
  5.1. Multi-objective optimization
  5.2. Dynamic optimization
5.3. Optimization of problems with constraints

* Unit 6. Experimental design and algorithm comparison.
  6.1. Experimental design.
  6.2. Execution of algorithms.
  6.3. Visualization of results.
  6.4. Statistical analysis of the results (Uncertainty analysis)

**TEACHING METHODS**

In this lesson we will have four types of activities:

Lectures - Theoretical content will be presented and illustrated with simple examples. Student participation will be encouraged, with small exercise challenges focused on reflection.

Individual laboratory practice - Students will individually program heuristic algorithms for optimization problems in the Python language. The aim will be to illustrate the theoretical content.

Group project - In groups, they will have to develop a project. The teachers will ask them an optimization problem, and formalize the problem, and they will have to propose two algorithms to optimize it. Finally, they will have to develop an experimental design to compare the performance of the two. They will have to write all the work in a 4-page scientific article at the end of the semester.

Seminars - In these special sessions we will work on some concrete content that is additional to the workshop. Using a relaxed format, students will initially work on the content, followed by discussion.

**TYPES OF TEACHING**

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**Evaluation tools and percentages of final mark**

- Continuous evaluation
- End-of-course evaluation

**ORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT**

Two types of assessment will be available: CONTINUOUS and FINAL.

During the CONTINUOUS evaluation you will have to complete six tasks: 2 tests (one practical and one theoretical), 2 project submissions and 2 laboratory submissions. By default, all students will go through this type of assessment. In this type of evaluation, the grade will be calculated through the evaluation of the following tasks:

- Project - 20% (divided into 2 phases, 10% each)
- Laboratory test - 20% (two tests, 10% each)
- 1. Theoretical test - 30%
- 2. Practical test - 30%

In order to be able to keep the CONTINUOUS evaluation, a minimum grade of 3.5 out of 10 must be obtained in each test. A minimum grade must also be passed in the laboratory assignments. Those who do not pass the minimum will automatically go to the FINAL evaluation.

In the assessment, the FINAL will be evaluated through a theoretical-practical exam and the delivery of the project:

- Project - 20%
- Theoretical-practical test - 80%

If the student did not pass, he would have another opportunity to do the theoretical-practical test in the non-regular call.

If desired, the student can proceed to the final assessment, always before the second exam.

Given the content of the course and its practical nature, it is recommended to carry out the assessment on a continuous
EXTRAORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT

In the non-ordinary exam, there will be only one theoretical-practical test worth 80% of the grade, which will cover the theoretical and practical concepts of the subject. The other 20% can be obtained with the delivery of the project.

MANDATORY MATERIALS

Course notes that will be provided in eGela, as well as numerous scientific articles that the professor will recommend to the students. Finally, the practical exercises will be programmed in Python and using Jupyter Notebooks or Google Colab.

BIBLIOGRAPHY

Basic bibliography
- C. Blum, A. Roli. Metaheuristics in combinatorial optimization: Overview and conceptual comparison. ACM Comput. Surv. 35, 3 (Sep. 2003), 268-308

Detailed bibliography

Journals
- IEEE Trans. On Evolutionary Computation
- Evolutionary Computation Journal
- European Journal of Operational Research
- Computers and Operations Research
- Journal of Heuristics
- Journal of Machine Learning Research
- Information Sciences

Web sites of interest
- Red Española de Metaheurísticos. http://heur.uv.es/
- Dirección de LIO una librería de algoritmos heurísticos http://www.dsi.uclm.es/investigacion/simd/SOFTWARE/LIO/

OBSERVATIONS