



## Course guide

# 270011 - SO - Operating Systems

Last modified: 30/01/2024

**Unit in charge:** Barcelona School of Informatics  
**Teaching unit:** 701 - DAC - Department of Computer Architecture.

**Degree:** BACHELOR'S DEGREE IN INFORMATICS ENGINEERING (Syllabus 2010). (Compulsory subject).

**Academic year:** 2023    **ECTS Credits:** 6.0    **Languages:** Catalan, Spanish, English

### LECTURER

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**Coordinating lecturer:** YOLANDA BECERRA FONTAL

**Others:**

Primer quadrimestre:

DAVID ÀLVAREZ ROBERT - 43, 53  
ADRIÀ ARMEJACH SANOSA - 13, 33  
YOLANDA BECERRA FONTAL - 21, 22, 23, 51, 52, 53  
JULITA CORBALAN GONZALEZ - 31, 32, 33  
JORGE FORNES DE JUAN - 11, 12, 13, 21  
JORDI GUITART FERNANDEZ - 51  
AMADOR MILLÁN VIZUETE - 41, 42, 43, 44  
ENRIQUE MORANCHO LLENA - 52  
JAVIER VERDU MULA - 41

Segon quadrimestre:

DAVID ÀLVAREZ ROBERT - 14  
ADRIÀ ARMEJACH SANOSA - 42  
YOLANDA BECERRA FONTAL - 11, 12, 13, 14  
JULITA CORBALAN GONZALEZ - 11, 12, 13, 14  
JORGE FORNES DE JUAN - 12  
JORDI GUITART FERNANDEZ - 41  
AMADOR MILLÁN VIZUETE - 41, 42, 43  
JAVIER VERDU MULA - 11, 13

### PRIOR SKILLS

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The student must have the technical capabilities that will confer the subjects studied previously and a minimum level of technical English (to read a documentation). In terms of technical capabilities could be summarized as:

- In terms of structure of computers: Understanding the main elements of a computer, these elements relate to each other, internal representation of data and basic knowledge of machine language.
- In terms of programming: Ability to program from scratch to include definition of data types, design a program more or less complex in different functions (which may be more than one file) and phases of creation an executable.

### REQUIREMENTS

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- Prerequisite EC
- Prerequisite IC

## DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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### Specific:

CT2.3. To design, develop, select and evaluate computer applications, systems and services and, at the same time, ensure its reliability, security and quality in function of ethical principles and the current legislation and normative.

CT3.6. To demonstrate knowledge about the ethical dimension of the company: in general, the social and corporative responsibility and, concretely, the civil and professional responsibilities of the informatics engineer.

CT6.1. To demonstrate knowledge and capacity to manage and maintain computer systems, services and applications.

CT6.2. To demonstrate knowledge, comprehension and capacity to evaluate the structure and architecture of computers, and the basic components that compound them.

CT6.3. To demonstrate knowledge about the characteristics, functionalities and structure of the Operating Systems allowing an adequate use, management and design, as well as the implementation of applications based on its services.

CT7.1. To demonstrate knowledge about metrics of quality and be able to use them.

CT7.2. To evaluate hardware/software systems in function of a determined criteria of quality.

CT7.3. To determine the factors that affect negatively the security and reliability of a hardware/software system, and minimize its effects.

CT8.4. To elaborate the list of technical conditions for a computers installation fulfilling all the current standards and normative.

### Generical:

G8. APPROPRIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

## TEACHING METHODOLOGY

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The course will mainly have two types of class: Theory and laboratories. The theory classes are mainly oriented to generic or to explain concepts applied to the particular case of Linux. These classes will be supported by slides. The laboratory classes are weekly and include work performed prior to the student, in class exercises to do individually and some questions that must be delivered at the end of class. Attendance to at least 80% of the laboratory sessions is a necessary condition to pass the continuous evaluation of the course. Although all the sessions will include these questions to deliver, not all of them will be evaluated, only those that are marked as such. The rest will be used to track students and monitor the implementation of previous work and attitude of students in class. Especially in laboratory classes will be assessed issues such as student punctuality and positive attitude to the subject.

## LEARNING OBJECTIVES OF THE SUBJECT

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1. Know the main functions of an OS and because of its necessity (abstraction / virtualization hardware, security, efficiency)
2. Understanding how the OS manages and provides its services and capabilities internally through data representation and management of resources, algorithms and hardware support
3. An overview of information systems: know the different interfaces and components that interact with the OS (hardware, system libraries, libraries + language user programs)
4. For each basic functionality of the system (process management, memory and I/O) know influencing basic aspects of the different architectures and environments that can support operating systems
5. For each basic functionality of the system (process management, memory and I/O): Understanding the hardware element that we want virtualizing
6. For each basic functionality of the system (process management, memory and I/O) know and be able to use the basic functionality offered by the system to the user.
7. For each basic functionality of the system (management processes, memory and I/O) know the basic elements of design (data types, data management structures and management algorithms) to offer this functionality.
8. For each basic functionality of the system (process management, memory and I/O): to know the basic architecture of the basic design elements in SO
9. For each basic resource which manages the OS (processes, virtual memory and I/O): to know the basic metric to assess service system and be able to apply the theoretical level.
10. For each basic resource which manages the system (processes, memory, I/O), know and be able to use basic tools to analyze a system's implementation and to monitor the state of the system to detect potential problems.
11. Understanding the implications, from the viewpoint of system and user of a multi-user parallel system.
12. Being able to participate in proactive professional development, demonstrating attendance, punctuality and respect
13. Being able to show motivation for quality and continuous improvement



## STUDY LOAD

Type	Hours	Percentage
Guided activities	6,0	4.00
Hours small group	30,0	20.00
Hours large group	30,0	20.00
Self study	84,0	56.00

**Total learning time:** 150 h

## CONTENTS

### Introduction to Operating Systems

**Description:**

This chapter will give an overview of what is an OS that manages hardware resources, what are the services, functions etc.. We also introduced different types of users and applications that interact with the OS and the various forms of access.

### Process Management

**Description:**

This chapter will address the following points: concept of process. Context of a process. The life of a process. Concept planning processes.. Mechanism of change of context. Management of events (signals). Concept of thread. Concept of concurrency. Issues related to concurrency. Inter-process communication: shared memory and message passing (only in terms of concept).. Basic services for process management: Calls to system and management efficiency, security between users, reliability, etc.. Idea / Context: registros, stack, memory (address space) / Member / signals / users / environment variables. Representation of internal processes in Linux as well as the Round-robin scheduling algorithm to illustrative mode .

### Memory management

**Description:**

This chapter will address the following points regarding memory requirements of a general purpose system (definition of address space of a process and need for virtual memory). Basic services offered by the memory management system: support for address translation, protection of processes, loading processes, dynamic memory management, virtual memory, etc.. Structures and algorithms for management in virtual memory.

### Management of input / output

**Description:**

This topic will address the following points: Characteristics and types of devices. Concept of independence of devices. Relationship between the management of input / output and process management: operations blocking operations. Type of logical devices: pipes, console, sockets and files. Basic services and data structures necessary. Management namespace. Internal representation and algorithms to support the efficient management of devices (buffering, spooling, caching, locking). Concept of File System (FS) and services offered by it. Layered architecture of SF. Introduction to the VFS. Different types of files and utilities associated with files. Internal organization in Linux directories, i-nodes.. Organization of the disk space: fragmentation, partitions, services associated with SF's, space management free / busy. Reliability for SF's.



## ACTIVITIES

### Development of the subject Introduction to OS

**Description:**

During this activity students will be an overview of what is an OS, what are their functions and services which are the main components of the system will develop during the course.

**Specific objectives:**

1, 2, 3

**Full-or-part-time:** 4h

Theory classes: 2h

Self study: 2h

### Overview of the execution environment

**Description:**

During this activity, we will use basic commands to work with a Linux working environment, especially working from the command line but also understand the relationship with a graphical environment. Practiced commands to navigate the file system for manipulating files, etc..

**Specific objectives:**

1, 2, 3, 12, 13

**Related competencies :**

G8. APPROPRIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

**Full-or-part-time:** 4h

Laboratory classes: 2h

Self study: 2h

### C Programming and development

**Description:**

During this activity we will work on C programming and give some basic guidelines for developing small projects that will make students in the lab sessions so they have a similar structure in terms of tools, organizing files and so on.

**Specific objectives:**

1, 2, 3, 12, 13

**Related competencies :**

G8. APPROPRIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

**Full-or-part-time:** 4h

Laboratory classes: 2h

Self study: 2h



### Development of concepts associated to process management

**Description:**

During these hours we will practice the concepts and basic services related to processes and threads. We will explain the concepts related to the internal organization and management that makes the OS to provide these services and features. We also discussed issues related to systems efficiency, reliability, security, etc..

**Specific objectives:**

4, 5, 6, 7, 8, 9, 10, 11

**Full-or-part-time:** 16h

Theory classes: 8h

Self study: 8h

### Basic services-related processes

**Description:**

During this activity we will practice basic system calls that we can find in a Linux system to create a process, change the executable and wait for the process exit. We will also practice from an administrative point of view related to the monitoring processes.

**Specific objectives:**

6, 7, 10, 11, 12, 13

**Related competencies :**

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**Full-or-part-time:** 4h

Laboratory classes: 2h

Self study: 2h

### Using advanced process and threads services

**Description:**

During this sesion we will work with threads (POSIX). We also introduce the management of events between processes (signals) both as a means of communication and as advanced service process management. We willl also work aspects related to concurrency processes.

**Specific objectives:**

4, 5, 6, 7, 10, 11, 12, 13

**Related competencies :**

G8. APPROPRIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

**Full-or-part-time:** 4h

Laboratory classes: 2h

Self study: 2h



### Process management: problems solving session

**Description:**

During that session we will solve some process management exercises

**Specific objectives:**

4, 5, 6, 7, 8, 9, 10, 11

**Full-or-part-time:** 4h

Laboratory classes: 2h

Self study: 2h

### Development of concepts associated with memory management

**Description:**

During these hours you will practice the basic concepts related to memory management, services and functionalities offered by the system users (including optimizations that are typically at the level of library) and describe the mechanisms and algorithms internal management of the kernel to manage virtual memory.

**Specific objectives:**

4, 5, 6, 7, 8, 9, 10, 11

**Full-or-part-time:** 8h

Theory classes: 4h

Self study: 4h

### Basic services for memory management

**Description:**

During this session we will practice with basic services for managing the memory processes and some commands to monitor the status of processes

**Specific objectives:**

5, 6, 12, 13

**Related competencies :**

G8. APPROPRIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a wide vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

**Full-or-part-time:** 4h

Laboratory classes: 2h

Self study: 2h



### Metrics of performance and scheduling processes. Multiprocess environment impact.

**Description:**

We will evaluate different programs with different configurations in terms of processes and system load analytically. The goal is to understand how system status and application itself influences in the application performance

**Specific objectives:**

4, 5, 6, 7, 8, 9, 11, 12, 13

**Related competencies :**

G8. APPROPRIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a wide vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

**Full-or-part-time:** 4h

Laboratory classes: 2h

Self study: 2h

### First continuous assessment control

**Description:**

This control will include the topics Introduction, Processes and memory. This exam may include both theoretical questions such problems.

**Specific objectives:**

1, 2, 3, 4, 5, 6, 7, 8, 9

**Full-or-part-time:** 9h

Guided activities: 2h

Self study: 7h

### Development of concepts associated with the input / output data

**Description:**

During these hours, we explain the concepts related to managing the input / output data: devices, services and functions related to input / output management system and device independence.

**Specific objectives:**

4, 5, 6, 7, 8, 9, 10, 11

**Full-or-part-time:** 20h

Theory classes: 10h

Self study: 10h



### Basic services for I/O Management

**Description:**

In this session we will practice with basic services to manage the input / output of data from/to processes. There will be exercises to consolidate the concepts related to the independence of devices.

**Specific objectives:**

5, 6, 12, 13

**Related competencies :**

G8. APPROPRIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a wide vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

**Full-or-part-time:** 4h

Laboratory classes: 2h

Self study: 2h

### Advanced services to manage the input / output of data from/to processes

**Description:**

During this session we will practice into more complex services and commands for managing input / output of data from/to processes and relationships with other system services such as management of events (signals)

**Specific objectives:**

4, 5, 6, 7, 11, 12, 13

**Related competencies :**

G8. APPROPRIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a wide vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

**Full-or-part-time:** 4h

Laboratory classes: 2h

Self study: 2h

### Systems Files and data Files

**Description:**

During that session we will use specific commands for system file management and specific system calls for data file management.

**Specific objectives:**

5, 6, 7, 8, 9, 12, 13

**Related competencies :**

G8. APPROPRIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a wide vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

**Full-or-part-time:** 4h

Laboratory classes: 2h

Self study: 2h



### Input/Output management: Problem solving session

**Description:**

During that sessions, we will solve some exercises related with input/output data management and process communication

**Specific objectives:**

4, 5, 6, 7, 8, 9, 10, 11

**Full-or-part-time:** 4h

Laboratory classes: 2h

Self study: 2h

### File systems: problems

**Specific objectives:**

1, 2, 4, 5, 6

**Full-or-part-time:** 4h

Theory classes: 2h

Self study: 2h

### Final exam lab

**Description:**

Final exam will include any laboratory system calls, tools, concepts, etc. practiced in the laboratory.

**Specific objectives:**

6, 10, 11

**Full-or-part-time:** 10h

Guided activities: 2h

Self study: 8h

### Final Exam

**Description:**

Written exam will include all course content. This examination may include questions both theoretical and problems.

**Specific objectives:**

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

**Full-or-part-time:** 10h

Guided activities: 2h

Self study: 8h

### Practical exercise on process management

**Description:**

This activity consists of solving a statement of the same style and under the same conditions as the exams of the course.

**Full-or-part-time:** 7h

Laboratory classes: 2h

Self study: 5h



### First continuous assessment exam

**Description:**

This exam assesses the concepts worked at the laboratory sessions from 1 to 5

**Specific objectives:**

1, 2, 3, 4, 5, 6, 7, 8, 9, 11

**Full-or-part-time:** 9h

Guided activities: 2h

Self study: 7h

### Practical exercise on input-output management

**Full-or-part-time:** 9h

Laboratory classes: 2h

Self study: 7h

## GRADING SYSTEM

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The mark of the technical competition is based on two components: continuous\_assessment (EC) and non\_continuous\_assessment (EF). The EC component will only be taken into account for students who accredit a follow-up of the subject: they have attended at least 80% of the laboratory sessions and have done the work of the sessions. Delivering a non-original work (not done by the student) is considered fraud and involves a 0 of the EC component.

$$\text{Grade} = \max(\text{EF}, 0,6*\text{EF}+0,4*\text{EC}).$$

$$\text{EC} = \text{CT } 35\% + 10\% \text{ ST} + 30\% \text{ CL} + 25\% \text{ SL}$$

- CT: Resulting from 1 partial exam after finishing the chapter of processes. This exercise is taken outside of time class.
- ST (theory follow-up note): short tests about concepts explained in theory classes
- CL: Resulting from 1 laboratory exercise after finishing session 4. This exercise is taken outside of time class.
- SL (lab follow-up note): to evaluate work done in some laboratory sessions.

$$\text{EF} = \text{theory } 50\% + 50\% \text{ lab}$$

- final exam performed at the end of the course and composed of two parts: theory and laboratory. It assesses all the content of the course.

### Evaluation of Generic Competition

In this case, be considered the following points:

1) proactive (accuracy) in professional development.

- \* Attendance. Students must attend 80% of the lab sessions. They must make deliveries to all lab sessions but only explicitly marks 2.

- \* Punctuality. Students must get off to class with a margin of 10 minutes. Be penalized for students who repeatedly arrive late.

- \* Respect. Students must act with respect toward peers and teachers.

- The teacher will be responsible to detect and record cases of disrespect, either towards himself or towards fellow students. If during the course of this case do not improve the course will get a negative evaluation of the competition.

2) proactive attitude (motivation) for quality and continuous improvement.

- \* Quality. We assessed the quality of code delivered taking into account mainly: the fulfillment of the requirements of the statements, the clarity of the code and the organization of the document.

- \* Motivation and responsibility: In the lab sessions students are asked a previous work to be performed necessarily.

- The previous work related questions that will help identify and penalize students who do not perform these tasks properly. But be evaluated very positively about those students who perform outstanding work.

Grade:

The grade of the generic skill obtained from the values of the information obtained by: Attendance, Punctuality, Respect, Motivation, Quality and Responsibility.

Special cases:

- If a student doesn't attend the 80% of lab sessions, will receive automatically a D in the evaluation

- If a student copies in lab deliveries he or she automatically has a D on the competency grade

- If a student shows a clear unmotivation for the course, for instance, passing the deadline for the notification to the final exam, will be automatically evaluated with a D

## BIBLIOGRAPHY

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### Basic:

- Silberschatz, A.; Galvin, P.B.; Gagne, G. Operating system concepts. Global ed. (10th ed.). John Wiley & Sons, 2019. ISBN 9781119454083.
- Kerrisk, Michael. The Linux Programming Interface. San Francisco: No Starch Press, 2010. ISBN 1593272200.

### Complementary:

- Kernighan, B.W.; Ritchie, D.M. The C programming language. 2nd ed. Prentice Hall, 1988. ISBN 0131103628.
- Stallings, W. Operating systems: internals and design principles. 9th ed. Pearson Education Limited, 2017. ISBN 9781292214306.
- Bovet, D.P.; Cesati, M. Understanding the Linux kernel. 3rd ed. O'Reilly, 2005. ISBN 9780596005658.



## RESOURCES

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**Hyperlink:**

- <http://docencia.ac.upc.edu/FIB/grau/ASO/files/lab10-2q/aso-lab-bash-guide.pdf>- <http://www.elrincondelc.com/portal/index.php>-  
<http://www.gnu.org/prep/standards/standards.html>- <http://www.unixtutorial.org/commands/>