Universidad de Alcalá

TEACHING GUIDE

Operating systems

Degree in
Electronic Communications Engineering (GIEC)
Telecommunication Systems Engineering (GIST)

Universidad de Alcalá

Academic Year 2022/2023

4th Year - 2nd Semester (GIEC+GIST)

Approved by the School Board on June 3, 2022

TEACHING GUIDE

Course Name:	**Operating systems**
Code:	**350026 (GIEC+GIST)**
Degree in:	**Electronic Communications Engineering (GIEC)** **Telecommunication Systems Engineering (GIST)**
Department and area:	**Automatic**
Type:	**Optional (Generic) (GIEC+GIST)**
ECTS Credits:	**6.0**
Year and semester:	**4th Year - 2nd Semester (GIEC+GIST)**
Teachers:	J. Ignacio García Tejedor
Tutoring schedule:	Ask the teacher at the beginning of the course.
Language:	Spanish/English Friendly

1. COURSE SUMMARY

This guide is a tool that will allow the student to be familiar with the contents that comprise the subject, the skills that will be complemented through study, the distribution in time of the different activities, and the requirements for passing the subject as well as other relevant data. You can also download it at the UAH Virtual Classroom.

The goal of this course is to introduce the student to the need of using software systems that help provide sufficiently high levels of abstraction to undertake the development of other systems even more complex. The Operating Systems are in charge of putting the hardware resources of our platform, in a simple and secure way, at the disposal of the users. Its evolution has been frequently linked to that of Computer Architectures, taking from this discipline a great number of concepts and techniques. At the same time, Computer Architectures have evolved to support the requirements that, through the Operating Systems, have been dictated by users over time. This mutual feedback is vital for the understanding of the current state of this discipline, as well as for understanding its future trends.

The first part begins with an introduction to operating systems, using their historical evolution, from the first naked machine models to the current interactive, real time and distributed systems. Throughout this description, all the technologies necessary for the operating systems and that were studied in previous subjects in the curriculum will be mentioned.

In the next part, the operating systems will be studied from the functional point of view, going on to the structural description. This description will lead to the introduction of different design approaches and the role of the kernel, ending with the description of the system call mechanism.

The third part will allow the student to establish the differences between programs and processes, as well as the structure of both in each of the contexts in which they are developed. At the end of the lesson, the student will be able to justify the introduction of threads in modern Operating Systems, establish their characteristics, and create small programs that make use of them. This topic will conclude with a series of case studies of real Operating Systems. These cases will allow to contextualize all the theoretical concepts learned previously, as well as particular details of each implementation.

The fourth part is dedicated to CPU scheduling. In this section, the student will be shown the need to make a selection of the process to be executed at each moment in order to improve a series of performance parameters. The classic scheduling policies will also be studied, ending with the study of the techniques used by some commercial Operating Systems.

The fifth part deals with one of the most complex elements of operating systems: memory management and virtual memory. Once the problems of managing a limited and valuable resource such as memory have been raised, the classic techniques for solving these problems will be studied, as well as the necessary hardware support to implement them.

The last topic will be dedicated to the Input/Output system. First, the student will be introduced to the current needs of this system and the typical layered structure that helps meet these needs. Then the disk will be studied as an archetype of input and output device, and the file system will be built on it. The latter will be studied from both a functional and structural point of view, using some of the most commonly used implementations as case studies.

Prerequisites and Recommendations

This course is based on the knowledge acquired by students in subjects related to computer architectures and programming, such as Computer Systems, Programming, Digital Electronics, Digital Electronic Systems, and especially Computer Architecture that is taught in the first quarter of the third year. It is therefore highly recommended to have successfully completed these subjects before tackling Operating Systems.

2. SKILLS

Basic, Generic and Cross Curricular Skills.

As an optative course, this course contributes to acquire the following generic skills, which are defined in the Section 3 of the Annex to the Orden CIN/352/2009:

en_TR2 - Knowledge of basic subjects and technologies that enables to learn new methods and technologies, as well as to provide versatility that allows adaptation to new situations.

en_TR3 - Aptitude to solve problems with initiative, decision making, creativity, and to communicate and to transmit knowledge, skills and workmanship, comprising the ethical and professional responsibility of the activity of the Technical Engineer of Telecommunication.

en_TR8 - Capacity of working in a multidisciplinary and multilingual team and of communicating, both in spoken and written language, knowledge, procedures, results and ideas related to telecommunications and electronics.

Professional Skills

As an optative course, this course complements the students training in relation to the following professional skills, which are defined in the Section 5 of the Annex to the Orden CIN/352/2009:

en_CTE1 - Ability to build, operate and manage telecommunications networks, services, processes and applications, understood as systems for capturing, transporting, representing, processing, storing, managing and presenting multimedia information, from the point of view of telematic services.

en_CTE7 - Programming capacity of services and telematic applications, in network and distributed.

Upon successful completion of this course/teaching, students will be able to:

RA1. Acknowledge the need for operating systems in today's computing environments and their role as an interface between hardware and user programs.

RA2. Differentiate between different operating systems and operating environments, contrasting their differences in terms of services, performance and requirements; and applying this knowledge, choose the most appropriate one for a given function.

RA3. Acknowledge the need for concurrent activities and the problems they cause, and be able to solve these problems, as well as differentiate the most relevant task scheduling techniques, both for batch and interactive systems and real time.

RA4. Acknowledge the most relevant memory management techniques, their advantages and disadvantages, and choose the most appropriate one for a given operating environment.

RA5. Differentiate the distinct ways of treating and storing information and the implications of using a specific input and output device or mechanism, and choose the most appropriate technique for the implementation of an information system.

RA6: Develop programs using the API of an operating system exercising the services of the operating system.

RA7. Demonstrate awareness of the responsibility of engineering practice, social and environmental impact, and commitment to professional ethics, responsibility and standards of engineering practice.

3. CONTENTS

Content blocks Theoretical part	Total attendance hours
PART 1: Introduction to Operating Systems and previous concepts on Computer Architecture. • Definition of Computer • Definition of Operating System • Bare-machine model • Simple Resident Monitor • Batch Processing • Multiprogrammed systems • Time-sharing • Design techniques	2 hours
PART 2: Operating System Structure • Restricted and extensive views of an Operating System. • Operating System Functions • Operating system interfaces • Operating System Layered Decomposition • The Operating System kernel Description and basic functions Design Case Studies: Linux, Windows, Mach • System call mechanisms Description Types of system calls	4 hours
PART 3: Processes and Threads • Programs vs. processes • Structure of a program • Concept of process • Program image in the user memory context • Threads • Use cases: Linux and Windows	4 hours
PART 4: CPU Scheduling • CPU switching mechanism • Scheduling concepts • Scheduler Types • Basic scheduling policies • Concepts of priority and preemption • Advanced scheduling policies • Use cases: Linux and Windows	4 hours
PART 5: Virtual Memory and Memory System Management • Memory management fundamentals: hierarchy, locality and fragmentation. • Process memory management. • Memory management mechanisms: segmentation, paging and paged segmentation. • Case studies. • Introduction to virtual memory • Basic concepts: dynamic load, pagers, working set. • Virtual memory algorithms and policies	8 hours

PART 6: I/O System and File Systems • I/O Software Layers • I/O elements • Disks as an example of an I/O device • File System Functionality • Internal structure of file systems	6 hours

Content blocks Lab practicum	Total attendance hours
ASSIGNMENT 1: Introduction to Linux and the Development Tools • Login • Basic Linux Commands • Use of basic programming tools	6 hours
ASSIGNMENT 2: System Calls • Use of POSIX system calls Time-related system calls File management-related system calls Memory Mapping of files and related System Calls • Development of a project with multiple source files • Using Automation Tools for Software Development	8 hours
ASSIGNMENT 3: Multi-threaded programming and synchronization • Creation and destruction of threads • Using the POSIX pthreads thread library • Parallelization of a problem • Multi-thread synchronization	8 hours
ASSIGNMENT 4: Signals, processes and communication mechanisms • Working with signals: registering, handling and sending • Process management primitives: creation and termination of processes and program execution • Process communication primitives	8 hours

Chronogram

Week	Contents
1st-3rd	PARTS 1 and 2: Theory (6h) + Practicum 1 + evaluation (6h)
4th-7th	PARTS 3 and 4: Theory (8h) + Practicum 2 + evaluation (8h)
8th-11th	PART 5: Theory (8h) + Practicum 3 y evaluation (8h)
12th-15th	PART 6: Theory (6h) + Practicum 4 y evaluation (8h)

4. TEACHING - LEARNING METHODOLOGIES. FORMATIVE ACTIVITIES.

4.1. Credits Distribution

Number of on-site hours:	58 hours (56 hours on-site +2 exams hours)
Number of hours of student work:	92
Total hours	150

4.2. Methodological strategies, teaching materials and resources

Classroom sessions	**Theory lectures**: these lectures will be given in large groups and in them, through masterclasses, the teacher will develop the most important concepts for understanding the contents of the subject. **Resolution of practical cases**: they will be done in small groups. During the sessions, problems that are susceptible to resolution will be presented using techniques explained in the lesson. These techniques will be applied in a guided way to solve the problem. **Presentation of reports and assignments**: the student must present reports and assignments individually or in small groups to his/her classmates and the teacher. Presentations will make use of appropriate multimedia techniques. **Partial exams**: throughout the course the teacher will propose various partial exams to assess the acquisition of knowledge and its application.
Self-study	**Readings** **Activities**: exercises, concept maps, examples, information search. **Participation in forums and activities**, generally through the teaching platform of the course.
Mentoring	The mentoring can be both group-based and individual. During the mentoring sessions, the teacher will be able to assess the acquisition of competences and will review the reports provided by the students on the work assigned.

Resources

The resources for the preparation of the classroom sessions, as well as the activities to be carried out by the individual student, can be found in the space dedicated to the course of the Virtual Classroom of the UAH. The functionality of this teaching tool will be detailed in the presentation class of the subject.

For each activity, the teacher will provide a series of bibliographical references that can be consulted in the Polytechnic School's library.

For those activities that require it, the teacher will indicate the way of planning this activity as well as the deliverables that must result from the realization of the same one.

5. ASSESSMENT: procedures, evaluation and grading criteria

Preferably, students will be offered a continuous assessment model that has characteristics of formative assessment in a way that serves as feedback in the teaching-learning process.

5.1. PROCEDURES

The evaluation must be inspired by the criteria of continuous evaluation (Regulations for the Regulation of Teaching Learning Processes, NRPEA, art 3). However, in compliance with the regulations of the University of Alcalá, an alternative process of final evaluation is made available to the student in accordance with the Regulations for the Evaluation of Apprenticeships (approved by the Governing Council on March 24, 2011 and modified in the Board of Directors). Government of May 5, 2016) as indicated in Article 10, students will have a period of fifteen days from the start of the course to request in writing to the Director of the Polytechnic School their intention to take the non-continuous evaluation model adducing the reasons that they deem convenient. The evaluation of the learning process of all students who do not apply for it or are denied it will be done, by default, according to the continuous assessment model. The student has two calls to pass the subject, one ordinary and one extraordinary.

This subject will be assessed continuously through a series of summative tests distributed throughout the course, which allow the student to approach the subject progressively. In each block of contents, at least one evaluation test will be carried out, which may be related to practical, theoretical or combined contents.

Continuous evaluation guarantees early feedback in the student's learning process and allows teachers, coordinators and other elements of the Quality Assurance System to follow up globally, with the possibility of taking action in the event that particular indicators or situations advise it.

5.2. EVALUATION

EVALUATION CRITERIA

The following criteria will be used for the evaluation of the course, related to the learning outcomes:

CE1. The student has acquired technical knowledge about the role and necessity of the operating system in any computer system, its operating philosophy, its structure and design approaches, as well as the services it can provide to the application programmer.

CE2. The student has acquired knowledge about the way in which the operating system manages and uses computer resources such as memory, processors, communications or storage.

CE3. The student shows ability to solve practical problems associated with the design and operation of the operating system and the resources it manages (CPU, memory, communications and storage).

CE4. The student is able to use a professional operating environment that allows him/her to develop software and knows the necessary tools for doing so.

CE5. The student is able to develop software that uses the services and capabilities of the operating system using the tools at his disposal, and to search and use the necessary documentation for this.

CE6. The student is able to develop work of his own production, adequately citing the sources when such work is based on third party material, according to the criteria of correct professional ethics in the practice of engineering.

GRADING CRITERIA

The evaluation of the students will be carried out on a continuous basis throughout the course. Their performance will be evaluated by their work, knowledge and skills acquired and the improvement of their learning process. The following methods will be used:

1. Carrying out continuous assessment activities proposed by the teacher for each of the thematic blocks. Overall, these activities will account for 60% of the student's grade. The total of the proposed activities will be communicated to the student during the presentation class. These activities include:

- Undertaking laboratory practices or tests (PL1-PL4) (30% of the final grade). In order for these tests to be considered valid, it will be mandatory to attend a minimum of 90% of the laboratory sessions, and no more than one absence may occur in the laboratory sessions dedicated to a specific activity. In addition, proof of weekly work by the student will be required, using for example a version control tool that records the student's activity. If this requirement is not met, the tasks will be considered as not carried out and the practicum part will be considered as not passed.
- Intermediate evaluation tests (PEI1-PEI4) during the teaching period (30% of the final grade).

2. A theoretical-practical final evaluation test (PEF) at the end of the teaching period (40% of the final grade).

If the subject is not passed in the ordinary evaluation period, there exists the possibility of taking an extraordinary evaluation that will be made up of the following parts:

- Test on the practicum laboratory tasks carried out during the course (PL5). This part is optional. If it is not taken, the grade obtained in the corresponding part of the continuous evaluation will be maintained. If it is taken, the new score will prevail over the continuous one. This part constitutes 30% of the final grade.
- Final evaluation test (PEF2) on the theoretical-practical contents. This part will be worth 70% of the final grade.

Those students who have been granted the evaluation by means of a final exam will be evaluated by means of a single global exam about all the contents of the subject with the same format as the extraordinary evaluation, except that the PL5 test is not optional. If a student does not pass the subject in this exam, he or she will have the opportunity to take the extraordinary exam described above.

In the spirit of applying the continuous evaluation criteria, all the tests described (partial exams, practicum deliverables and final exam) will be considered non-compulsory, the subject being graded according to the percentages and criteria set out above, and a student will only be considered as Not Presented if he/she does not take any of the aforementioned tests.

The only exception is if a student decides to abandon the course at any time during the four-month period and wishes to appear as Not Presented, for which it must be requested in writing to the coordinator of the course before taking the final test.

In the ordinary evaluation, the relationship between the criteria, instruments and grades is as follows.

Competence	Learning Outcome	Assessment Criteria	Assessment Instrument	Weight in the grade
TR2, TR3, TR8, CTE1	RA1, RA2, RA7	CE1, CE2, CE3, CE6	PEI1	7.5%
	RA3, RA7		PEI2	7.5%
	RA4, RA7		PEI3	7.5%
	RA5, RA7		PEI4	7.5%
TR2, TR3, TR8, CTE7	RA6, RA7	CE4, CE6	PL1	7.5%
		CE5, CE6	PL2	7.5%
			PL3	7.5%
			PL4	7.5%
TR2, TR3, TR8, CTE1	RA1-RA5, RA7	CE1, CE2, CE3, CE6	PEF	40%

In the extraordinary evaluation, as well as in the case in which the student has been granted the evaluation by means of a final test, the relation between the criteria, instruments and qualification is the following.

Competence	Learning Outcome	Assessment Criteria	Assessment Instrument	Weight in the grade
TR2, TR3, TR8, CTE7	RA6, RA7	CE4, CE5, CE6	PL5	30%
TR2, TR3, TR8, CTE1	RA1-RA5, RA7	CE1, CE2, CE3, CE6	PEF2	70%

Specific grading criteria for practicum activities

Practicum assignments, in the case of evaluation through continuous assessment, will only be considered valid if the mandatory laboratory attendance and weekly progress requirements set out above are met. These exercises will be delivered on the dates established for each of them during the development of the course. If this requirement is not met, the exercises delivered in the two weeks following the deadline will be graded with a maximum score of 4 points out of 10. After this period, the delivery will not be admitted and will be graded with a score of 0 points. Unless expressly indicated otherwise, the assignments will be delivered exclusively within the laboratory group assigned to the student.

Students who have been granted grading by final evaluation will not have to attend the laboratory sessions and will not deliver practices, but they will also have to complete them at their own account as they will be subjected to evaluation about their contents and implementation in a single final test, as stated above.

Article 34. Originality of works and tests.

- The University will convey to students that plagiarism is a practice contrary to the rules and principles governing university education.
- The University will provide students with the necessary training for the preparation of assignments or other assessment tests in order to teach them to use and cite the sources used, as well as to develop and put into practice the required competencies.
- Plagiarism is understood as the copying of texts without citing their origin and giving them as their own elaboration and will automatically lead to the qualification of failing (0) in the works or tests in

which it was detected. The teacher who notices signs of plagiarism in the work or evaluation tests presented to them will inform the degree coordinator of this fact within a maximum period of two days, so that he may proceed, if necessary, to bring it to the Rector's attention in case it could constitute a disciplinary infraction or a crime.
- The teaching guides may include the provision that the student must sign in the papers and materials submitted for the evaluation of his learning an explicit statement in which he assumes the originality of the work, understood in the sense that he has not used sources without citing them properly.

Likewise, the aforementioned regulation establishes the course of action in case fraud is detected in the evaluation of an assignment in its article 22, paragraphs 5 and 7, as follows:

Article 22. Issues in the evaluation process.

[...]

5. The evaluation test carried out by the student in which fraudulent conduct has been detected**will be graded with a fail mark (0) and will imply a fail, with a final grade of zero (0), in the corresponding call of the course**. In no case will the grade of "Not Taken" correspond to a test in which fraud has been detected.

[...]

7. If during the grading of the tests the examiner detects a fraudulent practice, he/she will act according to what is established in section 5 of this article.

Therefore, and given that the laboratory assignments are for all purposes evaluation tests, a plagiarism in its development constitutes a fraud in this test and therefore entails, in application of the regulations of the University of Alcalá, **a grade of fail in the ordinary call of the subject**

6. BIBLIOGRAPHY

6.1. Basic Bibliography

- Sistemas Operativos. S. Sánchez Prieto. Second edition. UAH publications service. 2005.

6.2. Additional Bibliography

- Operating Systems. Stallings, William. Alhambra Editorial.
- Unix. Programación avanzada. Francisco M. Márquez García. Ra-Ma 2004.
- Operating System Concepts. A. Silberschatz, P. B. Galvin y G. Gagne. McGraw Hill. 2006.
- Modern Operating Systems. A.S. Tanenbaum. Prentice Hall, 2009.
- Operating Systems. Design and Implementation. Tanenbaum, A.S. y Woodhull, A.S. Prentice-Hall Hispanoamericana, S. A. 1998.
- Computer Architecture and Organization. William Stallings. Prentice-Hall International, 2006.
- Computer architecture: a quantitative approach. Hennessy, John L., Patterson, David A., Elsevier 2006.

Disclosure Note

The University of Alcalá guarantees to its students that, if due to health requirements the competent authorities do not allow the total or partial attendance of the teaching activities, the teaching plans will achieve their objectives through a teaching-learning and evaluation methodology in online format, which will return to the face-to-face mode as soon as these impediments cease.