Universidad de Alcalá

TEACHING GUIDE

Expansion of Operating Systems

Degree in
Telematics Engineering

Universidad de Alcalá

Academic Year 2025/2026

4th Year - 1st Semester

Approved by the EPS School Board on June 16th, 2025

TEACHING GUIDE

Course Name:	**Expansion of Operating Systems**
Code:	**380015**
Degree in:	**Telematics Engineering**
Department and area:	**Automática** **Computer Architecture and Technology**
Type:	**Optional (Oriented)**
ECTS Credits:	**6.0**
Year and semester:	**4th Year, 1st Semester**
Teachers:	Óscar García Población.
Tutoring schedule:	Tutoring and office hours will be published on the presentation day
Language:	Spanish/English Friendly

1. COURSE SUMMARY

This guide is an essential tool for the students to know the contents of the subject, the competences they will acquire during their study, the time distribution of the activities, the requirements to pass the course and other relevant information.

The subject “Expansion of Operating Systems” is taught in the first four-month period of the fourth year of the Degree in Telematics Engineering. It is an elective subject that delves into the role of operating systems as an essential component of the structure of information systems. It is assigned 6 ECTS credits, with an attendance of four hours per week, and its content is structured in three blocks:

This first block addresses the traditional administration of operating systems, starting with its fundamental role in the governance and configuration of computer systems. Initially, we will situate the professional figure of systems administration in the current organizational context. We will identify the most common responsibilities and introduce a discipline that has gained special relevance in recent years: development operations or DevOps.

Subsequently, we will study essential techniques and tools for the administration of computer systems, methods for obtaining reports on systems and strategies for automating repetitive tasks. We will delve into shell programming, a powerful tool for automating administrative tasks and providing various services. Bourne's Shell (BASH) will be used as a shell because of its wide implementation in the Unix environment. We will conclude with identity management, authentication mechanisms and basic aspects of file system access control.

During the last decade, technologies based on hardware virtualization have significantly transformed the conception, design and construction of computer systems. In this second block, we will study the fundamental building blocks of cloud technology, starting with computing services, continuing with storage, networking and communications. We will also cover aspects related to security, managed services and automation of frequent operations such as provisioning and deployment.

We will conclude by analyzing the influence of cloud environments on current software development, extending known concepts of distributed systems to new paradigms such as serverless systems and microservices-based architectures.

In the third block we will examine another outstanding result of virtualization: container technology, using Docker containers as an example. In addition to their conceptual presentation and a detailed description of their main operations, we will show how these containers can be combined to form complex software architectures. We will also analyze their role in software development stages and strategies for their deployment in production environments.

Prerequisites and Recommendations.

This course is based on several knowledge developed during the previous courses, especially in the subjects of Operating Systems and Programming. Therefore, it is highly recommended that students have passed these subjects before starting to learn Operating Systems Expansion, thus guaranteeing a solid base to deepen in the new concepts and practices that will be addressed.

2. SKILLS

Basic, Generic and Cross Curricular Skills.

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.

Professional Skills

This course contributes to acquire the following professional skills, which are defined in the Section 5 of the Annex to the Orden CIN/352/2009:

en_CTE3 - Ability to build, operate and manage telematic services using analytical planning, sizing and analysis tools.

en_CTE6 - Ability to design network architectures and telematic services.

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

Learning Outcomes

After succeeding in this subject the students will be able to:

RA1. Manipulate tools and procedures to efficiently perform the tasks of the administration.
RA2. Use the procedures and techniques related to the management of users of computer services.
RA3. Understand the basics of the mass storage of information.
RA4. Adapt the knowledge related to mass storage of information for its use in administration tasks
RA5. Install and configure in a basic way some of the most universal computer services.
RA6. Demonstrate awareness of the responsibility of engineering practice, social and environmental impact, and commitment to professional ethics, accountability, and standards of engineering practice.

3. CONTENTS

Contents Blocks	Total number of hours
BLOCK 1: Introduction to administration and basic tools. Introduction to the administration of operating systems. Business and organizational scope. Basic administration tools: Initial shell concepts. Redirections (input, output, errors). Communication between processes: pipes and signals. Process management commands: ps, pstree, time, who. Background execution: &, jobs, fg, bg. Filter concept. Filters wc, cut, paste, head, tail, tr, sort, uniq, tee and grep. Regular expressions: definition, sets, ranges and quantifiers. AWK, basic operation, rule types, pattern types, flow control, predefined functions, arrays. Sed flow editor. Find command. Other interesting commands: date, cal, diff, cmp, comm, iconv. Introduction to shell scripts. Modes of execution of a script. Expansion of variables. Parameter passing. Language elements. Control structures. List and vector processing. Input and output. Redirections. User management in Linux/Unix. Users and groups and their role in operating systems. Identification and Authentication, UID concept. Relationship with the file system. The /etc/passwd file. Detailed study of authentication using shared secrets. Shadow password system. Seed/password encryption with MD5. mkpasswd command. Manual user registration in the system. Adduser and useradd scripts. Scripts for mass registrations. Problems with commands that must be executed with administrator privileges: passwd and the SUID bit. Other scripts for user and group management: deluser, addgroup, delgroup. Aging and other password policies. Chage command. Storage and storage device management. storage devices. Information storage mechanisms: raw data, file cabinets and file systems. Block mode devices, major and minor number. Archivers: tar. Meta information, modifiers c: create, v: verbose, f: file, t: test, x: eXtract. Compression of stored data: modifiers z: gzip, j: bzip. File systems. Creating a file system with mkfs, modifier -t. Mounting a file system. Mount command. dd command. Using the /dev/zero device to create images. Mounting images, -o loop RAID and LVM	18h hours
BLOCK 2: Cloud technologies Introduction to cloud technologies. Google Cloud as an example of cloud infrastructure. Ways of interacting with the cloud. Computing services. Concept of IaaS and PaaS. Usage scenarios. IaaS in GCP: Compute Engine. Virtual private clouds. Introduction to networking and communications security. PaaS, description and alternatives: Cloud Functions, App Engine and Cloud Run. Managed storage services. Introduction to Cloud Storage. Bucket properties. Usage scenarios. Relational databases managed with Cloud SQL. In-memory databases: Redis. Custom networking and security. Task automation in GCP.	20h hours

BLOQUE 3: Container technologies. Introduction to container technology. Differences with hardware virtualization and other virtualization techniques. Introduction to Docker. Building a basic image. Containers with interactive processes. Building complex images. Image operations. Publishing images. Execution of services inside containers. Containers and networks. Data volumes and shared volumes. Docker as a development environment. Container orchestration with docker-compose, internal networks, name resolution service and services. Introduction to Kubernetes. Related cloud services: Google Cloud Run and Google Kubernetes example.	20h hours

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	• **Theory and lab classes**: these classes will be given in the laboratory. The professor will present the theoretical concepts and will then guide the students through their practical application on a Unix system set up for this purpose in the laboratory. • **Resolution of practical cases:** during the laboratory sessions several problems susceptible of being solved by means of techniques exposed in class will be presented. The application of these techniques to solve the problem will be guided. • **Presentation of assigments and works**: students will have to present to their classmates and to the teacher assignments and projects that they have carried out individually or in small groups. The presentations will make use of the appropriate multimedia techniques. • **Partial tests:** during the development of the course the professor will propose several partial tests to review the acquisition of knowledge and its application.
Individual work	• **Readings** • **Activities**: exercises, concept maps, exemplifications, information search. • **Participation in forums and activities**, generally through the teaching platform of the subject.
Tutoring	The tutoring may be either in groups or individually. During the tutoring sessions the tutor will be able to evaluate the acquisition of the competencies and will review the reports provided by the students on the work assigned.
Resources	The materials for the preparation of the face-to-face sessions, as well as the activities to be carried out by the student individually, can be found in the Virtual Classroom of the UAH. The operation of this teaching tool will be detailed in the presentation class of the course. It will explain, among other things, the way in which students will register in the general message forum, which will be the usual mechanism of communication with students. For each activity, the tutor will provide a series of references, both bibliographical, which can be consulted in the library of the Polytechnic School, and of any other nature. For those activities that require it, the tutor will indicate how to plan such activity as well as the deliverables that should result from the realization of the same.

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 (Learning Assesment Guidelines, LAG, 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 Learning Assesment Guidelines 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.

The evaluation can be done on a continuous basis or by means of a final evaluation, and in each case there will be two calls for each registration: ordinary and extraordinary.

Ordinary call

Continuous evaluation:

Continuous assessment evaluates the development of competencies throughout the learning process of the subject by means of a series of formative tests distributed throughout the course, which allow the student to approach the subject progressively.

This form of evaluation guarantees early feedback in the student's learning process and allows professors, coordinators and other elements of the Quality Assurance System to make a global follow-up, with the possibility of acting in case indicators or specific situations make it advisable.

The evaluation of each part will be carried out at the end of its corresponding block.

Evaluation by means of a final exam:

It will be requested in writing following the regulations of Evaluation of Learning of the Higher Polytechnic School.

Extraordinary call

The procedure will be the same as the one described for the evaluation by final exam in the ordinary call.

Requirements for participation in the continuous evaluation

Only those students who have actively participated (obtained a grade) in at least two of the established evaluation instruments will be considered participants in the continuous evaluation process. Participation in only one evaluation instrument or not participating in any of them will mean that the student has not followed the continuous evaluation process, so he/she will receive the grade of “Not Presented” (NP) in the ordinary call. In this case, the student must use the final evaluation system in the extraordinary call, as established in the regulations for the evaluation of learning.

5.2. EVALUATION

Assessment criteria

The following assessment criteria will be taken into account to verify whether the student has achieved the expected objectives:

CE1. Knows and knows how to apply the basic tools offered by Shell for system administration.

CE2. Develops programs for the Shell that allow automating maintenance and monitoring tasks of systems.

CE3. Knows how to register users and groups in local systems as well as in centralized systems.

CE4. Knows the procedures to integrate storage media in a computer system.

CE5. Is able to install, configure and start up a computer service.

CE6. Is able to develop own production works, properly citing the sources when such works are based on third party material, according to the criteria of correct professional ethics in the practice of engineering.

CE7. Is able to define and operate managed services typical of cloud environments.

CE8. Understands the general aspects of cloud technologies, in particular those related to computing, storage and communications provisioning services. In addition, he/she is able to assemble simple architectures combining these elements for the provision of services.

CE9. Understands container technology, distinguishes between containers and container images, knows how to build simple images and publish their services through basic network mechanisms.

CE10. Is able to orchestrate the services provided by several containers to synthesize complex architectures.

CE11. Is able to assemble software development environments using containers.

Grading instruments

Continuous assessment

The evaluation of students will be carried out continuously throughout the academic year. Their performance will be assessed through the work done, the knowledge and skills acquired, as well as the improvement in their learning process. The evaluation method will consist of the realization of different activities of continuous evaluation proposed by the teaching staff, ensuring the coverage of each block of contents.

Together, these activities will represent 100% of the final grade of each student, without any of them exceeding 40% of the final grade of the course. These activities are divided into:

- PEI: Intermediate evaluation tests, which will examine the theoretical contents of the subject.
  TR: Personal work elaborated by each student according to the guidelines established by the faculty of the course.

Non-continuous assessment and Extraordinary assessment

Students who have been granted the Non-continuous assessment will be graded through the following activities:

- PEF: Theoretical-practical assessment test about the theoretical contents of the course.

Evaluation criteria

Continuous assessment

Competence	Learning outcome	Assessment criteria	Grading instrument	Grading weight
TR2, TR3, CTE7	RA1, RA2, RA3, RA4	CE1, CE2, CE3, CE4, CE6	PEI1	35%
TR2, TR3, CTE6, CTE3	RA2, RA3, RA4, RA5, RA6	CE7, CE8, CE6, CE5	PEI2	40%
TR2, TR3, CTE6, CTE7	RA5, RA6	CE9, CE10, CE11, CE6, CE5	E	25%

Non-continuous assessment and extraordinary call

Competence	Learning outcome	Assessment criteria	Grading instrument	Grading weight
TR2, TR3, CTE3, CTE6, CTE7	RA1 - RA6	CE1 - CE11	PEF	100%

According to Article 34 of the Regulations for the Assessment of Learning, regarding Originality of Papers and Tests:

1. The University will inform students that plagiarism is a practice contrary to the rules and principles governing university education.
2. The University will provide students with the necessary training for the preparation of papers or other assessment tests in order to teach them to handle and cite the sources used, as well as to develop and put into practice the required skills.
3. Plagiarism is understood as the copying of texts without citing the source and giving them as their own elaboration and will automatically lead to the grading of failure (0) in the work or tests in which it has been detected. The tutor who notices signs of plagiarism in the assessment papers or tests presented to him/her shall report this fact to the dean or director of the center within a maximum period of two days, so that he/she may proceed, if necessary, to inform the Rector in case it could constitute a disciplinary infraction or a crime.
4. The teaching guides may include the provision that the student must sign in the work and materials submitted for the assessment of their learning an explicit statement in which he/she assumes the originality of the work, understood in the sense that he/she has not used sources without properly citing them.

The teaching-learning methodology and the evaluation process will be adjusted when necessary, with the guidance of the Unit for Attention to Diversity, to apply curricular adaptations for students with specific needs.

6. BIBLIOGRAPHY

6.1. Basic Bibliography

Unix and Linux: Guía Práctica. 3rd Edition.
Sebastián Sánchez Prieto and Óscar García Población. Editorial RA-MA. Manual in Spanish that offers a practical and detailed vision of Unix and Linux systems, ideal for students who are starting in system

administration. It covers from basic concepts to advanced administrative tasks with a didactic approach.

The Google Cloud documentation
https://cloud.google.com/docs
Official Google Cloud Platform documentation that provides technical guides, tutorials and references for deploying, configuring and managing cloud services. Indispensable resource for understanding contemporary cloud architectures.

The Docker project documentation
https://docs.docker.com/
Official Docker project documentation covering all aspects of this container technology, from fundamental concepts to advanced configurations. Includes practical examples and design patterns for container-based architectures.

6.2. Additional Bibliography

UNIX and Linux System Administration Handbook, 5th Edition
Evi Nemeth, Garth Snyder, Trent R. Hein, Ben Whaley, Dan Mackin. Comprehensive reference work on Unix/Linux system administration, considered one of the most complete in the industry. Addresses networking, security, storage, and automation with practical examples and case studies of real-world environments.

Modern Operating Systems, 4th Edition Andrew S. Tanenbaum, Herbert Bos
Fundamental academic text that explores the theoretical and design principles of contemporary operating systems. Provides a solid conceptual foundation for understanding the more advanced aspects covered in the course.

Cloud Computing: Concepts, Technology & Architecture Thomas Erl, Ricardo Puttini, Zaigham Mahmood.
This book establishes a theoretical and architectural framework for cloud technologies, addressing service models, deployment and security considerations. Provides an in-depth understanding of the fundamental principles of cloud computing.

DevOps Handbook: How to Create World-Class Agility, Reliability, & Security in Technology Organizations Gene Kim, Jez Humble, Patrick Debois, John Willis.
Essential guide to DevOps methodologies that explores the integration between development and operations in the software lifecycle. Addresses practices, workflows and case studies relevant to infrastructure automation.

Advanced Bash Scripting Guide Mendel Cooper.
Comprehensive online resource that delves into Bash programming, covering everything from basic concepts to advanced techniques. Excellent complement to the automation and scripting portion of the course.

Container Security: Fundamental Technology Concepts that Protect Containerized Applications
Liz Rice.
Specialized work that examines security issues in container environments, addressing vulnerabilities, best practices and tools for protecting containerized applications. Provides a fundamental perspective for secure deployment in production.

AWS Documentation - Amazon Web Services
Official documentation of this cloud computing platform that complements the Google Cloud vision, offering alternative perspectives on cloud deployments and allowing comparative studies between different vendors.

Microsoft Azure Documentation
Official documentation of Microsoft's cloud platform that provides a third approach to cloud technologies, especially relevant in enterprise environments integrated with other Microsoft technologies. It allows to

complete the view of the cloud ecosystem with an additional vendor.

Disclosure Note

During the evaluation tests, the guidelines set out in the Regulations establishing the Rules of Coexistence of the University of Alcalá must be followed, as well as the possible implications of the irregularities committed during said tests, including the consequences for committing academic fraud according to the Regulation of Disciplinary Regime of the Students of the University of Alcalá.