Universidad de Alcalá

TEACHING GUIDE

Computer Architecture and Engineering

Degree in
Computer Engineering (GIC)

Universidad de Alcalá

Academic Year 2024/2025

2nd Year - 2nd Semester (GIC)

Approved by the EPS School Board on June 14th, 2024

TEACHING GUIDE

Course Name:	**Computer Architecture and Engineering**
Code:	**590005 (GIC)**
Degree in:	**Computer Engineering (GIC)**
Department and area:	**Automática** **Computer Architecture and Technology**
Type:	**Basic (GIC)**
ECTS Credits:	**6.0**
Year and semester:	**2nd Year - 2nd Semester (GIC)**
Teachers:	Agustín Martínez Hellín
Tutoring schedule:	Check at begininig of course
Language:	English

1. COURSE SUMMARY

Computer Architecture and Engineering is a compulsory 6 ECTS course taught in the second year of the Degree in Computer Engineering.

Its main objective is to provide a vision of the architectural aspects of computers that increase performance. It deals with parallelism and its implementation with emphasis on Pipelining. It also analyses other alternative computer architectures.

To take this subject it is mandatory to have successfully completed the course on Computer Structure and Organisation as it is a natural starting point of the current course and therefore requires the skills and knowledge acquired on this required course.

2. SKILLS

Basic, Generic and Cross Curricular Skills.

This course contributes to acquire the following basic, generic and cross curricular skills:

en_CG1 - Ability to conceive, write, organize, plan, develop and sign projects in the field of computer engineering that are intended, in accordance with the knowledge acquired as established in section 5, annex 2, of resolution BOE-A -2009-12977, the conception, development or exploitation of computer systems, services and applications.

en_CG2 - Ability to direct the activities object of the projects in the field of information technology in accordance with the knowledge acquired in accordance with the provisions of section 5, annex 2, of resolution BOE-A-2009-12977.

en_CG4 - Ability to define, evaluate and select hardware and software platforms for the development and execution of computer systems, services and applications, in accordance with the knowledge acquired as set out in section 5, annex 2, of resolution BOE-A-2009 -12977.

en_CG6 - Ability to conceive and develop centralized or distributed computer systems or architectures integrating hardware, software and networks in accordance with the knowledge acquired as set out in section 5, annex 2, of resolution BOEA-2009-12977.

en_CB1 - That students have demonstrated to possess and understand knowledge in an area of study that is based on general secondary education, and is usually found at a level that, although supported by advanced textbooks, also includes some aspects that involve knowledge from the forefront of their field of study.

en_CB2 - That the students know how to apply their knowledge to their work or vocation in a professional manner and possess the competencies that are usually demonstrated through the elaboration and defense of arguments and the resolution of problems within their area of study.

en_CB3 - That students have the ability to gather and interpret relevant data (usually within their area of study) to make judgments that include a reflection on relevant social, scientific or ethical issues.

en_CB4 - That students can transmit information, ideas, problems and solutions to both a specialized and non-specialized public.

en_CB5 - That the students have developed those learning skills necessary to undertake further studies with a high degree of autonomy.

en_TRU1 - Capacity of analysis and synthesis.

en_TRU2 - Oral and written competencies.

en_TRU3 - Ability to manage information.

en_TRU4 - Autonomous learning skills.

en_TRU5 - Team work.

Specific Skills

This course contributes to acquire the following specific skills:

en_CIC1 - Ability to design and build digital systems, including computers, microprocessor-based systems and communications systems.

en_CIC3 - Ability to analyze and evaluate computer architectures, including parallel and distributed platforms, as well as develop and optimize software for them.

Learning Outcomes

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

RA1. Organize a simple pipeline processing proving the necessary structural elements and calculate its performance vs a conventional computer.

RA2. Discriminate hazards in pipeline architectures identifying factors causing or influencing them. For integer processing pipelines, learn and experiment with different techniques used to mitigate data and control hazards. Obtain quantitative estimation of these improvements.

RA3. Floating point processing and Pipelining: learn about data dependency types a program or algorithm may contain and learn static and dynamic techniques implemented in compilers and processor hardware. Same about Control hazards.

RA4: Learn fundamentals of superscalar processing, Vector processors and other parallel architectures.

3. CONTENTS

Contents Blocks	Total number of hours
Module 1. Introduction • Review: Levels of description and design of a computer, • Within the processor, chips performance metrics: "Benchmarks", consumption, technology, etc. • How to increase performance	8 hours
Module 2. RISC-V architecture • RISC-V assembly language machine language • Addressing modes • Compilation, assembly and loading • Exceptions and interrupts	12 hours
Module 3. Microarchitecture - Segmentation using RISC-V: • Introduction to segmentation • Concepts and structural requirements of segmentation • ISA CISC/RISC repertoires and their influence on segmentation • Types of hazards, forwarding of operands, jumps • Study of hazards in different pipelines	24 hours
Module 4. Advanced Micro-Architectures • Loop rearrangement and unwinding • Dynamic hop planning • Fuzzy exceptions and interrupts • Speculative execution • Superscalar processors	12 hours

4. TEACHING - LEARNING METHODOLOGIES. FORMATIVE ACTIVITIES.

4.1. Credits Distribution

Number of on-site hours:	60 hours (56 hours on-site + 4 exams hours)
Number of hours of student work:	90
Total hours	150

4.2. Methodological strategies, teaching materials and resources

	The face-to-face classes will be held in the classroom and in the laboratory.
Learning in large groups and learning/working in small groups and in the laboratory.	• Oral presentations are accompanied by slides and in the elaboration of drawings and written diagrams that support and clarify the explanation. To encourage student participation and debate, will be used questionnaires (usually online) and will be asked practical situations in which they must apply the concepts that are explained, in order to fix these. • In classes laboratory, written guides are used that propose by experimenting an incremental acquisition of knowledge and skills, as well as tools such as simulators with which to test and analyze the program code proposed as activity. • Occasionally the Fliipped Classroom technique may be used: it consists of the preparation by the student of a thematic block using the material recommended by the teacher, replacing the traditional master class with a consultation session of doubts and comprehension tests and assimilation of matter.
Team, cooperative activities.	• Teamwork in solving practical exercises and Laboratory activities will be a common practice. is also possible to propose individual or team projects for presentation and discussion before the group, assistance to relevant conferences making a subsequent summary, etc. depending on availability and number of students participating in the course. • Following principles of formative evaluation it will be possible to apply peer evaluation, which consists of the delivery and subsequent evaluation of work or exercises submitted by other colleagues and / or self-evaluation. It will count with the assistance of the teacher in the evaluation process, defining criteria to apply for corrections and providing solutions and guidance.
Individual study.	• Weekly activities are proposed to fix the lessons learned and some of these may also be deliverables. The purpose of these activities is to reinforce the necessary periodic revisit of recent concepts learned, further dig into the learning experiences and prepare next lesson.
Resources and Materials	• In all cases, Information and Communication Technologies may be used to support training activities According to the convenience and circumstances, the lessons may be recorded and left and made available in the Virtual Classroom Platform (BlackBoard)

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.

Ordinary Call

The evaluation can be carried out continuously or through a final evaluation, existing for each case two calls per enrollment: ordinary and extraordinary

Continous Assessment:

Continuous assessment assesses the development of competencies throughout the learning process of the subject through a series of training tests distributed throughout the course, that allow the student to tackle the subject progressively. This guarantees early feedback in the learning process of the student and allows teachers, coordinators and other elements of the Quality Assurance System to make a global follow-up, with the possibility of acting in case of certain indicators or situations.

The most important evaluation tools to use are:

- Peers evaluation: Submit a problem, experiment or exercise followed by the correction of other mates' deliveries under convenient professor's guidance and well stablished criteria.
- Group Tests: these are questions posed to all the class that should be answered individually or in group followed by a discussion about the solution
- Lab Deliverables: submition and normally oral exposition of selected lab exercises of 2-3 min per student/group
- Individual exams: written tests about theoretical and practical contents of the course

Assessment through final exam:

Should be explicitly requested by the student following School Procedures. It will consist on an Individual written tests about theoretical and practical contents of the course.

Extraordinary Call

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

5.2. EVALUATION

EVALUATION CRITERIA

The assessment criteria measure the level in which the competences have been acquired by the student. For that purpose, the following are defined::

CE1. Domain of the contents and concepts of the subject.

CE2. Correct and substantiated resolution of problems and proposed practices.

CE3.Application of the theoretical contents to practical situations.

CE4. Interest and motivation in the follow-up of classes and participation in proposed activities.

CE5. Honesty, originality and authorship.

GRADING TOOLS

The work of the student is graded in terms of the assessment criteria above, through the following tools:

- **PEC: Continuous Evaluation Tests**: Consists on different and tests, deliverables, participation surveys, and activities such as peers evaluation, laboratory exercises, etc.
- **PE**: **Partial Evaluation** Test: There will be 2 of this exams: one as mid-term, and another at the end of course.
- **PEF - Final Exam:** Single test similar to PE tests which is intended for those students in the Final Evaluation option only.

GRADING CRITERIA

In the **ordinary call-continuous assessment** the relationship between the competences, learning outcomes, criteria and evaluation instruments is as follows.

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
en_CIC1-en_CIC3; en_CG1-en_CG6; en_CB1- en_CB5	RA1-RA4	CE1-CE5	PEC	20%
en_CIC1-en_CIC3,en_CG1-en_CG6; en_CB1- en_CB5	RA1, RA2	CE1-CE3, CE5	PE	40%
en_CIC1-en_CIC3,en_CG1-en_CG6; en_CB1- en_CB5	RA3, RA4	CE1-CE3, CE5	PE	40%

Students who do show-up at any of the 40% PEs will have a grade of “Not presented”.

In the **ordinary call-final evaluation**, the relationship between the competences, learning outcomes, criteria and evaluation instruments is as follows.

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
en_CIC1-en_CIC3,en_CG1-en_CG6; en_CB1- en_CB5	RA1-RA4	CE1-CE5	PEF	100%

Extraordinary call

In the case of the extraordinary call, the same percentages that have been established in the case of the evaluation by means of a final exam will be maintained.

6. BIBLIOGRAPHY

6.1. Basic Bibliography

- Computer Organization and Design. RISC-V Edition”, David A. Patterson, John Hennessy. 2nd Edition, Morgan-Kaufman 2021.

- Digital Design and Computer Architecture, RISC-V Edition, First Edition", Sarah Harris y David Harris, Morgan Kaufmann 2021.

6.2. Additional Bibliography

- Computer Architecture. A quantitative Approach", David A. Patterson, John Hennessy. Morgan-Kaufman 2019.
- Guía Práctica de RISC-V: El Atlas de una Arquitectura Abierta. Primera Edición, 1.0.5. David A. Patterson, Andrew Waterman. 2018.
- Digital Design Using VHDL, a Systems Approach", W. J. Dally, R. Curtis Hartin, Tor M. Aamodt, Cambridge University Press 2016.

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.