



## IDENTIFYING DATA

### Concurrent, parallel and distributed computing

Subject	Concurrent, parallel and distributed computing			
Code	O06G460V01208			
Study programme	(*)Grao en Intelixencia Artificial			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	2nd	2nd
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Rodríguez Liñares, Leandro			
Lecturers	Olivieri Cecchi, David Nicholas Rodríguez Liñares, Leandro			
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Web	<a href="http://moovi.uvigo.gal">http://moovi.uvigo.gal</a>			
General description	This course aims to educate students on the fundamentals of concurrent computing and programming for parallel and distributed systems. The objective is to develop the necessary skills to select, design, and develop efficient computational solutions that can solve previously intractable problems using alternative computing paradigms. The goal is to empower students to develop code that harnesses the full potential of these computing solutions to support artificial intelligence applications.			

English Friendly subject: International students may request from the teachers: a) resources and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.

## Training and Learning Results

Code	
A2	That 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.
A5	That students have developed those learning skills necessary to undertake further studies with a high degree of autonomy.
B2	Ability to solve problems with initiative, decision making, autonomy and creativity.
B5	Ability to design new computational systems and/or evaluate the performance of existing systems, integrating artificial intelligence models and techniques.
C6	Know the structure, organization, operation and interconnection of computer systems (computer, operating systems and computer networks).
C7	Understand and apply the basic principles and techniques of parallel and distributed programming for the development and efficient execution of artificial intelligence techniques.
C8	Ability to perform the analysis, design and implementation of applications that require working with large volumes of data, applying appropriate hardware/software architectures.
C9	Ability to deploy in the cloud artificial intelligence applications that run efficiently with defined computational resources.
D3	Ability to create new models and solutions in an autonomous and creative way, adapting to new situations. Initiative and entrepreneurial spirit.

## Expected results from this subject

Expected results from this subject	Training and Learning Results			
To be able to develop code that makes an optimal use of the hardware resources available in the computer.	A2	B2	C6 C7 C8	D3

To understand the relationship between the software of the operating system and the hardware on which it is executed.	A2	B5	C6 C7 C8	D3
To know the distinct models of parallel systems and their programming.	A2	B5	C6 C7 C9	D3
To be able to develop code that runs in parallel systems with concurrent, shared and distributed memory, as well as in hardware accelerators			C7 C9	D3
To understand mechanisms to analyze the performance and to optimize the efficiency of parallel code	A5	B2	C6 C7 C8 C9	D3

## Contents

### Topic

Concepts of parallel processing	Introduction to parallel systems Concepts of parallel processing Classification of parallel models Parallelization techniques Parallelization concepts and measures
Programming with threads	Thread independence Introduction to Thread synchronization Synchronization mechanisms and data structures. Concurrency API collections. Thread Executors and Futures Distructed threads with Sockets Distributed threads with RMI library
MPI	Introduction to MPI Collective communication Complex data Communicators Topologies Features of MPI-2 Remote memory access Parallel input/output Dynamic process control
OpenMP	Introduction to OpenMP Distribution of parallel tasks Synchronisation Data sharing
NVidia CUDA	What is NVidia CUDA? Introduction to CUDA Python and Numba The execution model in CUDA Kernels and stride kernels Atomic operations Warps and coalescence 2D and 3D kernels Shared memory Occupancy Dynamic parallelism

## Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	19	21	40
Practices through ICT	28	52	80
Objective questions exam	2	10	12
Essay questions exam	2	16	18

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

## Methodologies

	Description
Lecturing	Presentation by the teachers of the contents of the subject under study, the theoretical bases and guidelines. Teachers may request the active participation of students.

Practices through ICT	Activities involving the application of knowledge to specific situations and the acquisition of basic skills and procedural abilities related to the subject under study. These activities are carried out in computer laboratories independently by the students. CONTINUOUS ASSESSMENT: practices are mandatory
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## Personalized assistance

Methodologies	Description
Lecturing	Academic activity carried out by the teachers with the purpose of addressing the needs and inquiries of students related to their studies and/or topics related to the subject, providing guidance, support, and motivation in the learning process. Tutoring sessions can take place using online resources (email, video conferencing, Moovi forums, etc.) always with previous appointment.
Practices through ICT	Academic activity carried out by the teachers with the purpose of addressing the needs and inquiries of students related to their studies and/or topics related to the subject, providing guidance, support, and motivation in the learning process. Tutoring sessions can take place using online resources (email, video conferencing, Moovi forums, etc.) always with previous appointment.

## Assessment

	Description	Qualification	Training and Learning Results			
Practices through ICT	Programming tests and exercises used to verify whether students have achieved the training and learning results of the subject. The assessed expected results are: RA1, RA2, RA3, RA4, RA5.	30	A2 A5	B2 B5	C6 C7 C8 C9	D3
Objective questions exam	Questionnaires (at least two) consisting mostly of multiple-choice questions used to verify whether the training and learning results of the subject have been achieved. The assessed expected results are: RA1, RA2, RA3, RA4, RA5.	30	A2 A5	B2 B5	C6 C7 C8 C9	D3
Essay questions exam	Final questionnaire that includes questions of different types, aiming to verify whether the training and learning results of the subject have been achieved. The assessed expected results are: RA1, RA2, RA3, RA4, RA5.	40	A2 A5	B2 B5	C6 C7 C8 C9	D3

## Other comments on the Evaluation

### CONTINUOUS ASSESSMENT

#### PARTIAL EXAMS

**Description:** questionnaires conducted throughout the course

**Applied Methodology:** objective questions exam

**Weighting:** 30%

**Minimum required grade:** a grade equal to or higher than 5 must be obtained

**Assessed training and learning results:** A2 A5 B2 B5 C6 C7 C8 C9 D3

**Assessed expected results:** RA1 RA2 RA3 RA4 RA5

#### LAB ASSIGNMENTS:

**Description:** Practical exercises related to the contents

**Applied Methodology:** practices through ICT

**Weighting:** 30%

**Minimum required grade:** a grade equal to or higher than 5 must be obtained

**Assessed training and learning results:** A2 A5 B2 B5 C6 C7 C8 C9 D3

**Assessed expected results:** RA1 RA2 RA3 RA4 RA5

#### FINAL EXAM:

**Description:** final questionnaire consisting of different types of questions

**Applied Methodology:** essay questions exam

**Weighting:** 40%

**Minimum required grade:** a grade equal to or higher than 5 must be obtained

**Assessed training and learning results:** A2 A5 B2 B5 C6 C7 C8 C9 D3

**Assessed expected results:** RA1 RA2 RA3 RA4 RA5

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- In all the methodologies/tests, a score equal to or greater than 5 points out of 10 must be obtained.
- Students must necessarily upload a ID-type photo to the profile of the Moovi platform in the first 2 weeks of the course.
- After the period for choosing the evaluation modality, students who carry out an evaluable activity, whatever the type, and who have not opted for the global evaluation system, will follow the continuous evaluation procedure described above.
- If a student does not show up for any of the evaluation activities, he/she will be assigned a grade of 0 in it.
- If a student abandons the continuous evaluation system having already been evaluated on some content of the subject, it will be considered that the he/she is suspended, and he/she will not be able to opt for the global evaluation system.

## **GLOBAL ASSESSMENT**

### **FINAL EXAM:**

**Description:** final questionnaire consisting of different types of questions

**Applied Methodology:** essay questions exam

**Weighting:** 100%

**Minimum required grade:** a grade equal to or higher than 5 must be obtained

**Assessed training and learning results:** A2 A5 B2 B5 C6 C7 C8 C9 D3

**Assessed expected results:** RA1 RA2 RA3 RA4 RA5

Students who follow the global assessment procedure must take an exam with questions and exercises of various types in which they must obtain a grade greater than 5 out of 10 to pass.

## **EVALUATION CRITERIA FOR EXTRAORDINARY AND END OF CAREER EXAMS**

The global evaluation system described above will be used.

## **QUALIFICATION PROCESS**

To pass the subject it is ESSENTIAL to get a score equal to or greater than 5

## **ASSESSMENT DATES**

The dates for the exams corresponding to the continuous assessment system will be published on the activity calendar, available on the ESEI website <http://esei.uvigo.es/docencia/horarios>

The official exam dates for the different exam periods, officially approved by the ESEI, are posted on the ESEI website <http://esei.uvigo.es/docencia/horarios>

## **USE OF MOBILE DEVICES**

All students are reminded of the prohibition on the use of mobile or electronic devices and laptops in exercises and practices, in compliance with article 13.2.d) of the Statute of the University Student, regarding the duties of university students, which establishes the duty to refrain "from the use and cooperation in fraudulent procedures in the evaluation tests, in all academic assessments and reports, or in official documents of the university".

## **ACADEMIC FRAUD**

All students are reminded that, according to article 3.2 of the Regulations for the Disciplinary Regime of the University of Vigo, the following will be considered very serious offences:

"e) Altering, falsifying, stealing or destroying academic documents or applications and computer systems of the University as well as using false documents or statements before the university.

...

i) Impersonate a person who is part of the university community in their own work or give consent to be impersonated, in relation to university activities."

It is also recalled that, according to the same Regulation, article 3.3, the following will be considered serious offenses:

"d) Committing academic fraud, when it does not constitute a very serious offense.

e) Improper use of content or means of reproduction and recording of university activities subject to intellectual property rights."

Article 3.5 indicates that "In accordance with the provisions of article 11. g) of the University Harmony Law, academic fraud is understood to be any premeditated behavior that tends to falsify the results of an exam or work, one's own or that of another, carried out as a requirement to pass a subject or accredit academic performance"

## OFFICE HOURS

Office hours can be found on the personal pages of the teachers, through <https://esei.uvigo.es/docencia/profesorado/>.

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### Sources of information

#### Basic Bibliography

Kirk, David B. y Hwu, Wen-Mei W., **Programming massively parallel processors: a hands-on approach**, 978-0323912310, 4ª edición, Morgan Kaufmann Publishers, 2022

Gropp, W., Lusk, E. y Skjellum, A., **Using MPI: Portable Parallel Programming with the Message-Passing Interface (Scientific and Engineering Computation)**, 978-0262527392, 3ª edición, The MIT Press, 2014

Breshears, C., **The Art of Concurrency**, 978-0596521530, 1ª edición, O'Reilly Media, Inc, 2009

Fernández González, J., **Java 9 Concurrency Cookbook**, 978-1787124417, 2ª edición, Packt Publishing, 2017

#### Complementary Bibliography

Hwu, Wen-Mei W. (editor), **GPU computing gems: jade edition**, 978-0123859631, 1ª edición, Morgan Kaufmann Publishers, 2011

Chapman, B., Jost, G. y van der Pass, R., **Using OpenMP: Portable Shared Memory Parallel Programming**, 978-0262533027, 1ª edición, The MIT Press, 2007

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### Recommendations

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#### Subjects that it is recommended to have taken before

IT/O06G460V01104

IT: Programming 1/O06G460V01103

IT: Programming 2/O06G460V01109

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#### Other comments

Advice for the students:

- Attend to classes.
- Carry out the exercises proposed in practices.
- Review the recommended bibliography and web resources.

Guidelines for improvement and recovery:

- Students who have difficulties in keeping up with the pace of the subject should make use of the office hours with the teachers, and increase the time dedicated to autonomous learning.