



## Teaching Guide

| Teaching Guide           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |        |                                                       |           |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-------------------------------------------------------|-----------|
| Identifying Data         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |        |                                                       | 2019/20   |
| Subject (*)              | Parallel Programming                                                                                                                                                                                                                                                                                                                                                                                                                                                       |        | Code                                                  | 614973102 |
| Study programme          | Mestrado Universitario en Computación de Altas Prestacións / High Performance Computing (Mod. Virtual)                                                                                                                                                                                                                                                                                                                                                                     |        |                                                       |           |
| Descriptors              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |        |                                                       |           |
| Cycle                    | Period                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Year   | Type                                                  | Credits   |
| Official Master's Degree | 1st four-month period                                                                                                                                                                                                                                                                                                                                                                                                                                                      | First  | Obligatory                                            | 6         |
| Language                 | Spanish                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |        |                                                       |           |
| Teaching method          | Face-to-face                                                                                                                                                                                                                                                                                                                                                                                                                                                               |        |                                                       |           |
| Prerequisites            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |        |                                                       |           |
| Department               | Departamento profesorado másterEnxeñaría de Computadores                                                                                                                                                                                                                                                                                                                                                                                                                   |        |                                                       |           |
| Coordinador              | Martin Santamaria, Maria Jose                                                                                                                                                                                                                                                                                                                                                                                                                                              | E-mail | maria.martin.santamaria@udc.es                        |           |
| Lecturers                | García Loureiro, Antonio Jesús<br>Martin Santamaria, Maria Jose<br>Pichel Campos, Juan Carlos<br>Tourinho Dominguez, Juan                                                                                                                                                                                                                                                                                                                                                  | E-mail | maria.martin.santamaria@udc.es<br>juan.tourino@udc.es |           |
| Web                      | aula.cesga.es                                                                                                                                                                                                                                                                                                                                                                                                                                                              |        |                                                       |           |
| General description      | The global objectives of this subject are: to train the student in the different programming paradigms of parallel computers; to teach software techniques for the design and implementation of algorithms and efficient parallel applications; and apply these techniques in a practical way for the programming of parallel computers with different architectures, using supercomputing resources such as those available at the Galicia Supercomputing Center (CESGA). |        |                                                       |           |

## Study programme competences

| Code | Study programme competences                                                                                                                                                                                                    |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A1   | CE1 - Define, evaluate and select the most appropriate architecture and software to solve a problem                                                                                                                            |
| A2   | CE2 - Analyze and improve the performance of a given architecture or software                                                                                                                                                  |
| A3   | CE3 - Know the high performance computing basic concepts                                                                                                                                                                       |
| A4   | CE4 - Deepen in the knowledge of different programming tools and programming languages in the field of the high performance computing                                                                                          |
| A5   | CE5 - Analyze, design and implement efficient parallel algorithms and applications                                                                                                                                             |
| B1   | CB6 - Possess and understand the knowledge that give a baseline or opportunity to be original in the development and/or application of ideas, often in a research environment                                                  |
| B2   | CB7 - The students have to know how to apply the acquired knowledge and their capacity to solve problems in new or hardly explored environment inside wider contexts (or multidisciplinary) related to its area of development |
| B5   | CB10 - The students have to possess learning skills that allows them to continue to study in a mainly self-driven or autonomous manner                                                                                         |
| B6   | CG1 - Be able to search and select useful information to solve complex problems, using the bibliographic sources of the field                                                                                                  |
| C1   | CT1 - Use the basic technologies of the information and computing technology field required for the professional development and the long-life learning                                                                        |

## Learning outcomes

| Learning outcomes                                                                                                        | Study programme competences |            |     |
|--------------------------------------------------------------------------------------------------------------------------|-----------------------------|------------|-----|
| Understand the main organizational differences in parallel architectures                                                 | AJ1<br>AJ3                  | BJ1<br>BJ5 |     |
| Understand the main programming models                                                                                   | AJ1<br>AJ3<br>AJ4           |            |     |
| Apply the knowledge acquired to the efficient implementation of parallel applications using different programming models | AJ2<br>AJ5                  | BJ2<br>BJ6 | CJ1 |



| Contents             |                                                                                                                                                         |
|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| Topic                | Sub-topic                                                                                                                                               |
| Parallel programming | Introduction<br>Parallel programming paradigms<br>Parallel programs using shared memory directives<br>Parallel programs using message-passing libraries |

| Planning                       |                                  |                      |                               |             |
|--------------------------------|----------------------------------|----------------------|-------------------------------|-------------|
| Methodologies / tests          | Competencies                     | Ordinary class hours | Student's personal work hours | Total hours |
| Laboratory practice            | A1 A2 A3 A4 A5 B1<br>B2 B5 C1    | 18                   | 54                            | 72          |
| Supervised projects            | A1 A2 A3 A4 A5 B1<br>B2 B5 B6 C1 | 0                    | 54                            | 54          |
| Guest lecture / keynote speech | A1 A2 A3 A4 A5 B1                | 23                   | 0                             | 23          |
| Personalized attention         |                                  | 1                    | 0                             | 1           |

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

| Methodologies                  |                                                                                                                                                     |
|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| Methodologies                  | Description                                                                                                                                         |
| Laboratory practice            | Practical classes in the laboratory to familiarize the students, from a practical point of view, with the contents seen in the theoretical classes. |
| Supervised projects            | Realization of works in which the student has to use the acquired knowledge to solve different problems in an autonomous way.                       |
| Guest lecture / keynote speech | Theoretical classes in which the content of each subject is exposed.                                                                                |

| Personalized attention                     |                                                                                                                                                                                                                                                                                         |
|--------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Methodologies                              | Description                                                                                                                                                                                                                                                                             |
| Supervised projects<br>Laboratory practice | The personalized attention in the accomplishment of the laboratory practices and the supervised projects is indispensable to direct to the students in the development of the work. It is recommended that students use the personalized attention to validate the work they are doing. |

| Assessment          |                                  |                                                   |               |
|---------------------|----------------------------------|---------------------------------------------------|---------------|
| Methodologies       | Competencies                     | Description                                       | Qualification |
| Supervised projects | A1 A2 A3 A4 A5 B1<br>B2 B5 B6 C1 | Evaluación dos traballos académicamente dirixidos | 50            |
| Laboratory practice | A1 A2 A3 A4 A5 B1<br>B2 B5 C1    | Evaluación das prácticas                          | 50            |

| Assessment comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>The subject is divided into two parts (directive-based programming and message passing). Each part represents 50% of the final grade of the subject. To pass the subject, the student must obtain a minimum grade of 5 averaging both parts, with a minimum of 4 in each one. In the second chance only is possible to improve the grade of the supervised projects. The qualification of the lab practices will be the one obtained previously throughout the academic year.</p> |

| Sources of information |
|------------------------|
|------------------------|



|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Basic         | <ul style="list-style-type: none"><li>- W.P. Petersen, P. Arbenz (2001). Introduction to Parallel Computing. Oxford University Press</li><li>- F. Almeida, D. Giménez, J.M. Manta, A.M. Vidal (2008). Introducción a la programación paralela. Paraninfo</li><li>- P. Pacheco (2011). An Introduction to Parallel Programming. Morgan Kaufmann Publishers</li><li>- W. Gropp, E. Lusk and R. Thakur (1999). Using MPI-2. The MIT Press</li><li>- P.S. Pacheco (1997). Parallel Programming with MPI. Morgan Kaufmann Publishers</li><li>- Barbara Chapman, Gabriele Jost and Ruud Van der Pas (2008). Using OpenMP. The MIT Press</li></ul> |
| Complementary |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |

## Recommendations

Subjects that it is recommended to have taken before

Subjects that are recommended to be taken simultaneously

Subjects that continue the syllabus

Advanced Parallel Programming/614473107

Other comments

(\*)The teaching guide is the document in which the URV publishes the information about all its courses. It is a public document and cannot be modified. Only in exceptional cases can it be revised by the competent agent or duly revised so that it is in line with current legislation.