



| Teaching Guide           |                                                                                                                                                                                                                             |        |                        |           |
|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------------------------|-----------|
| Identifying Data         |                                                                                                                                                                                                                             |        | 2020/21                |           |
| Subject (*)              | High performance computing in bioinformatics                                                                                                                                                                                |        | Code                   | 614522011 |
| Study programme          | Mestrado Universitario en Bioinformática para Ciencias da Saúde                                                                                                                                                             |        |                        |           |
| Descriptors              |                                                                                                                                                                                                                             |        |                        |           |
| Cycle                    | Period                                                                                                                                                                                                                      | Year   | Type                   | Credits   |
| Official Master's Degree | 2nd four-month period                                                                                                                                                                                                       | First  | Obligatory             | 6         |
| Language                 | SpanishGalicianEnglish                                                                                                                                                                                                      |        |                        |           |
| Teaching method          | Hybrid                                                                                                                                                                                                                      |        |                        |           |
| Prerequisites            |                                                                                                                                                                                                                             |        |                        |           |
| Department               | Enxeñaría de Computadores                                                                                                                                                                                                   |        |                        |           |
| Coordinador              | González Domínguez, Jorge                                                                                                                                                                                                   | E-mail | jorge.gonzalezd@udc.es |           |
| Lecturers                | González Domínguez, Jorge                                                                                                                                                                                                   | E-mail | jorge.gonzalezd@udc.es |           |
| Web                      | campusvirtual.udc.es/moodle                                                                                                                                                                                                 |        |                        |           |
| General description      | Analysis of different parallel architectures that can be exploited in bioinformatics. Introduction to different parallel programming models. Usage of parallel systems to accelerate the execution of bioinformatics tools. |        |                        |           |



|                  |                                                                                                                                                          |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Contingency plan | 1. Modifications to the contents                                                                                                                         |
|                  | No modifications will be performed                                                                                                                       |
|                  | 2. Methodologies                                                                                                                                         |
|                  | *Teaching methodologies that are maintained                                                                                                              |
|                  | - Oral lecture (through Teams)                                                                                                                           |
|                  | - Objective test (through Moodle)                                                                                                                        |
|                  | - Laboratory practice (through Teams and Moodle)                                                                                                         |
|                  | - Supervised projects (through email and Teams)                                                                                                          |
|                  | - Oral presentation (through Teams)                                                                                                                      |
|                  | *Teaching methodologies that are modified                                                                                                                |
|                  | No methodology will be modified but all of them will be performed through online platforms available at UDC.                                             |
|                  | 3. Mechanisms for personalized attention to students                                                                                                     |
|                  | ? Email and chat in Teams: daily. In order to ask questions, ask for virtual meetings to solve problems and follow the work in the supervised projects.  |
|                  | ? Moodle: Weekly. The students will have news about the planning, the grades and different events. Moreover, the tasks will be submitted through Moodle. |
|                  | ? Teams: Online lectures through Teams videoconference. The oral presentations will also be through Teams.                                               |
|                  | 4. Modifications in the evaluation                                                                                                                       |
|                  | No modification                                                                                                                                          |
|                  | *Evaluation observations:                                                                                                                                |
|                  | No modification                                                                                                                                          |
|                  | 5. Modifications to the bibliography or webgraphy                                                                                                        |
|                  | No modification                                                                                                                                          |

| Study programme competences |                                                                                                                                                                                                                |
|-----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Code                        | Study programme competences                                                                                                                                                                                    |
| A2                          | CE2 ? To define, evaluate and select the architecture and the most suitable software for solving a problem in the field of bioinformatics                                                                      |
| A3                          | CE3 ? To analyze, design, develop, implement, verify and document efficient software solutions based on an adequate knowledge of the theories, models and techniques in the field of Bioinformatics            |
| B2                          | CB7 - Students should know how to apply the acquired knowledge and ability to problem solving in new environments or little known within broad (or multidisciplinary) contexts related to their field of study |
| B5                          | CB10 - Students should possess learning skills that allow them to continue studying in a way that will largely be self-directed or autonomous.                                                                 |



|    |                                                                                                                                                       |
|----|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| B7 | CG2 - Maintain and extend well-founded theoretical approaches to enable the introduction and exploitation of new and advanced technologies            |
| C1 | CT1 - Express oneself correctly, both orally writing, in the official languages of the autonomous community                                           |
| C3 | CT3 - Use the basic tools of the information technology and communications (ICT) necessary for the exercise of their profession and lifelong learning |

| Learning outcomes                                                                      |  |                             |                   |
|----------------------------------------------------------------------------------------|--|-----------------------------|-------------------|
| Learning outcomes                                                                      |  | Study programme competences |                   |
| To understand the main differences in the organization of parallel architectures       |  | AJ2                         | BJ7               |
| To understand the main programming models for high performance computing               |  | AJ3                         | BJ2<br>BJ5        |
| To apply the new knowledge to the efficient execution of parallel bioinformatics tools |  | AJ2                         | BJ5<br>CJ1<br>CJ3 |

| Contents                                                    |                                                                                                                                                                                                                                 |
|-------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Topic                                                       | Sub-topic                                                                                                                                                                                                                       |
| 1) Introduction to parallel programming                     | 1.1) Basic concepts of parallel computing<br>1.2) Parallel computer architectures<br>1.3) Parallel programming paradigms<br>1.4) Performance evaluation of parallel algorithms                                                  |
| 2) Parallel programming on shared memory architectures      | 2.1) Shared memory architectures<br>2.2) Shared memory programming model<br>2.3) Programming languages for shared memory architectures                                                                                          |
| 3) Parallel programming on distributed memory architectures | 3.1) Distributed memory architectures<br>3.2) Message-passing programming model<br>3.3) Programming languages for distributed memory architectures                                                                              |
| 4) Parallel programming on emerging architectures           | 4.1) GPUs<br>4.2) Programming languages for GPUs<br>4.3) Big Data Frameworks                                                                                                                                                    |
| 5) Executing parallel bioinformatics tools                  | 5.1) Analysis of parallel bioinformatics tools<br>5.2) Execution on shared memory systems<br>5.3) Execution on distributed memory systems<br>5.4) Execution on GPUs<br>5.5) Usage of execution queues on supercomputers centers |

| Planning                                                                                                                        |                |                      |                               |             |
|---------------------------------------------------------------------------------------------------------------------------------|----------------|----------------------|-------------------------------|-------------|
| Methodologies / tests                                                                                                           | Competencies   | Ordinary class hours | Student's personal work hours | Total hours |
| Guest lecture / keynote speech                                                                                                  | A2 A3 B2 B5 B7 | 14                   | 28                            | 42          |
| Laboratory practice                                                                                                             | A2 B2 B5 C3    | 21                   | 52.5                          | 73.5        |
| Supervised projects                                                                                                             | A2 C1 C3       | 3                    | 18                            | 21          |
| Oral presentation                                                                                                               | A2 C1 C3       | 2                    | 6                             | 8           |
| Objective test                                                                                                                  | A2 A3 B2 B5 B7 | 2                    | 0                             | 2           |
| Personalized attention                                                                                                          |                | 3.5                  | 0                             | 3.5         |
| (*)The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. |                |                      |                               |             |

| Methodologies |             |
|---------------|-------------|
| Methodologies | Description |



|                                |                                                                                                                                                                                                                                                                                                                                                   |
|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Guest lecture / keynote speech | Oral lectures with slides and questions from the students. The goal of these presentations is to provide information and to help in the adquisition of knowledge. There will be oral lectures related to the contents 1, 2, 3 and 4. I will be the basis for the rest of activities.                                                              |
| Laboratory practice            | Activity to increase the knowledge of the concepts explained in the oral lectures, by performing practical sessions in computers. The students will understand the practical concepts of high performance computing. Particularly, these sessions will focus on content 5, and it will be necessary for the supervised project and the oral test. |
| Supervised projects            | The student will develop an individual work where he must use a parallel bioinformatic tool. This project will be used to evaluate whether the student learnt the concepts explained during the laboratory prcatices and he is able to use the new knowledge on different scenarios.                                                              |
| Oral presentation              | Activity where students must expose to the teacher and the colleagues the results of their projects. There will enough time so that the other students can ask questions about the work (they must be active).                                                                                                                                    |
| Objective test                 | Activity to evaluate the knowledge acquired by the students during the oral lectures. It consists of a written test with several questions.                                                                                                                                                                                                       |

## Personalized attention

| Methodologies                                                                     | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Objective test<br>Oral presentation<br>Laboratory practice<br>Supervised projects | <p>In the laboratory practical sessions the students will be allowed to ask questions. The teacher will use any necessary activity to solve the questions and doubts. Moreover, it is recommended that students attend to tutorships in the teacher office, where they will be allowed to ask questions related to the theoretical and practical concepts that will be evaluated.</p> <p>Partial-time students must use the tutorships and the personalized attention to follow the lectures and laboratory practices when they are not able to attend the original date.</p> |

## Assessment

| Methodologies       | Competencies   | Description                                                                                                                                                                                                                                                                                                                  | Qualification |
|---------------------|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| Objective test      | A2 A3 B2 B5 B7 | Written test about the contents presented in the lectures and the laboratory practices.                                                                                                                                                                                                                                      | 30            |
| Oral presentation   | A2 C1 C3       | <p>Presentation of the results of the supervised project in front of the teacher and the other students.</p> <p>It is necessary (but not sufficient) to perform this oral presentation and actively attend to the colleagues presentations in order to pass the subject.</p>                                                 | 10            |
| Laboratory practice | A2 B2 B5 C3    | The mark will be obtained by correctly completing a practical exercise as well as attending to the laboratory sessions.                                                                                                                                                                                                      | 20            |
| Supervised projects | A2 C1 C3       | <p>The mark of these supervised project depends on both the quality of the results and the quality of the final report.</p> <p>It is necessary (but not sufficient) to write the final report and obtain at least 25% of its qualification (equivalent to 10% of the global qualification) in order to pass the subject.</p> | 40            |

## Assessment comments



In order to pass the subject it is necessary to fulfill the following conditions:

- To obtain global qualification equal or higher than 50%.
- To obtain qualification equal or higher than 2.5/10 in the supervised project.
- To complete the oral presentation.
- To actively attend to the colleagues presentations.

If the student obtains global qualification equal or higher than 50% but any of the previous conditions is not fulfilled, the final qualification will be Fail (4.5/10).

In the second chance the student will be allowed to retake 80% of the total qualification: supervised project, oral presentation and objective test. Only the qualification of the laboratory practices can not be retaken. The qualification of the laboratory practices obtained in the first chance will be kept for the second chance.

All students that do not complete the objective test will be considered as "not presented", even though they complete the laboratory practices, the supervised project and/or the oral presentation.

Qualification for partial-time students will be assigned using the same rules as for ordinary students. Partial-time students must attend to the oral presentations of their colleagues too. Attendance to lectures and laboratory practices are not compulsory for any student.

Those students who repeat the subject because they did not reach the minimum mark the previous year will be able to maintain the partial marks (practical exam, supervised project, oral presentation or theoretical exam). In order to save these partial marks they have to tell the teacher the first week of the course.

## Sources of information

|                      |                                                                                                                                                                                                                                                                                                                                                                    |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Basic</b>         | <ul style="list-style-type: none"><li>- Thomas Rauber [et al.] (2013). Parallel Programming for Multicore and Cluster Systems. Springer</li><li>- Peter S. Pacheco (2011). An introduction to parallel programming. Morgan Kaufmann</li><li>- Jason Sanders (2011). CUDA by example : an introduction to general-purpose GPU programming. Addison-Wesley</li></ul> |
| <b>Complementary</b> | <ul style="list-style-type: none"><li>- Francisco Almeyda [et al.] (2008). Introducción a la programación paralela. Paraninfo Cengage Learning</li><li>- Bertil Schmidt (2010). Bioinformatics: High Performance Parallel Computer Architectures. CRC Press</li></ul>                                                                                              |

## Recommendations

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

### Subjects that are recommended to be taken simultaneously

### Subjects that continue the syllabus

### Other comments

It is advisable to have certain knowledge about programming and computer architecture

(\*)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.