



# *Computação em Larga Escala*

*General Description*

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## *Bolonha Model*

- It promotes a student-centred teaching by
  - stimulating an autonomous learning
  - proposing the *problem solving* paradigm as the main methodological strategy for teaching
  - stressing the development of specific skills vs. a more or less automatic building up of general knowledge.
- It establishes very precise metrics on the work being carried out
  - the academic week is defined to be 40 hours of effective work, meaning a total of 30 ECTS credits
    - 1 ECTS = 4/3 h of weekly study
  - each course of the curriculum is assigned a very definite work load
    - CLE: 6 ECTS  $\Rightarrow$  8 h of weekly study (attending classes + home work).

## *Main Objectives*

- to acquaint the students to the principles of high performance computing
- to introduce the most important paradigms of algorithmic design, communication and synchronization in parallel programming.

## *Learning Outcomes*

- to gain a good understanding on the main issues related to programming at different levels of parallelism (coarse, medium and fine)
- to develop skills for the design and the implementation of simple parallel applications on multiprocessing architectures
- to acquaint the students with the functionality of C-based parallel programming environments using the pthread library, MPI and CUDA.

## *Prerequisites*

- basic knowledge of computer architecture
- basic knowledge about operating systems and multiprogrammed environments
- fair to advanced working knowledge of C language and some knowledge of the principles of concurrent programming.

# *Syllabus*

## *High performance computing*

- Architectural basics of a parallel machine
- Decomposition techniques
- Law of Amdahl
- Tools used in programming parallel applications

## *Medium-grain parallelism*

- Revision of basic notions about computer architecture
- General principles of concurrency
- Synchronization devices
- Decomposition model
- Library pthread

## *Coarse-grain parallelism*

- Concept of message exchange
- Decomposition model
- Synchronization devices
- Computational model provided by MPI

## *Fine-grain parallelism*

- Heterogeneous computing using GPUs (Graphical Processing Units)
- Architecture of a GPU
- Language CUDA C
- Computational model
- Decomposition techniques.

## *Main bibliography*

- *Introduction to HPC with MPI for Data Science*, F. Nielsen, Springer, 2016
- *Parallel Programming in C with MPI and OPeNMP*, M. Quinn, McGraw-Hill, 2003
- *Professional Cuda C Programming*, J. Cheng, M. Grossman, T. McKercher, John Wiley & Sons, 2014
- *Programming Massively Parallel Processors*, D. Kirk, W. Hwu, Morgan Kaufmann, 2017

## *Lectures*

Lectures present specific topics of the syllabus. The adopted approach tries to entice the students to participate actively in the discussion and to help them to develop skills of critical reasoning and to learn general techniques of problem solving.



## ***Lab classes***

Labs follow the motto "*you learn by doing*" and are mostly devoted to discuss implementation issues about the solution of a set of problems.

### ***Work assignment 1***

Purely concurrent (multithreaded) solution of the problems.

### ***Work assignment 2***

Parallel solution of the problems based on message passing using MPI.

### ***Work assignment 3***

Parallel solution of the problems based on shared variables using CUDA.

Students are organized in working groups composed of two elements. Each group must present and defend its approach to the solution and its implementation during a query session.

## *Tutorials*

Tutorials take place every week on Mondays, at 14h.

Tutorials have for the most part an exposition character and aim to help the students to overcome deficiencies on the background knowledge some of them may have, as well as to provide a space for the discussion of specific aspects of the course.

## *Grading - 1*

$$\text{course grade} = \frac{5 \times \text{theoretical mark} + 5 \times \text{lab mark}}{10}$$

- rounding is always carried out *half up* to unities, except when the lab mark is higher than the theoretical mark by more than three units; in this case, rounding is carried out *half down*
- *theoretical grading*
  - written examination (época normal ou época de recurso)
- *lab grading*
  - composed of *work assignments* 1 through 3, each having equal weight

## *Grading - 2*

- *Pass*
  - both theoretical and lab marks higher or equal to 8,5 units *and* course grade higher or equal to 10 units
- *Fail*
  - theoretical mark lower than minimum mark *or* lab mark lower than minimum mark *or* final grade lower than 10 units
- *Fail by minimum mark*
  - lab mark lower than minimum mark
- *Fail by absence (regular student)*
  - missing more than three lab classes

## *Final remarks*

- special dates
  - deadline for delivering work assignment 1: 31 de Março de 2024
  - deadline for delivering work assignment 2: 4 de Maio de 2024
  - deadline for delivering work assignment 3: 5 de Junho de 2024
- all documentation about the course can be found in the *elearning* site (moodle)
- any further questions may be answered by the course operational document or by myself.

# elearning site

The screenshot shows a web browser window displaying the elearning site for 'Computação em Larga Escala'. The URL is <https://elearning.ua.pt/course/view.php?id=5446>. The page has a green header with the course title and a navigation bar with links like Home, Painel do utilizador, Eventos, Minhas UC, and Esta UC. The main content area is divided into sections: 'Fórum Notícias', 'About the course', 'General Info' (with links for 'Operational document' and 'Course list'), 'Documentation' (with links for 'Eclipse site', 'The development of C language', 'Elementos', 'Complementos', 'Acesso a ficheiros', and 'Processamento da linha de comando'), 'Lectures', 'Labs', and 'Grades'. The footer contains links for 'Manuais', 'Suporte', and 'Outros sites'.

Computação em Larga Escala

Home Painel do utilizador Eventos Minhas UC Esta UC

Mostrar blocos

As minhas UC > 40753-CLE

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About the course

General Info

Operational document  
Documento PDF

Enrolled students

Course list  
Documento PDF

Documentation

IDE

Eclipse site

C Language

The development of C language  
Documento PDF

Elementos  
Documento PDF

Complementos  
Documento PDF

Acesso a ficheiros  
Documento PDF

Processamento da linha de comando  
Documento PDF

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Labs

Grades

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Notícias UA  
Formulários

Reportar a demonstração ao utilizador nesta página