The main objectives of this course are:

- Paradigms concurrency, parallel and distributed systems: (client-server, load sharing, tasks, etc.).
340384 - PACO-I5001 - Parallelism and Concurrence

- Platforms parallel (shared memory architectures, distributed memory).
- Tools to aid the development of parallel programs.
- Programming and evaluation of parallel programs (programming models for different parallel platforms).
- Memory Coherence and consistency. Communication sincronizació, race conditions, mutex, critical section, monitors, deadlock.

### Study load

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group: 45h</th>
<th>30.00%</th>
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<tbody>
<tr>
<td></td>
<td>Hours medium group: 0h</td>
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<tr>
<td></td>
<td>Hours small group: 15h</td>
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<td>Guided activities: 0h</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Self study: 90h</td>
<td>60.00%</td>
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</tbody>
</table>
## 1. Introduction to parallelism

**Description:**
Need of parallelism. Parallelism versus concurrence. Problems using concurrence: deadlock, lifelock, starvation, fairness, data races

**Related activities:**
Activity 1. Unit 1 problems
Activity 2. Lab 0: Experimental setup, tools and programming model

**Learning time:** 9h
- Theory classes: 1h
- Practical classes: 2h
- Self study: 6h

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## 2. Analysis of parallel applications

**Description:**
Can a computation be divided into different parts? It is divided based on the tasks to do or based on the input/output data.
Will there be dependence of data between the tasks? How will they be solved? A good decomposition determines the parallel degree achievable.

**Related activities:**
Activity 1. Problems: Analysis of parallel applications
Activity 2: Lab 0: Experimental setup, tools and programming model

**Learning time:** 11h
- Theory classes: 1h
- Practical classes: 2h
- Laboratory classes: 2h
- Self study: 6h
### 3. Introduction to (shared-memory) Parallel Architectures

**Learning time:** 20h  
- Theory classes: 2h  
- Practical classes: 4h  
- Laboratory classes: 2h  
- Self study: 12h

**Description:**  
Parallelism inside a processor (IDLP, DLP, TLP), multiprocessors with share memory, multiprocessors with distributed memory.

**Related activities:**  
- Activity 1. Unit 3 problems  
- Activity 2. Lab 0: Experimental setup, tools and programming model  
- Activity 4. Knowledge test

### 4. Basics of parallel programming: Tasks decomposition

**Learning time:** 22h  
- Theory classes: 2h  
- Practical classes: 4h  
- Laboratory classes: 2h  
- Guided activities: 2h  
- Self study: 12h

**Description:**  
Identification of concurrence patterns. Tasks decomposition, granularity and analysis of dependences. Identification of parallelism patterns: task parallelism versus divide and conquer. Mechanisms to implement the task decomposition: thread creation and destruction, thread synchronization patterns, exclusion when accessing share data.

**Related activities:**  
- Activity 1. Task parallelism problems  
- Activity 2. Lab 1: Embarrassingly parallelism with OpenMP: Mandelbrot set
5. Programing with share memory

Learning time: 31h
- Theory classes: 3h
- Practical classes: 6h
- Laboratory classes: 2h
- Guided activities: 2h
- Self study: 18h

Description:
Parallel regions, threads and tasks. Task threads, barriers, mutual exclusion locks. Work distributors: loops, sections.

Related activities:
- Activity 1. Share memory problems
- Activity 2. Lab 2: Divide and Conquer parallelism with OpenMP: Sorting
- Activity 3. Directed work. Additional practise

6. Basics of parallel programing: Data decomposition

Learning time: 31h
- Theory classes: 3h
- Practical classes: 6h
- Laboratory classes: 4h
- Self study: 18h

Description:
Data decomposition (geometric versus recursive structure), data flow organization (regular versus irregular). Mechanisms to implement the data decomposition: creation and destruction process, process synchronization (barrier) and communications patterns (point-to-point communication, synchronous and asynchronous communication)

Related activities:
- Activity 1. Data decomposition problems
- Activity 2. Lab 3: Geometric decomposition: solving the heat equation

Qualification system

1st partial knowledge test *0.2+ problems * 0.1 + 0.3 * Laboratory + complementary * 0.1 Working + 2nd partial knowledge test * 0.3 = 5
The 1st and 2nd partial knowledge tests are reevaluable

Regulations for carrying out activities

Activities 1, 2 and 4 are in person.
Activity 3 is non-attendance, although there may be a short presentation in class.
In the activities that take place in group the mark will be the same for all group members
Basic:


Others resources:

- Computer material
  - Software a Boada
    - Connection and software in boada.ac.upc.edu