270004 - IC - Introduction to Computers

Coordinating unit: 270 - FIB - Barcelona School of Informatics
Teaching unit: 701 - AC - Department of Computer Architecture

Academic year: 2018
Degree: BACHELOR'S DEGREE IN INFORMATICS ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)
ECTS credits: 7.5

Teaching languages: Catalan

Teaching staff

Coordinator: - Josep-Llorenç Cruz Diaz (cruz@ac.upc.edu)
Others: - Angel Olivé Duran (angel@ac.upc.edu)
- Enric Morancho Llena (enricm@ac.upc.edu)
- Isaac Sánchez Barrera (isaac.sanchez.barrera@upc.edu)
- Josep Larriba Pey (larri@ac.upc.edu)
- Josep Sole Clotet (joseps@ac.upc.edu)
- Josep Sole Pareta (pareta@ac.upc.edu)
- Marc Gonzàlez Tallada (marc@ac.upc.edu)
- Marc Ruiz Ramírez (mruiz@ac.upc.edu)
- Octavio Castillo Reyes (octavio.castillo@upc.edu)
- Toni Cortés Rosselló (toni@ac.upc.edu)

Prior skills

Students should have acquired the skills expected of a student starting a bachelor's degree in Informatics.

Degree competences to which the subject contributes

Specific:
CT1.1B. To demonstrate knowledge and comprehension about the fundamentals of computer usage and programming. Knowledge about the structure, operation and interconnection of computer systems, and about the fundamentals of its programming.
CT6.2. To demonstrate knowledge, comprehension and capacity to evaluate the structure and architecture of computers, and the basic components that compound them.

General:
G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.
Teaching methodology

The teaching method for the subject is the Pygmalion method described by the Institute of Education Sciences of the UPC, summarised as 10 points (see Atenea for detailed information, as the course guide is merely a summary):

1. An ambitious final goal. Students will progress from knowing nothing of digital circuits or how they are built to designing a computer with all its details and 3,000 logic gates. This is an important motivational element.

2. A list of 100 specific learning objectives, describing what students should be able to do by the end of the course. These learning objectives are subject to assessment (students will know if they have achieved them or not) and there is an undertaking not to assess any learning objective not included in this list.

3. A detailed programme of activities for students to do in and (especially important) out of class. After each 2-hour theory/problem-solving class, students will spend a further 1.5 hours completing exercises (Moodle questionnaires for electronic delivery and other more complex exercises for hard-copy delivery) to be submitted at the beginning of the next class.

4. A step-by-step programme of activities. These will progressively cover the 100 specific learning objectives for the subject (the ambitious final goal is intended to be motivational and the step-by-step approach makes progress feasible).

5. Outcomes for each programmed activity embodied in the delivery of an assignment that shows whether the student has done the work. Students will be issued with the solutions to exercises and problems and with the quality criteria necessary to evaluate these assignments.

6. Timely feedback mechanisms based on assignment deliveries. Students and the lecturer can monitor progress as follows: 1) Students immediately know if a Moodle exercise solution is wrong and can resubmit as often as necessary until they get the right answer. 2) As feedback at the beginning of each class, doubts regarding the Moodle exercises and the written assignments done at home will be cleared up. 3) Students will complete exercises individually or in groups in class that will keep them informed on their progress. 4) Throughout the course, four theory/problem-solving and six laboratory exams/tests will be issued, for which timely feedback will be given.

7. Special activities for students with difficulties (and also for more advanced students): individual consultations, problem-solving workshops, etc.

8. Cooperative learning techniques to motivate students for the activities. Active learning techniques will be used in the theory classes to keep lecturer presentations short and ensure that students participate actively.

9. The grading method. This represents a further incentive to complete activities on time, learn and successfully complete the course.

10. Systematic data collection over the entire course. These data will be used to drive the continuous improvement process.

Learning objectives of the subject

1. Explain the operation of a von Neumann computer using their own words, including the internal structure in terms of processor subsystems, bus, storage, input/output and execution of a program in machine language, as well as the most important differences between the machine language of RISC and CISC computers.

2. Define the conventional numbering system in base b for representing natural numbers, particularly the binary case (b=2), and also the system for representing integers in two’s complement (Ca2).

3. Explain natural number representation in base 2, 10 or 16 converted to another of these bases.

4. Explain a combinational logic circuit and specify the truth table for the basic logic gates (NOT, AND, OR and XOR) and the multiplexer and decoder blocks.
5. Analyse small combinational circuits (obtain truth tables and propagation time and create operational time schedules).
6. Synthesise small combinational circuits (obtain logic diagrams with one of the following sets of devices: NOT, AND and OR gates as a sum of minterms or minimum products), a decoder and OR gates, and a ROM and multiplexers.
7. Apply arithmetic algorithms to basic operations (addition, subtraction, comparison, multiplication and division by powers of two) with vectors of bits representing natural numbers in binary and integers in two’s complement.
8. Draw the internal logic diagram for combinational blocks (combinational circuits that manipulate n-bit words) that perform basic arithmetic operations on natural numbers represented in binary and on integers represented in two’s complement, as well as the internal logic block diagram that performs basic bitwise operations (NOT, AND, OR and XOR).
9. Explain sequential logic circuits (general Mealy and particular Moore cases) and specify the operation of an edge-triggered D-type flip-flop and depict its internal logic diagram using two multiplexers.
10. Analyse small Moore sequential circuits (obtain state graphs and minimum cycle time and draw simplified operational time schedules).
11. Synthesise small Moore sequential circuits (using the minimum number of edge-triggered D-type flip-flops and any of the combinational circuit synthesis techniques studied).
12. Design specific-purpose processors that manipulate n-bit words generated by a processing unit (designed ad hoc with combinational and sequential blocks) and a control unit (specified by a Moore state graph).
13. Explain the asynchronous four-phase handshaking communication protocol and apply it to data input/output in specific-purpose processors.
14. Draw the interconnection diagram for the general processing unit (GPU) at the block level and the internal logic diagram for each block (register bank and arithmetic logic unit).
15. Draw the Moore state graph for a specific-purpose control unit so that it implements specific functions along with the general processing unit (GPU).
16. Explain the steps necessary to transform a specific-purpose control unit (implementation of a state graph) into a general-purpose control unit which, together with the general processing unit (GPU), will form a simple RISC processor, and explain implicit sequencing and instruction coding.
17. Justify the need for a large data memory and explain the operation of a block of RAM by means of a schedule of its input and output signals (simplified model).
18. Depict the internal logic diagram for a simple input/output subsystem with keyboard and printer.
19. Depict an interconnection diagram for the storage and input/output subsystems with the processor (GCU+GPU) so as to configure a simple RISC computer.
20. Define, for each instruction to a simple RISC processor (some 20 instructions), format in machine language, syntax in assembly language and semantics (how the computer status is modified).
21. Indicate how computer status is modified (register co

### Study load

<table>
<thead>
<tr>
<th>Total learning time: 187h 30m</th>
<th>Theory classes: 30h 16.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practical classes: 30h 16.00%</td>
<td>Laboratory classes: 15h 8.00%</td>
</tr>
<tr>
<td>Guided activities: 7h 30m 4.00%</td>
<td>Self study: 105h 56.00%</td>
</tr>
</tbody>
</table>

Last update: 05-02-2019
# Content

## Introduction

**Degree competences to which the content contributes:**

**Description:**
A brief introduction to digital information, digital information representation and digital circuits, special purpose processors, the Von Neumann machine, machine and assembly languages and their relationship to high-level languages (compilation/translation).

## Representing natural numbers

**Degree competences to which the content contributes:**

**Description:**
Representation of natural numbers in decimal and binary and generalisation to the conventional system in base b. Hexadecimal. Representation range. Range extension algorithm. Change of basis between conventional systems.

## Combinational logic circuits

**Degree competences to which the content contributes:**

**Description:**
Definition of a combinational logic circuit. Time schedules. Variables and logic functions. Truth tables. NOT, AND and OR logic gates. Logic circuit diagram. Interconnection rules for constructing valid combinational logic circuits. Logical analysis (from the diagram to the truth table). Synthesis (from the functional description to the truth table and from the truth table to the logic circuit): in sum of minterms with a decoder and OR gates, with a ROM and minimal sum of products using Karnaugh maps. Temporal analysis (time schedules and input-output propagation times).

## Natural numbers: combinational arithmetic blocks

**Degree competences to which the content contributes:**

**Description:**
Arithmetic algorithms for addition, subtraction, multiplication and division by powers of two natural numbers represented in binary. Full adder, half adder and full subtractor. Combinational blocks that implement the above arithmetic algorithms with detection results that cannot be represented in n bits. Comparators for equal, less and less or equal. Non-arithmetic combinational blocks (bitwise logical operators and tree multiplexer design). New arithmetic block design.

## Integers: representation and combinational arithmetic blocks

**Degree competences to which the content contributes:**
**Description:**
Representing integers. Two's complement. Range and range extension algorithm. Changing integer representation between sign and magnitude in the decimal system and two's complement. Arithmetic algorithms and implementing combinational blocks (with detection of results that cannot be represented in n bits): addition, sign change, subtraction, multiplication and division by powers of two and the less and less or equal comparators. Adder/subtractor with results detection that cannot be represented by natural numbers or integers.

### Sequential logical circuits

**Degree competences to which the content contributes:**

**Description:**
Memory needs and synchronisation. The clock signal. Definition of synchronous sequential circuit. Edge-triggered D-type flip-flops: definition and implementation with two multiplexers, time propagation and time schedules. Interconnection rules for constructing valid sequential circuits. Sequential circuit structures (Mealy and Moore models). Transition tables and output tables. State graphs for the Moore model. Simplified time schedules. Logic analysis: from the circuit to the state graph. Synthesis: from the functional specification to the state graph and from the state graph to the logic circuit diagram with a minimum number of flip-flops. Temporal analysis: critical paths and minimum cycle times.

### Special purpose processors

**Degree competences to which the content contributes:**

**Description:**
Introduction. Special-purpose processor design, with a processing unit (for n-bit words) and a control unit (generating the control word for each cycle). The processing unit is designed ad hoc using combinational and sequential blocks of n bits and the control unit is specified by a Moore state graph. Examples with synchronous data input/output: add four numbers, calculate the GCD of two numbers with the Euclidean algorithm, etc. Asynchronous communication protocol for data input/output: four-phase handshaking. Examples with asynchronous data input/output.

### General processing unit

**Degree competences to which the content contributes:**
**Description:**
Introduction: from special purpose to general purpose processors. Register bank with one write and two read buses. Arithmetic logic unit with bitwise functionality for logic operations, arithmetic operations (addition, subtraction, multiplication and division by powers of two for natural numbers and integers), comparators (equal, less and less or equal for natural numbers and integers) and movement. General processing unit (GPU) structure. Connections between the GPU and the control unit: control word and zero bit condition. Actions to implement in such problems using the GPU. Mnemonics of actions (AND, OR, XOR, NOT, ADD, SUB, SHA, SHL, CMPLT, CMPLE, CMPEQ, CMPLTU, CMPLE, MOV, IN, OUT and NOP) and associated control word bits. Actions with immediate values and actions that do not alter records. Special purpose processor design using the GPU (specifying the control unit via a state graph and the control word via mnemonics). Input/output address spaces and IN and OUT actions. Asynchronous data input/output via the four-phase handshaking protocol. Model designs based on high-level language code that specifies processor functionality (four-bit adder, GCD calculation for the Euclidean algorithm, etc.).

**General control unit**

**Degree competences to which the content contributes:**

**Description:**
Initial implementation of the control unit (just like any other sequential circuit): with a state register, a ROM (where each word is stored in the next two possible states, depending on the Z-bit condition and the control word governing the GPU during a cycle) and a bus multiplexer to select the next state depending on Z. Von Neumann and Harvard computer models. ROM instruction storage. From the state graph to the program in machine/assembly language. Definitive control unit structure with implicit sequencing, 16-bit instructions and an instruction decoder to obtain the 50-bit control word from 16 instruction bits. SISA instructions format (with one, two or three registers) and coding. Uses: arithmetic, logical and comparative, sequence breaking, input-output, movement (register loading with a constant) and addition of a small constant. Examples of passing from graphs (specifying a control unit with specific objectives which executes an algorithm with the GPU) to code snippets in SISA assembly language so as to perform the same function (although usually requiring more cycles).

**Storage and input/output**

**Degree competences to which the content contributes:**

**Description:**
RAM, a simple operational model (read and write schedules, access times for reading and set-up and signal pulse width permission to write scripts). Memory address space. Processor and data memory connections. Read (load: LD) and write instructions (store: ST): semantics, machine language format and assembler syntax. Examples of state modifications for specific load and store computer instructions. Examples of small programs with memory access. Simple input/output subsystem consisting of a keyboard and printer with the side effect of the state register (port) for data reading (keyboard) and data writing (printer) set to zero. Input/output with synchronisation by polling. Examples of small programs with data input/output data.

**Machine and assembly languages**

**Degree competences to which the content contributes:**
270004 - IC - Introduction to Computers

**Single-cycle processors**

**Description:**
General review of SISA machine and assembly language (25 instructions) as per the previous two topics. Exercises on: a) SISA code assembly and disassembly; b) computer state modification after execution of an instruction or small program; and c) writing small programs in assembly language.

**Degree competences to which the content contributes:**
Complete single-cycle implementation details (SISC Harvard unicycle) for a processor running programs in SISA machine language (as developed in topics 8, 9 and 10): a) minor GPU ALU modification to execute immediate instructions to move the largest 8-bits in a register to MOVHI; b) single address bus for the input/output space; and c) instruction decoder design to obtain a 46-bit control word from a 16-bit instruction using a small ROM and a small number of multiplexers and gates. ROM content of the instruction decoder. Temporary restrictions on write permission signals for storage and data input/output. Examples of changes to SISC Harvard unicycle design so that it executes a new instruction as well as the more than 25 original instructions. Calculating the critical path and minimum cycle time for a single-cycle computer. Small program run times.

**Multicycle processors**

**Description:**
Introduction: justification for multicycle implementation (SISC Harvard multicycle) rather than single-cycle implementation (SISC Harvard unicycle). Changes to the processor control unit. Sequential control unit design: state graphs and their implementation. Temporary restrictions on write permission signals for storage and data input/output. Examples of changes to SISC Harvard multicycle design so that it executes a new instruction as well as the more than 25 original instructions. Calculating the critical path and minimum cycle time for a multicycle computer. Small program run times.
### Planning of activities

| Topics 1 and 2 theory/problem-solving classes | Hours: 5h  
Theory classes: 1h  
Practical classes: 1h  
Laboratory classes: 0h  
Guided activities: 0h  
Self study: 3h |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> Participate actively in a two-hour explanatory-participatory theory/problem-solving class (2 hours). Home study of the assigned topic (1.5 hours). Complete the topic exercises for electronic delivery (Atenea questionnaires) and hard-copy delivery (at the beginning of each theory/problem-solving class) (1.5 hours). <strong>Specific objectives:</strong> 1, 2, 3</td>
<td></td>
</tr>
</tbody>
</table>

| Practical 0 | Hours: 3h  
Theory classes: 0h  
Practical classes: 0h  
Laboratory classes: 2h  
Guided activities: 0h  
Self study: 1h |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> Prepare the practical beforehand and complete a report for delivery at the start of the laboratory session (1.5 hours). Participate actively in laboratory sessions. Complete the pre-set test and the practical and complete and submit a final report (1 hour). <strong>Specific objectives:</strong> 26</td>
<td></td>
</tr>
</tbody>
</table>

| Practical 1 | Hours: 5h  
Theory classes: 0h  
Practical classes: 0h  
Laboratory classes: 2h  
Guided activities: 0h  
Self study: 3h |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> Prepare the practical beforehand and complete a report for delivery at the start of the laboratory session (3 hours). Participate actively in laboratory sessions. Complete the pre-set test and the practical and complete and submit a final report (2 hours). <strong>Specific objectives:</strong> 26</td>
<td></td>
</tr>
</tbody>
</table>
## L1

<table>
<thead>
<tr>
<th>Description:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>In laboratory session 1, practical 1 will be assessed on the basis of the previous session's report, the individual pre-set test (completed at the beginning of the session) and the final report. Learning objective 26 for the first part of topic 3 will be assessed. This will be done shortly after the four 2-hour theory/problem-solving classes, so that students have acquired the knowledge necessary to perform the practical.</td>
<td></td>
</tr>
</tbody>
</table>

**Specific objectives:**

26

<table>
<thead>
<tr>
<th>Hours:</th>
<th>0h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guided activities:</td>
<td>0h</td>
</tr>
<tr>
<td>Self study:</td>
<td>0h</td>
</tr>
</tbody>
</table>

## Topic 3 theory/ problem-solving classes

<table>
<thead>
<tr>
<th>Hours:</th>
<th>15h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes:</td>
<td>3h</td>
</tr>
<tr>
<td>Practical classes:</td>
<td>3h</td>
</tr>
<tr>
<td>Laboratory classes:</td>
<td>0h</td>
</tr>
<tr>
<td>Guided activities:</td>
<td>0h</td>
</tr>
<tr>
<td>Self study:</td>
<td>9h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Participate actively in three 2-hour explanatory-participatory theory/problem-solving classes (6 hours). Home study of the assigned topic (4.5 hours). Complete the topic exercises for electronic delivery (Atenea questionnaires) and hard-copy delivery (at the beginning of each theory/problem-solving class) (4.5 hours).</td>
<td></td>
</tr>
</tbody>
</table>

**Specific objectives:**

4, 5, 6

## E1

<table>
<thead>
<tr>
<th>Hours:</th>
<th>1h 30m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guided activities:</td>
<td>1h 30m</td>
</tr>
<tr>
<td>Self study:</td>
<td>0h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory/problem-solving exam 1 for continuous assessment, assessing all the learning objectives for topics 2 and 3.</td>
<td></td>
</tr>
</tbody>
</table>

**Specific objectives:**

1, 2, 3, 4, 5, 6

## Topic 4 theory/ problem-solving classes

<table>
<thead>
<tr>
<th>Hours:</th>
<th>10h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes:</td>
<td>2h</td>
</tr>
<tr>
<td>Practical classes:</td>
<td>2h</td>
</tr>
<tr>
<td>Laboratory classes:</td>
<td>0h</td>
</tr>
<tr>
<td>Guided activities:</td>
<td>0h</td>
</tr>
<tr>
<td>Self study:</td>
<td>6h</td>
</tr>
</tbody>
</table>
### Description:
Participate actively in two 2-hour explanatory-participatory theory/problem-solving sessions (4 hours). Home study of the assigned topic (3 hours). Complete the topic exercises for electronic delivery (Atenea questionnaires) and hard-copy delivery (at the beginning of each theory/problem-solving class) (3 hours).

### Specific objectives:
7, 8

#### Topic 5 theory/ problem-solving classes

<table>
<thead>
<tr>
<th>Hours</th>
<th>Theory classes: 1h</th>
<th>Practical classes: 1h</th>
<th>Laboratory classes: 0h</th>
<th>Guided activities: 0h</th>
<th>Self study: 3h</th>
</tr>
</thead>
</table>

#### Description:
Participate actively in a two-hour explanatory-participatory theory/problem-solving class (2 hours). Home study of the assigned topic (1.5 hours). Complete the topic exercises for electronic delivery (Atenea questionnaires) and hard-copy delivery (at the beginning of each theory/problem-solving class) (1.5 hours).

### Specific objectives:
7, 8

#### Topic 6 theory/ problem-solving classes

<table>
<thead>
<tr>
<th>Hours</th>
<th>Theory classes: 3h</th>
<th>Practical classes: 3h</th>
<th>Laboratory classes: 0h</th>
<th>Guided activities: 0h</th>
<th>Self study: 9h</th>
</tr>
</thead>
</table>

#### Description:
Participate actively in three 2-hour explanatory-participatory theory/problem-solving classes (6 hours). Home study of the assigned topic (4.5 hours). Complete the topic exercises for electronic delivery (Atenea questionnaires) and hard-copy delivery (at the beginning of each theory/problem-solving class) (4.5 hours).

### Specific objectives:
9, 10, 11

#### Practical 2

<table>
<thead>
<tr>
<th>Hours</th>
<th>Theory classes: 0h</th>
<th>Practical classes: 0h</th>
<th>Laboratory classes: 2h</th>
<th>Guided activities: 0h</th>
<th>Self study: 3h</th>
</tr>
</thead>
</table>

---

7, 8

9, 10, 11

7, 8
**Description:**
Prepare the practical beforehand and complete a report for delivery at the start of the laboratory session (3 hours). Participate actively in laboratory sessions. Complete the pre-set test and the practical and complete and submit a final report (2 hours).

**Specific objectives:** 26

<table>
<thead>
<tr>
<th>L2</th>
<th>Hours: 0h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Guided activities: 0h</td>
</tr>
<tr>
<td></td>
<td>Self study: 0h</td>
</tr>
</tbody>
</table>

**Description:**
In the laboratory session 2, practical 2 of the subject will be assessed on the basis of the previous session's report, the individual pre-set test (completed at the beginning of the session) and a final report. Learning objective 26 for topics 3, 4 and 6 will be assessed. This will be done shortly after the nine 2-hour theory/problem-solving classes, so that students have acquired the knowledge necessary to perform the practical.

**Specific objectives:** 26

<table>
<thead>
<tr>
<th><strong>Topic 7 theory/ problem-solving classes</strong></th>
<th>Hours: 10h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 2h</td>
</tr>
<tr>
<td></td>
<td>Practical classes: 2h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Guided activities: 0h</td>
</tr>
<tr>
<td></td>
<td>Self study: 6h</td>
</tr>
</tbody>
</table>

**Description:**
Participate actively in two 2-hour explanatory-participatory theory/problem-solving sessions (4 hours). Home study of the assigned topic (3 hours). Complete the topic exercises for electronic delivery (Atenea questionnaires) and hard-copy delivery (at the beginning of each theory/problem-solving class) (3 hours).

**Specific objectives:** 12, 13

<table>
<thead>
<tr>
<th><strong>Practical 3</strong></th>
<th>Hours: 5h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Practical classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 2h</td>
</tr>
<tr>
<td></td>
<td>Guided activities: 0h</td>
</tr>
<tr>
<td></td>
<td>Self study: 3h</td>
</tr>
</tbody>
</table>

**Description:**
Prepare the practical beforehand and complete a report for delivery at the start of the laboratory session (3 hours). Participate actively in laboratory sessions. Complete the pre-set test and the practical and complete and submit a final report (2 hours).
### Specific objectives:

- 26

### L3

**Hours:** 0h  
- Guided activities: 0h  
- Self study: 0h  

**Description:**  
In laboratory session 3, practical 3 of the subject will be assessed on the basis of the previous session's report, the individual pre-set test (completed at the beginning of the session) and a final report. Learning objective 26 for the first part of topic 7 will be assessed. This will be done shortly after the twelve 2-hour theory/problem-solving classes, so that students have acquired the knowledge necessary to perform the practical.

**Specific objectives:**

- 26

### Recuperation of theory (if necessary) and completion of problems from topics 4, 5, 6 and 7

**Hours:** 4h  
- Theory classes: 1h  
- Practical classes: 1h  
- Laboratory classes: 0h  
- Guided activities: 0h  
- Self study: 2h

**Description:**  
Participate actively in a two-hour problem-solving class (or theory recuperation if necessary) (2 hours).

**Specific objectives:**

- 7, 8, 9, 10, 11, 12, 13

### E2

**Hours:** 2h  
- Guided activities: 2h  
- Self study: 0h

**Description:**  
Theory/problem-solving exam 2 for continuous assessment, assessing all the learning objectives for topics 4 to 7.

**Specific objectives:**

- 2, 7, 8, 9, 10, 11, 12, 13

### Practical 4

**Hours:** 5h  
- Theory classes: 0h  
- Practical classes: 0h  
- Laboratory classes: 2h  
- Guided activities: 0h  
- Self study: 3h
**Description:**
Prepare the practical beforehand and complete a report for delivery at the start of the laboratory session (3 hours). Participate actively in laboratory sessions. Complete the pre-set test and the practical and complete and submit a final report (2 hours).

**Specific objectives:**
26

---

**L4**

**Hours:** 0h
Guided activities: 0h
Self study: 0h

**Description:**
In laboratory session 4, practical 4 of the subject will be assessed on the basis of the previous session's report, the individual pre-set test (completed at the beginning of the session) and a final report. Learning objective 26 for the second part of topic 7 will be assessed (handshaking). This will be done shortly after the thirteen 2-hour theory/problem-solving classes, so that students have acquired the knowledge necessary to perform the practical.

**Specific objectives:**
26

---

**Topic 8 theory/problem-solving classes**

**Hours:** 15h
Theory classes: 3h
Practical classes: 3h
Laboratory classes: 0h
Guided activities: 0h
Self study: 9h

**Description:**
Participate actively in three 2-hour explanatory-participatory theory/problem-solving classes (6 hours). Home study of the assigned topic (4.5 hours). Complete the topic exercises for electronic delivery (Atenea questionnaires) and hard-copy delivery (at the beginning of each theory/problem-solving class) (4.5 hours).

**Specific objectives:**
14, 15

---

**Practice 5**

**Hours:** 5h
Theory classes: 0h
Practical classes: 0h
Laboratory classes: 2h
Guided activities: 0h
Self study: 3h
### Description:
Prepare the practical beforehand and complete a report for delivery at the start of the laboratory session (3 hours). Participate actively in laboratory sessions. Complete the pre-set test and the practical and complete and submit a final report (2 hours).
Actively participate in the lab session. Make previous examination, perform practice and complete and submit the final report (2 hours).

### Specific objectives:
- **26**

### L5

<table>
<thead>
<tr>
<th>Hours: 0h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guided activities: 0h</td>
</tr>
<tr>
<td>Self study: 0h</td>
</tr>
</tbody>
</table>

### Description:
In laboratory session 5, practical 5 of the subject will be assessed on the basis of the previous session's report, the individual pre-set test (completed at the beginning of the session) and a final report. Learning objective 26 will be assessed for topics 3, 4 and 6. This will be done shortly after the fifteen 2-hour theory/problem-solving classes, so that students have acquired the knowledge necessary to perform the practical.

### Specific objectives:
- **26**

### Topic 9 theory/ problem-solving classes

<table>
<thead>
<tr>
<th>Hours: 10h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 2h</td>
</tr>
<tr>
<td>Practical classes: 2h</td>
</tr>
<tr>
<td>Laboratory classes: 0h</td>
</tr>
<tr>
<td>Guided activities: 0h</td>
</tr>
<tr>
<td>Self study: 6h</td>
</tr>
</tbody>
</table>

### Description:
Participate actively in two 2-hour explanatory-participatory theory/problem-solving sessions (4 hours). Home study of the assigned topic (3 hours). Complete the topic exercises for electronic delivery (Atenea questionnaires) and hard-copy delivery (at the beginning of each theory/problem-solving class) (3 hours).

### Specific objectives:
- **16, 20, 21**

### Topic 10 theory/ problem-solving classes

<table>
<thead>
<tr>
<th>Hours: 10h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 2h</td>
</tr>
<tr>
<td>Practical classes: 2h</td>
</tr>
<tr>
<td>Laboratory classes: 0h</td>
</tr>
<tr>
<td>Guided activities: 0h</td>
</tr>
<tr>
<td>Self study: 6h</td>
</tr>
</tbody>
</table>
**Description:**
Participate actively in two 2-hour explanatory-participatory theory/problem-solving sessions (4 hours). Home study of the assigned topic (3 hours). Complete the topic exercises for electronic delivery (Atenea questionnaires) and hard-copy delivery (at the beginning of each theory/problem-solving class) (3 hours).

**Specific objectives:**
17, 18, 19, 20, 21

---

**Recuperation of theory (if necessary) and completion of problems for topics 8, 9 and 10**

**Hours:** 4h
- Theory classes: 1h
- Practical classes: 1h
- Laboratory classes: 0h
- Guided activities: 0h
- Self study: 2h

**Description:**
Participate actively in a 2-hour problem-solving class (or theory recuperation if necessary (4 hours).

**Specific objectives:**
14, 15, 16, 17, 18, 19, 20, 21, 22

---

**E3**

**Hours:** 2h
- Guided activities: 2h
- Self study: 0h

**Description:**
Theory/problem-solving exam 3 for continuous assessment, assessing all the learning objectives for topics 8 to 10.

**Specific objectives:**
14, 15, 16, 17, 18, 19, 20, 21, 22

---

**Topic 11 theory/problem-solving classes**

**Hours:** 5h
- Theory classes: 1h
- Practical classes: 1h
- Laboratory classes: 0h
- Guided activities: 0h
- Self study: 3h

**Description:**
Participate actively in a 2-hour explanatory-participatory theory/problem-solving class (2 hours). Home study of the assigned topic (1.5 hours). Complete the topic exercises for electronic delivery (Atenea questionnaires) and hard-copy delivery (at the beginning of each theory/problem-solving class) (1.5 hours).

**Specific objectives:**
20, 21, 22
### Topic 12 theory/problem-solving classes

**Description:**
Participate actively in two 2-hour explanatory-participatory theory/problem-solving sessions (4 hours). Home study of the assigned topic (3 hours). Complete the topic exercises for electronic delivery (Atenea questionnaires) and hard-copy delivery (at the beginning of each theory/problem-solving class) (3 hours).

**Specific objectives:**
23, 24, 25

<table>
<thead>
<tr>
<th>Hours</th>
<th>Theory classes: 2h</th>
<th>Practical classes: 2h</th>
<th>Laboratory classes: 0h</th>
<th>Guided activities: 0h</th>
<th>Self study: 6h</th>
</tr>
</thead>
</table>

### Practical 6

**Description:**
Prepare the practical beforehand and complete a report for delivery at the start of the laboratory session (3 hours). Participate actively in laboratory sessions. Complete the pre-set test and the practical and complete and submit a final report (3 hours).

**Specific objectives:**
26

<table>
<thead>
<tr>
<th>Hours</th>
<th>Theory classes: 0h</th>
<th>Practical classes: 0h</th>
<th>Laboratory classes: 3h</th>
<th>Guided activities: 0h</th>
<th>Self study: 3h</th>
</tr>
</thead>
</table>

### L6

**Description:**
In laboratory session 6, practical 6 of the subject will be assessed on the basis of the previous session's report, the individual pre-set test (completed at the beginning of the session) and a final report. Learning objective 26 will be assessed for topics 11 and 12. This will be done shortly after the twenty 2-hour theory/problem-solving classes, so that students have acquired the knowledge necessary to perform the practical.

**Specific objectives:**
26
## Topic 13 theory/ problem-solving classes

**Hours:** 10h  
Theory classes: 2h  
Practical classes: 2h  
Laboratory classes: 0h  
Guided activities: 0h  
Self study: 6h

**Description:**  
Participate actively in two 2-hour explanatory-participatory theory/problem-solving sessions (4 hours). Home study of the assigned topic (3 hours). Complete the topic exercises for electronic delivery (Atenea questionnaires) and hard-copy delivery (at the beginning of each theory/problem-solving class) (3 hours).

**Specific objectives:**  
23, 24, 25

---

## Recuperation of theory (if necessary) and completion of problems from topics 11, 12 and 13

**Hours:** 10h  
Theory classes: 2h  
Practical classes: 4h  
Laboratory classes: 0h  
Guided activities: 0h  
Self study: 4h

**Description:**  
Participate actively in three 2-hour participatory problem-solving classes (or theory recuperation if necessary (6 hours).

**Specific objectives:**  
20, 21, 22, 23, 24, 25

---

## E4

**Hours:** 2h  
Guided activities: 2h  
Self study: 0h

**Description:**  
Theory/problem-solving exam 4 for continuous assessment, assessing all the learning objectives for topics 11 to 13.

**Specific objectives:**  
21, 22, 23, 24, 25

---

## Task to evaluate the transferable competency referring to sound use of information resources

**Hours:** 8h  
Theory classes: 2h  
Practical classes: 0h  
Laboratory classes: 0h  
Guided activities: 0h  
Self study: 6h
### Description:
Attendance at the two-hour face-to-face session (2 hours). Task completion (6 hours).

### Specific objectives:
28

<table>
<thead>
<tr>
<th>Final Exam</th>
<th>Hours: 0h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Guided activities: 0h</td>
</tr>
<tr>
<td></td>
<td>Self study: 0h</td>
</tr>
</tbody>
</table>

### Description:
Final exam in which all learning objectives for all the topics will be assessed. It is not necessary for students to sit this exam as they can obtain the maximum final mark via continuous assessment of the theory/problem-solving sessions (80% of NTP) and laboratory sessions (20% of NL). For students who have not passed via continuous assessment, the final exam mark may be replaced by the theory/problem-solving mark obtained via continuous assessment. Students who have passed but who want to improve their mark may request to do the exam by informing the course coordinator at least a week in advance.

### Specific objectives:
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25
Mark:

The subject final mark (NF) is obtained by weighting the theory/problem-solving mark (NTP) and the laboratory practicals mark (NL):

\[ NF = 0.8 \times NTP + 0.2 \times NL \]

The course is planned in such a way that it can be passed via continuous assessment. However, students who cannot participate in or who fail the continuous assessment can obtain an NTP mark by sitting the final exam.

Theory/problem-solving mark (NTP) for continuous assessment:

The NTP is obtained by weighting four marks (N1, N2, N3, N4). Nk (for k=1, 2, 3, 4) is the mark for the exam Ek (taken in class but outside class time), provided that students have delivered 80% of the assignments corresponding to assessed topics/objectives. Nk will be 0 unless a score of 80% is obtained. Assignments include exercises and problems (which should be completed on time) set at the end of each theory/problem-solving session (for completion at home) and those completed in class (when the topics and learning objectives assessed in the Ek exam will be worked on).

The weights for each Nk mark are proportional to the relative importance of learning objectives for the course and the hours spent on completing planned activities in order to meet these objectives.

\[ NTP = 0.05 \times N1 + 0.30 \times N2 + 0.25 \times N3 + 0.40 \times N4 \]

Laboratory mark (NL):

The NL mark is based on the average for the six practicals assessed in the laboratory sessions (practical 0 is not assessed). The mark for each laboratory practical Li (NLi for i = 1 ... 6) is calculated using the following formula:

\[ NLi = 0.65 \times PPi + 0.35 \times IFi \] (otherwise \( NLi = 0 \)).

Where:

PPi is the mark for the individual pre-test (about 15 minutes long) issued at the beginning of the session and consisting of questions similar to those in the previous report.

IFi is the mark for the final report completed during the laboratory session.

Final mark:

Once classes conclude and within a few days of the E4 exam, students will know if they have passed the course on the basis of assessment of the theory/problem-solving and laboratory components (NF> = 5). Students who pass via continuous assessment do not need to sit the final exam.

Students who do not pass the course via continuous assessment may obtain the NTP mark via the final exam. The final mark is calculated with the same weighting (80% and 20% for NL and NTP, respectively) as used for students who pass via continuous assessment. The mark for continuous assessment or for the final exam, whichever is the highest, is the NTP mark.

Students who pass the subject via continuous assessment and who still want to sit the final exam must notify the course coordinator by e-mail at least a week in advance of the final exam (this facilitates exam planning according to student numbers). The higher of either the continuous assessment or final exam mark will be taken as the NTP mark.
The course will be graded with NP (not presented) if the student has not participated in any of the following evaluation acts:
exams E3 and E4, laboratory assignments L3, L4, L5 and L6 and the final exam.

REEVALUATION.
This course has reevaluation. You may check the school's information on reevaluation at
https://www.fib.upc.edu/en/reavaluacions-gei. Students signing in for reevaluation have to fulfill the general
requirements plus (1) a final score of 2.5 or higher in both the continuous evaluation and in the final exam; and (2) not
participating or not having the minimum score will result in the inadmissibility to the reevaluation.

Bibliography

Basic:
Navarro, J.J.; Juan, T. Introducción a los computadores.
Navarro, J.J. Introducción a los computadores: prácticas.
Navarro, J.J; Muntés Mulero, V.; Llorenç Cruz, J.; Palomar, Ò.; Sánchez Castaño, F.; Solé, M. Introducció als computadors:

Complementary:

Others resources:
Hyperlink
http://atenea.upc.edu