Computer Architecture

1. **Course number and name:** 020AROES3/020CARES3 Computer Architecture

2. **Credits and contact hours:** 4 ECTS credits, 2x1:15 contact hours

3. **Name of course coordinator:** Tina Yaacoub

4. **Instructional materials:** PowerPoint slides; course handouts

   References:
   - book (David A. Patterson and John L. Hennessy, *Computer Organization and Design: the hardware/Software Interface,* 6th edition, Maurgan Kaufmann, 2020.)

5. **Specific course information**
   a. **Catalog description:**
      This course explores the fundamental principles of computer architecture and organization, focusing on how computers are structured, how they process information, and how performance is optimized. Topics include the evolution of computer systems, performance metrics, and the Von Neumann model. The course examines key components such as interconnection structures, memory hierarchies, and input/output systems. Students will study instruction set architectures (ISA), processor structure and functions, and advanced concepts such as pipelining, RISC and CISC architectures, instruction-level parallelism (ILP), and superscalar processing. The course also introduces parallel architectures and organizational strategies used to enhance computational performance in modern systems.

   b. **Prerequisites:** 020TEDNI4/020DSDNI4 Digital Systems Design or 020TEDCI4 Digital Systems Design

   c. **Required** for students in the CCE Artificial Intelligence and Software Engineering Options; **Selected Elective** for students in the CCE Telecommunication Networks Option.

6. **Educational objectives for the course**
   a. **Specific outcomes of instruction:**
      - Explain and describe the principles of computer architecture and organization.
      - Understand, describe and evaluate the evolution of and advances in computer systems.
      - Understand the various components of computer systems and their interaction
      - Demonstrate understanding of interrupt mechanisms, bus interconnections, and various bus interfaces.
      - Describe different I/O mechanisms and peripherals.
      - Understand and implement the memory hierarchy of a computer system (including registers, cache, internal memory, external storage).

- Understand and compare various instruction set architectures of microprocessors, as well as instruction formats and addressing modes.
- Understand and apply pipelining concepts and control implementations in scalar and superscalar microprocessors.
- Describe and compare the parallel architectures and their implementations available on the market and understand the organization of these architectures.

b. PI addressed by the course:

PI	1.1	1.2	1.3	2.1	2.2	2.3	7.1
Covered	x	x	x	x	x	x	x
Assessed	x	x	x	x	x	x	

7. Brief list of topics to be covered

- Introduction, seven great ideas in Computer Architecture, Computer Structure and Function, Computer History (1 lecture)
- Computer Evolution, Performance, and power wall (1 lecture)
- Technologies for building processors and memory (1 lecture)
- Exercises and problems (1 lecture)
- Operations of the computer hardware, operands of the computer hardware, signed and unsigned numbers, representing instructions in the computer, logical operations, instructions for making decisions, MIPS Addressing for 32-bit immediates and addresses (2 lectures)
- Exercises and problems (2 lectures)
- Logic design conventions, building a datapah, a simple implementation scheme (2 lectures)
- Exercises and problems (2 lecture)
- An overview of pipelining, pipelined datapah and control, data hazards: forwarding vs stalling, control hazards (3 lectures)
- Exercises and problems (2 lectures)
- Memory technologies, the basics of caches (3 lectures)
- Measuring and improving cache performance (3 lectures)
- Exercises and problems (2 lectures)
- Introduction to parallel processors, parallelism via intructions, IPC and CPI, static and dynamic multiple issue, superscalar and VLIW, speculation, Loop unrolling, register renaming, out-of-order and in-order commit (2 lectures)
- Exercises and problems (1 lecture)