ESE-2005 Embedded Systems Architecture I

Computer Studies

Course Number:	Co-Requisites:	Pre-Requisites:
ESE-2005	N/A	ESE-1005 and ESE-1014
Prepared by:	Jay Nadeau, Outline Creator	
Approved by:	Chris Slade, Dean School of Business and International Ed.	
Approval Date:	Thursday, August 22, 2019	
Approved for Academic Year:	2019-2020	
Normative Hours:	75.00	

Course Description

Students are introduced to the Von Neumann and Harvard processor architectures. Students will recognize the differences between Microprocessors, Microcontrollers and System-on-Chip/System-on-Module, and the differences between Intel and ARM processors. Students are introduced to the building blocks of microcomputers and microprocessors such as memory, I/O, registers, the ALU and the control unit. The design of computer instruction sets and CPUs are reviewed with students designing systems that use peripherals such as real-time clocks, analog-to-digital converters, digital-to-analog converters and interfacing with GPIO pins. Students will write applications that use the ARM and Thumb instruction sets.

Course Learning Outcomes/Course Objectives

1. **Describe differences between Von Neumann and Harvard computer architectures.**
   - 1.1 Describe the Von Neumann architecture.
   - 1.2 Describe the Harvard architecture.
   - 1.3 List benefits and drawbacks of both the Von Neumann and Harvard architectures.

2. **List differences between microprocessors, microcontrollers and SoCs/SoMs.**
   - 2.1 Explain differences between a microprocessor and a microcontroller.
   - 2.2 Describe the features of a SoC/SoM.

3. **Describe the different types of computer memory.**
   - 3.1 Describe the differences between RAM and ROM.
   - 3.2 Describe the differences between SRAM and DRAM.
   - 3.3 Describe the differences between EPROM, EEPROM, Flash, Masked ROM and PROM.

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4. Explain the functions of the I/O bus, the ALU, the control unit and the register file within the CPU.
    4.1 Describe programmed I/O, interrupt I/O and direct memory access.
    4.2 List the different CPU registers.
    4.3 Describe the functions of the ALU.
    4.4 Explain the main purpose of the control unit.

5. Discuss differences between microcode, machine language, assembly language and high-level languages.
    5.1 Describe the purpose of an instruction set.
    5.2 Explain the differences between microcode and assembly language.
    5.3 Explain the difference between machine language and assembly language.
    5.4 Explain the relationship between a high-level programming language and assembly language.

6. Explain what a RISC computer is.
    6.1 Explain what a reduced instruction set computer is and the philosophy behind a RISC.
    6.2 List advantages and disadvantages of a RISC.

7. List differences between Intel and ARM processors.
    7.1 Describe the Intel x86 CPU architecture.
    7.2 Describe the ARM CPU architecture.

8. Describe and design systems that use peripherals, GPIOs, buses, interrupts, DACs/ADCs and PWM signals.
    8.1 List some examples of common computer peripherals.
    8.2 Explain what a GPIO is.
    8.3 Explain how GPIOs are used.
    8.4 List the different types of system buses.
    8.5 Explain what an interrupt is.
    8.6 Explain the difference between a hardware interrupt and a software interrupt.
    8.7 Write an interrupt service routine.
    8.8 Describe the function of DACs.
    8.9 Describe the function of ADCs.
    8.10 Explain what the sampling rate of an ADC is.
    8.11 Explain the term quantization with respect to ADC.
    8.12 Explain what pulse width modulation is.
    8.13 Explain the term duty-cycle with respect to PWM.

9. Write an assembly language program using ARM and Thumb instruction sets.
    9.1 Write an assembly language program that uses ARM instructions.

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9.2 Write an assembly language program that uses Thumb instructions.

9.3 Explain the difference between the ARM instruction set and the Thumb instruction set.

10. Design a simple 8-bit Harvard architecture CPU using VHDL.

10.1 Design and implement an ALU using VHDL.

10.2 Design and implement a register file using VHDL.

10.3 Design and implement a control unit using VHDL.

10.4 Design a simple 8-bit Harvard architecture CPU using the previously designed ALU, register and control unit.

11. Design an instruction set for use on an 8-bit Harvard architecture CPU.

11.1 Design an instruction set that makes use of the simple 8-bit Harvard microprogrammed CPU.

Learning Resources

a. Required

Digital Design and Computer Architecture: ARM Edition by Sarah Harris and David Harris; Morgan Kaufmann, (May 2016).

b. Supplemental

None

Student Evaluation

Tests 25%

Tests (1@10%, 1@15%)

Validates Outcomes: CLO 1, CLO 2, CLO 3, CLO 4, CLO 5, CLO 6, CLO 7, CLO 8, CLO 9, CLO 10, CLO 11, VLO 1, VLO 2, VLO 3

Assignments 15%

Assignments (3 equally weighted @ 5% each)

Validates Outcomes: CLO 1, CLO 2, CLO 3, CLO 4, CLO 5, CLO 6, CLO 7, CLO 8, CLO 9, CLO 10, CLO 11, VLO 1, VLO 2, VLO 3

Laboratory Sessions 60%

Laboratory Sessions (10 equally weighted @ 6% each)

Validates Outcomes: CLO 1, CLO 2, CLO 3, CLO 4, CLO 5, CLO 6, CLO 7, CLO 8, CLO 9, CLO 10, CLO 11, VLO 1, VLO 2, VLO 3

Grade Scheme

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The round off mathematical principle will be used. Percentages are converted to letter grades and grade points as follows:

Mark (%)	Grade	Grade Point	Mark (%)	Grade	Grade Point
94-100	A+	4.0	67-69	C+	2.3
87-93	A	3.7	63-66	C	2.0
80-86	A-	3.5	60-62	C-	1.7
77-79	B+	3.2	50-59	D	1.0
73-76	B	3.0	0-49	F	0.0
70-72	B-	2.7			

Prior Learning Assessment and Recognition

Students who wish to apply for prior learning assessment and recognition (PLAR) need to demonstrate competency at a post-secondary level in all of the course learning requirements outlined above. Evidence of learning achievement for PLAR candidates includes:

- Not Applicable: Post Graduate course and not eligible for PLAR.

Course Related Information

The course is designed to provide an emphasis on hands on experience via laboratory sessions and assignments. The labs will make use of a modern embedded IDE to implement laboratory programs on an ARM based processor.

College Related Information

Academic Integrity

Lambton College is committed to high ethical standards in all academic activities within the College, including research, reporting and learning assessment (e.g. tests, lab reports, essays).
The cornerstone of academic integrity and professional reputation is principled conduct. All scholastic and academic activity must be free of all forms of academic dishonesty, including copying, plagiarism and cheating.

Lambton College will not tolerate any academic dishonesty, a position reflected in Lambton College policies. Students should be familiar with the Students Rights and Responsibilities Policy, located at lambtoncollege.ca. The policy states details concerning academic dishonesty and the penalties for dishonesty and unethical conduct.

Questions regarding this policy, or requests for additional clarification, should be directed to the Lambton College Centre for Academic Integrity.

Students with Disabilities

If you are a student with a disability please identify your needs to the professor and/or the Accessibility Centre so that support services can be arranged for you. You can do this by making an appointment at the Accessibility Centre or by arranging a personal interview with the professor to discuss your needs.

Student Rights and Responsibility Policy

Acceptable behaviour in class is established by the instructor and is expected of all students. Any form of misbehaviour, harassment or violence will not be tolerated. Action will be taken as outlined in Lambton College policy.

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Date of Withdrawal without Academic Penalty

Please consult the Academic Regulations and Registrar's published dates.

Waiver of Responsibility

Every attempt has been made to ensure the accuracy of this information as of the date of publication. The content may be modified, without notice, as deemed appropriate by the College.

Students should note policies may differ depending on the location of course offering. Please refer to campus location specific policies:

- **Student Rights & Responsibilities & Discipline policy** (2000-5-1) - https://www.lambtoncollege.ca/custom/Pages/Policies/Policy.aspx?id=2147491640 Mississauga Campus Policies - https://www.lambtoncollege.ca/Programs/International/Lambton_in_Mississauga/Student_Policies/ Toronto Campus Policies
- https://www.lambtoncollege.ca/Programs/International/Lambton_in_Toronto/Student_Policies/

Note: It is the student’s responsibility to retain course outlines for possible future use to support applications for transfer of credit to other educational institutions.

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