COURSE SYLLABUS

COURSE TITLE:	**ELEN 166: Microcontrollers and PLCs**
TERM:	**2023F**
PREREQUISITE(S):	**Reserved for DND ESPEC program**
COURSE CREDITS:	**3 (4h lectures, 3h Lab)**
DELIVERY METHOD(S):	**Hybrid (Lectures online, Labs in-person)**

Microcontrollers are widely used in electronic devices from a home thermostat to a self-driving car. Programmable Logic Controllers (PLCs) are a staple device in many industrial settings used to control and operate a variety of systems. You will learn the basics of microcontrollers hardware, software and their interfacing. You will then move on to the basics of PLCs, their structure and PLC code.

Camosun College requires mandatory attendance for the first class meeting of each course. If you do not attend, and do not provide your instructor with a reasonable explanation in advance, you will be removed from the course and the space offered to the next waitlisted student.

INSTRUCTOR DETAILS

NAME:	**Ibrahim Hazmi**
EMAIL:	hazmii@camosun.ca
OFFICE:	**TEC 216**

As your course instructor, I endeavour to provide an inclusive learning environment. However, if you experience barriers to learning in this course, do not hesitate to discuss them with me. Camosun College is committed to identifying & removing institutional and social barriers that prevent access and impede success.

CALENDAR DESCRIPTION

This course consists of two sections:

1. Microcontrollers, which are widely used electronic devices from a home thermostat to a self-driving car.

   This section covers the basics of microcontrollers, emphasizing on Arduino (ATmega328P) microcontroller, including hardware architecture and interfacing, programming basics, and troubleshooting

2. PLCs (Programmable Logic Controllers), which are staple devices in many industrial settings and are used to operate motors, pumps, lights, and other hardware.

   This section covers the basics of PLCs, learning about their structure and how to apply and troubleshoot PLC code using ladder logic, data handling, addressing, timer & counter functions, and program flow control for a variety of peripherals.

COURSE LEARNING OUTCOMES / OBJECTIVES

Upon successful completion of this course a student will be able to:

Section I: Microcontrollers
1. Describe the architecture and hardware of a microcontroller;
2. Use an integrated development environment (IDE) to program microcontrollers;
3. Identify C programming language;
4. Program microcontrollers in C language;
5. Interface microcontrollers with peripherals;
    a. LEDs, RGB LED, 8x8 Dot Matrix, Switches and Potentiometers
    b. Seven segment display (One digit and Four digits)
    c. Liquid Crystal Display (LCD) and KeyPad
    d. SR04 Ultrasonic, photo-resistor, temperature and Infrared sensors
    e. Servo motors, Stepper Motors and Buzzers (Piezo)
6. Test, troubleshoot and emulate programs for microcontrollers systems.

Section II: PLCs (Programmable Logic Controllers)
8. Describe the architecture and hardware of PLC;
9. Create flow chart and ladder logic (rung and rail);
10. Use PLC software platforms;
11. Program a common PLC with ladder logic;
12. Interface PLC with peripherals;
13. Troubleshoot PLC systems;

REQUIRED MATERIALS & RECOMMENDED PREPARATION / INFORMATION

1) Course notes and handouts (shared on D2L)

2) Data sheets/manuals (shared on D2L)

3) Internet/Websites:

   - https://online.camosun.ca/d2l/le/content/264469/viewContent/3929200/View

   - https://www.arduino.cc/

   - https://www.tinkercad.com/

   - https://www.microchip.com/

   - https://www.tutorialspoint.com/arduino/index.htm

   - https://www.plcgurus.net/plc-basics/

   - https://dipslab.com/plc/

   - https://instrumentationtools.com/rslogix-500-plc-programming/

COURSE SCHEDULE, TOPICS, AND ASSOCIATED PREPARATION / ACTIVITY / EVALUATION

The following schedule and course components are subject to change with reasonable advance notice, as deemed appropriate by the instructor.

Section I   Microcontrollers

WEEK	ACTIVITY or TOPIC	NOTES
1	1. **Introduction to Microcontrollers and Arduino** **(4 hours)** 1.1. History of Computers 1.2. Types and Elements of Computers systems 1.3. Microprocessor/Microcontrollers Architectures 1.4. Binary, Decimal, Hexadecimal and Binary Coded Decimal (BCD) 1.5. Introduction to **ATmega328P** Microcontroller 1.5.1. AVR Microcontrollers Applications 1.5.2. **ATmega328P** Hardware Overview (Block Diagram) 1.6. Simple Arduino Program (LEDs: Digital Output) 1.6.1. LED Blinking 1.6.2. Morse COde	Arduino Kit Unboxing Video + **Lab1** LED Blinking & Morse Code
2	2. **Arduino Programming Basics in C Language** **(4 hours)** 2.1. Basic components and sections of C-programming structure 2.2. Variables, Data types, Format specifiers, and Escape sequences 2.3. Simple I/O 2.4. Conditional statements 2.4.1. "if", "if-else", "if-else if-else" Statements 2.4.2. "switch" Statement 2.5. Looping structures: "for" Loop, "while" and "do-while" Loops 2.6. Arduino Functions 2.6.1. pinMode(pin, mode) 2.6.2. digitalWrite(pin, value), digitalRead(pin) 2.6.3. analogWrite(pin, value), analogRead(pin) 2.6.4. delay(ms), delayMicroseconds(us) 2.7. Simple Arduino Programs: (D_In: Switches, A_Out: RGB) 2.7.1. Digital Input: Switches and LEDs Manipulation 2.7.2. Analog RGB vs Digital/Analog Red/Green/Blue LEDs	**Lab 2** Digital Input: Switches Analog Output: RGB
3	3. **Arduino Hardware Peripherals Applications** **(4 hours)** 3.1. Serial communications: Serial monitor and Serial Plotter 3.1.1. Serial.begin(), Serial.print(), Serial.println() 3.2. Arrays structures: 1-dimensional and 2-dimensional arrays 3.3. Common Anode vs Common Cathode 7-segment Display 3.4. Interfacing 8x8 Dot matrix and Timing aspect of display 3.5. Simple Arduino Programs: 3.5.1. Counter and Bit Manipulation on LEDs 3.5.2. Hex Counter on 1-digit 7-segment Display	**Lab 3** 7-segment Display + Reading Assignment #1
4	4. **Arduino and Seven Segment Displays** **(4 hours)** 4.1. Serial monitor user interface: **Serial.available**(), **Serial.parseInt**() 4.2. Introduction to using **Libraries.** 4.3. Simple Arduino Programs: 4.3.1. 4-digit 7-segment Displays (Numbers, Letters, Timing) 4.3.2. LCD Connection (16x2 LCD Pinout) and LCD.print 4.3.3. Including **Library** (LiquidCrystal.h)	**Lab 4** 7-Segment Display & Intro to LCD + Midterm Test I

WEEK	ACTIVITY or TOPIC	NOTES

5	**5. Arduino with LCDs and Keypads** (4 hours)
	5.1. ASCII Code (Character sets)
	5.2. Interfacing LCDs and keypads
	  5.2.1. 4x4 keypad Rows and Columns
	  5.2.2. Including **Libraries** (LiquidCrystal.h, Keypad.h)
	  5.2.3. Creating new characters using 8x5-pixels 2-D arrays
		Lab 5
		LCDs and Keypads

6	**6. Arduino and Sensors: Logic and Decision making** (4 hours) 6.1. Photo-resistors and Temperature Sensors - Analog inputs 6.2. Ultrasonic Distance Sensor (SR04) - Speed of sound 6.3. Infrared (Wireless Communication) 6.3.1. Infrared Receiver + Infrared Transmitter (Remote Control)	**Lab 6** Arduino and Sensors
7	**7. Arduino with Servo & Dc Motors** (4 hours) 7.1. Comparison between Servos, Stepper motors and DC motors 7.2. Interfacing Servos and DC motors + Stepper motor (w/ driver)	**Lab 7** Servo and DC motors

8	**8. Arduino w/ Motors & Buzzers + ATmega328P Hardware (4 hours)**
	8.1. Buzzers: Active (Piezo) and Passive Buzzers
	8.2. **ATmega328P** Hardware:
	  8.2.1. Processor Architecture and CISC/RISC
	  8.2.2. Registers, Memory and Buses (Address, Data, Control)
	  8.2.3. Ports and Analog to Digital Conversion
	  8.2.4. Timers and Pulse Width Modulation (PWM)
		lab 8
		Sounds: Buzzers
		+
		Controlled Movement
		(Motors with Sensors)

9	**9. ATmega328P Software, Midterm II Project and Quiz** (4 hours)
	9.1. Microcontroller Software Principles:
	  9.1.1. CPU "Fetch-Decode-Execute" Cycle and Instruction set
	  9.1.2. Mnemonic textual format vs Machine language
	9.2. **ATmega328P** Assembly language instruction set:
	  9.2.1. Registers and Data movement
	  9.2.2. Bit manipulation, Arithmetic and logic operation
		lab 9
		Midterm Test II Project
		+
		Quiz
		+
		Reading Assignment #2

Section II   PLCs (Programmable Logic Controllers)

WEEK	ACTIVITY or TOPIC	NOTES
10	**10. Introduction to PLCs** (4 hours) 10.1. What are PLCs, Input/output devices 10.2. PLC hardware – Allen-Bradley 500 controllers 10.3. PLC software – LogixPro 500 and RSLogix 500	**Lab 10** Introduction to PLCs and LogixPro
11	**11. PLC addressing and basic instructions:** (4 hours) 11.1. Allen-Bradley PLC addressing 11.2. Basic input/output instructions 11.3. Branches	**Lab 11** Garage Door Contro
12	**12. Ladder logic programming** (4 hours) **12.1.** Boolean logic (Logic gates) and truth table review **12.2.** Boolean statements and Ladder logic equivalents **12.3.** Commonly used ladder logic sequences **12.4.** Properly formatted outputs & Nine Rules for Drawing LLD	**Lab 12** Silo Simulation + Traffic Control
13	**13. PLC functions and operations** (4 hours)	
14	**Course Review** (4 hours)	
15	**Final Exam**	

LABS

Theme 1 **Awaken the Bot!**	Blinking LEDs (Digital Output) + Morse Code
	Switches and LEDs Manipulation + RGB vs Red/Green/Blue LEDs
	Interfacing 7-segment Display with Arduino and Displaying numbers
Theme 2 **The Bot Reads**	4-digit 7-segment Display: counters and user input + Into to LCD
	Liquid Crystal Display (LCD)s and Keypads + a simple calculator
Theme 3 **The Bot Sees & Feels**	**Sensors**: Analog inputs: Photo-resistors & Temperature Sensors Digital signal (input/output): Ultrasonic Sensor (SR04) & Infrared
Theme 4 **The Bot Moves & Sings**	Servo, DC and Stepper motors
	Active (Piezo) Buzzer can sing your favourite song!
PLCs	Introduction to PLCs and LogixPro
	Garage Door Contro
	Silo Simulation
	Traffic Control

Students registered with the Centre for Accessible Learning (CAL) who complete quizzes, tests, and exams with academic accommodations have booking procedures and deadlines with CAL where advanced noticed is required. Deadlines scan be reviewed on the CAL exams page.

EVALUATION OF LEARNING

DESCRIPTION		WEIGHTING
Labs		30%
Quizzes and Assignments		10%
Term test 1		15%
Term test 2 (Project + Quiz)		15%
Final Exam		30%
	TOTAL	100%

If you have a concern about a grade you have received for an evaluation, please come and see me as soon as possible. Refer to the Grade Review and Appeals policy for more information.
http://camosun.ca/about/policies/education-academic/e-1-programming-and-instruction/e-1.14.pdf

The following criteria must be met:

- **Students must obtain a minimum weighted average of 60% in theory evaluations (tests, examinations etc.) in any course that is a pre-requisite for subsequent courses.**

- **Students must obtain a minimum weighted average of 60% in lab evaluations (lab performance, reports, etc.) in any course that is a pre-requisite for subsequent courses.**

- **Students must obtain a minimum of 50% on the final examination for a course in order to receive a passing grade.**

- **Failure to meet any one of these criteria will result in a student receiving a failing grade.**

- **All assignments (laboratory work, reports, etc.) must be submitted prior to a student writing a final examination. ALL assignments must be submitted in order to qualify to write a final exam.**

- **Late assignments will have marks deducted; if handed in after assignments are returned to the class, then no mark will be awarded, but the assignment must be submitted.**

COURSE GUIDELINES & EXPECTATIONS

A passing grade must meet following three criteria:

1) Overall lab mark is equal to or greater than 60%;

2) Overall theoretical mark (assignments, tests, final exam) is equal to or greater than 60%;

3) The final exam mark is equal to or greater than 50%.

SCHOOL OR DEPARTMENTAL INFORMATION

- [Electronics and Computer Engineering Department](#)
- [School of Trades & Technology](#)

STUDENT RESPONSIBILITY

Enrolment at Camosun assumes that the student will become a responsible member of the College community. As such, each student will display a positive work ethic, assist in the preservation of College property, and assume responsibility for their education by researching academic requirements and policies; demonstrating courtesy and respect toward others; and respecting expectations concerning attendance, assignments, deadlines, and appointments.

SUPPORTS AND SERVICES FOR STUDENTS

Camosun College offers a number of services to help you succeed in and out of the classroom. For a detailed overview of the supports and services visit http://camosun.ca/students/.

Academic Advising	http://camosun.ca/advising
Accessible Learning	http://camosun.ca/accessible-learning
Counselling	http://camosun.ca/counselling
Career Services	http://camosun.ca/coop
Financial Aid and Awards	http://camosun.ca/financialaid
Help Centres (Math/English/Science)	http://camosun.ca/help-centres
Indigenous Student Support	http://camosun.ca/indigenous
International Student Support	http://camosun.ca/international/
Learning Skills	http://camosun.ca/learningskills
Library	http://camosun.ca/services/library/
Office of Student Support	http://camosun.ca/oss
Ombudsperson	http://camosun.ca/ombuds
Registration	http://camosun.ca/registration
Technology Support	http://camosun.ca/its
Writing Centre	http://camosun.ca/writing-centre

If you have a mental health concern, please contact Counselling to arrange an appointment as soon as possible. Counselling sessions are available at both campuses during business hours. If you need urgent support after-hours, please contact the Vancouver Island Crisis Line at 1-888-494-3888 or call 911.

COLLEGE-WIDE POLICIES, PROCEDURES, REQUIREMENTS, AND STANDARDS

Academic Accommodations for Students with Disabilities

The College is committed to providing appropriate and reasonable academic accommodations to students with disabilities (i.e. physical, depression, learning, etc). If you have a disability, the Centre for Accessible Learning (CAL) can help you document your needs, and where disability-related barriers to access in your courses exist, create an accommodation plan. By making a plan through CAL, you can ensure you have the appropriate academic accommodations you need without disclosing your diagnosis or condition to course instructors. Please visit the CAL website for contacts and to learn how to get started: http://camosun.ca/services/accessible-learning/

Academic Integrity

Please visit http://camosun.ca/about/policies/education-academic/e-1-programming-and-instruction/e-1.13.pdf for policy regarding academic expectations and details for addressing and resolving matters of academic misconduct.

Academic Progress

Please visit http://camosun.ca/about/policies/education-academic/e-1-programming-and-instruction/e-1.1.pdf for further details on how Camosun College monitors students' academic progress and what steps can be taken if a student is at risk of not meeting the College's academic progress standards.

Course Withdrawals Policy

Please visit http://camosun.ca/about/policies/education-academic/e-2-student-services-and-support/e-2.2.pdf for further details about course withdrawals. For deadline for fees, course drop dates, and tuition refund, please visit http://camosun.ca/learn/fees/#deadlines.

Grading Policy

Please visit http://camosun.ca/about/policies/education-academic/e-1-programming-and-instruction/e-1.5.pdf for further details about grading.

Grade Review and Appeals

Please visit http://camosun.ca/about/policies/education-academic/e-1-programming-and-instruction/e-1.14.pdf for policy relating to requests for review and appeal of grades.

Mandatory Attendance for First Class Meeting of Each Course

Camosun College requires mandatory attendance for the first class meeting of each course. If you do not attend, and do not provide your instructor with a reasonable reason in advance, you will be removed from the course and the space offered to the next waitlisted student. For more information, please see the "Attendance" section under "Registration Policies and Procedures" (http://camosun.ca/learn/calendar/current/procedures.html) and the Grading Policy at http://camosun.ca/about/policies/education-academic/e-1-programming-and-instruction/e-1.5.pdf.

Medical / Compassionate Withdrawals

Students who are incapacitated and unable to complete or succeed in their studies by virtue of serious and demonstrated exceptional circumstances may be eligible for a medical/compassionate withdrawal. Please visit http://camosun.ca/about/policies/education-academic/e-2-student-services-and-support/e-2.8.pdf to learn more about the process involved in a medical/compassionate withdrawal.

Sexual Violence and Misconduct

Camosun is committed to creating a campus culture of safety, respect, and consent. Camosun's Office of Student Support is responsible for offering support to students impacted by sexual violence. Regardless of when or where the sexual violence or misconduct occurred, students can access support at Camosun. The Office of Student Support will make sure students have a safe and private place to talk and will help them understand what supports are available and their options for next steps. The Office of Student Support respects a student's right to choose what is right for them. For more information see Camosun's Sexualized Violence and Misconduct Policy: http://camosun.ca/about/policies/education-academic/e-2-student-services-and-support/e-2.9.pdf and camosun.ca/sexual-violence. To contact the Office of Student Support: oss@camosun.ca or by phone: 250-370-3046 or 250-3703841

Student Misconduct (Non-Academic)

Camosun College is committed to building the academic competency of all students, seeks to empower students to become agents of their own learning, and promotes academic belonging for everyone. Camosun also expects that all students to conduct themselves in a manner that contributes to a positive, supportive, and safe learning environment. Please review Camosun College's Student Misconduct Policy at http://camosun.ca/about/policies/education-academic/e-2-student-services-and-support/e-2.5.pdf to understand the College's expectations of academic integrity and student behavioural conduct.

Changes to this syllabus: Every effort has been made to ensure that information in this syllabus is accurate at the time of publication. The College reserves the right to change courses if it becomes necessary so that course content remains relevant. In such cases, the instructor will give the students clear and timely notice of the changes.