CAMOSUN COLLEGE

ELECTRONICS & COMPUTER ENGINEERING DEPARTMENT

COURSE OUTLINE

CALENDAR DESCRIPTION

ELEN 165 Microcontrollers

This course introduces microcontrollers hardware and software to electronics technician students, with emphasizing the ATmega328P/PIC877A microcontroller and its applications. Topics include microcontrollers architecture, programming basics, hardware interfacing, and troubleshooting.

OFFERED:	Summer Semester
CREDIT:	3
IN-CLASS WORKLOAD:	4 lecture, 3 lab
OUT-OF-CLASS WORKLOAD:	5 hrs/wk
PREREQUISITES:	Reserved for DND MARTECH Program
Instructor:	**Solomon Lindsay**
Office:	**TEC 206**
Phone:	**(250) 370-4299**
Email:	**lindsays@camosun.ca**

LEARNING OUTCOMES:

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

- follow prescribed safety procedures appropriate to an electronics laboratory;
- describe the architecture of a microcontroller;
- program a microcontroller using assembly and C programming languages;
- design, compile and debug a microcontroller program in an integrated development environment (IDE);
- create programs to control hardware devices;
- handle exception processing and interrupt service routine;
- use a microcontroller to control hardware peripherals;
- test, troubleshoot and emulate programs for microcontrollers systems.

OUTLINE:

1. **Introduction to Microcomputers** **(4 hours)**
   - 1.1 History of Computers
   - 1.2 Types of Computers
     - 1.2.1 Mainframe Computers
     - 1.2.2 Mini-computers
     - 1.2.3 Microcomputers
   - 1.3 Elements of a Microprocessor System
     - 1.3.1 Basic Block Diagrams
     - 1.3.2 The CPU
     - 1.3.3 Memory (RAM, ROM, EPROM, EEPROM)
     - 1.3.4 Input/Output (I/O)
     - 1.3.5 Internal Buses/External Buses
     - 1.3.6 Speed
   - 1.4 Differences between Microprocessors, Microcontrollers, and Microcomputers
   - 1.5 Microprocessor Architectures
     - 1.5.1 Von Neumann Architecture
     - 1.5.2 Harvard Architecture
     - 1.5.3 Pipelining Architecture

2. **Number Systems Review** **(4 hours)**
   - 2.1 Binary, Decimal, Hexadecimal, and Their Conversions
   - 2.2 Decimal and BCD Code Conversion
   - 2.3 ASCII Code (Character sets) and Unicode (GCSE)
   - 2.4 Addition and Subtraction in Binary
   - 2.5 Signed numbers and Two's Complement
   - 2.6 Overview of Parity

3. **Introduction to ATmega328P/PIC877A Microcontroller** **(9 hours)**
   - 3.1 ATmega328P/PIC877A Hardware Overview (Block Diagram) (2 hours)
     - 3.1.1 Processor Architecture and CISC/RISC
     - 3.1.2 Registers and Memory
     - 3.1.3 Buses (Address, Data, Control)
     - 3.1.4 Ports
     - 3.1.5 Timers
     - 3.1.6 Analog to Digital Conversion
     - 3.1.7 Comparators
     - 3.1.8 Pulse Width Modulation
   - 3.2 Microcontroller Software Principles (2 hours)
     - 3.2.1 CPU “Fetch-Decode-Execute” Cycle and Instruction set
     - 3.2.2 Mnemonic Representation/textual format
     - 3.2.3 Introduction to Addressing Modes
     - 3.2.4 Interpreting the Data Book (Hand Assembly)
   - 3.3 ATmega328P/PIC877A Assembly language instruction set (4 hours)
     - 3.3.1 Accumulator and registers
     - 3.3.2 Data movement
     - 3.3.3 Bit manipulation
     - 3.3.4 Arithmetic and logic operation
     - 3.3.5 Conditional branching
   - 3.4 AVR/PIC Microcontrollers Applications (1 hour)

4. **Introduction to AVR/PIC Studio (IDE)** **(5 hours)**
   - 4.1 Editor
   - 4.2 Assembler
   - 4.3 Compiler
   - 4.4 Linker
   - 4.5 Programmer
   - 4.6 Simulator

5. **AVR/PIC Programming Basics in Assembly Language** **(8 hours)**
   - 5.1 Assembly Directives
     - 5.1.1 Intro to Arduino Inline Assembly
     - 5.1.2 Assembly Directives
   - 5.2 Data and Storage
   - 5.3 Simple I/O
   - 5.4 Decisions (selection)
   - 5.5 Repetition (loops)
   - 5.6 Simple PIC Programs (fragments)
     - 5.6.1 Conditional branches
     - 5.6.2 Loops
     - 5.6.3 Subroutines

6. **AVR/PIC Programming Basics in C Language** **(8 hours)**
   - 6.1 Five basic components and five basic sections of C-programming structure
   - 6.2 Variables, Data types, Format specifiers, and Escape sequences
   - 6.3 Simple I/O
   - 6.4 Looping structures
     - 6.4.1 “for” Loop
     - 6.4.2 “while” Loop
     - 6.4.3 “do-while” Loop
   - 6.5 Conditional statements
     - 6.5.1 “if” Statement
     - 6.5.2 “if-else” Statement
     - 6.5.3 “if-elseif-else” Statement
     - 6.5.4 “switch” Statement
   - 6.6 Arduino Functions *(*PIC877A will have a different set of functions)*
     - 6.6.1 Serial.begin(), Serial.available(), Serial.printf()
     - 6.6.2 pinMode(pin, mode)
     - 6.6.3 digitalWrite(pin, value), digitalRead(pin)
     - 6.6.4 analogWrite(pin, value), analogRead(pin)
     - 6.6.5 delay(ms)
   - 6.7 Simple AVR/PIC Programs (applications)
     - 6.7.1 Switch debouncing
     - 6.7.2 LED counter
     - 6.7.3 LCD display
     - 6.7.4 Matrix keypads

7. **Introduction to MPLAB C18 compiler** *(**For PIC877A only)* **(2 hours)**
   - 7.1 Overview
   - 7.2 Installation
   - 7.3 Integrating with MPLAB IDE

8. **AVR/PIC Exception Handling** **(4 hours)**
   - 8.1 Interrupt logic
   - 8.2 Interrupt service routines
   - 8.3 Interrupt priority
   - 8.4 Interrupt constraints

9. **AVR/PIC Hardware Peripherals Applications** **(4 hours)**
   - 9.1 Timers
   - 9.2 Interrupts
   - 9.3 Interfacing LCDs
   - 9.4 Interfacing keypads
   - 9.5 Implementing analog-to-digital converters
   - 9.6 Serial communications and interfacing
     - 9.6.1 RS-232
     - 9.6.2 RS-485
   - 9.7 I^2C embedded serial computer bus

10. **Development and Debugging Tools** **(4 hours)**
    - 10.1 Development Systems
    - 10.2 in-Circuit Emulation
    - 10.3 Logic Analyzer
    - 10.4 Signature Analysis
    - 10.5 Diagnostics
    - 10.6 Troubleshooting Techniques

Time Allocation

Lecture/Seminar	(4hrs/week x 14)	56
Term Test	(1hr x 2)	2
Final Exam	(3hrs x 1)	3
Labs	(3hrs x 14)	42
Total Hours		**103**

LABORATORY

Lab 1	Introduction to Lab Resources
Lab 2	Introduction to the Arduino IDE and UNO Board
Lab 3	LEDs Manipulation (I) by Arduino in C language
Lab 4	LEDs Manipulation (II) in C language
Lab 5	Serial communication in C language
Lab 6	Seven-Segment Display (I) in C language
Lab 7	Four-digit Seven-Segment Display in C language
Lab 8	8x8 Dot Matrix LED Display in C language
Lab 9	Introduction to AVR Studio 7 (for Assembly language)
Lab 10	LEDs Manipulation (III) in Assembly language
Lab 11	Seven-Segment Display (II) in Assembly language
Lab 12	Timer-CTC Application (PWM)
Lab 13	Analog-to-digital Converter (Sensors, Data Acquisition)
Lab 14	Interrupt Application (Exception Handling)

EVALUATION (Grading according to College policy):

Marks will be assigned to assignments, laboratory exercises, term tests and the final exam. These marks will be weighted according to the criteria defined in **Table 1: Evaluation Criteria** to obtain a composite percentage mark.

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%.

The percentage mark will be translated to a college standard letter grade according to **Table 2: Percentage to Letter Grade Translation**. Table 2 is applicable in this year and to this course only. The course outline identifies concepts and abilities that will be evaluated in this course.

Table 1: Evaluation Criteria*

Assignments	10%
Quizzes	30%
Final Exam	40%
Total theoretical marks	**80%**
Laboratory Evaluation	**20%**
Total	**100%**

**Labs and assignments delay levy: -10%*

Table 2: Percentage to Letter Grade Translation

GRADING (in accordance with College policy):

A+	90 – 100%	**B-**	70 – 72%
A	85 – 89%	**C+**	65 – 69%
A-	80 – 84%	**C**	60 – 64%
B+	77 – 79%	**D**	50 – 59%
B	73 – 76%	**F**	< 50%

TEXT BOOKS AND REFERENCES:

- Course notes and handouts
- Data sheets/manuals
- Internet/Websites:
  - https://www.arduino.cc/
  - https://www.microchip.com/
  - https://www.microchip.com/mplab/avr-support/atmel-studio-7
  - https://www.tutorialspoint.com/arduino/index.htm