The Open University of Sri Lanka
B.Sc. Degree Programme- Level 05
Final Examination 2024/2025
PHU5301 - Practical Physics

Duration: Two (02) hours

Date: 24.05.2025 **Time: 9.30 a.m. – 11.30 a.m.**

Answer any Four (04) Questions Only.

1. Flip-flops are basic memory elements in digital electronics used for storing binary data. They are the building blocks of sequential circuits and are crucial in timing and control applications.

(a) Define a flip-flop. Describe the basic operation of an SR flip-flop using logic gates. *(5 marks)*

(b) Draw the truth table and logic symbol for a J-K flip-flop. Explain what happens when both J and K are set to '1'. *(5 marks)*

(c) A D flip-flop receives a clock signal with a frequency of 1 kHz. If the D input is held at logic '1', what will be the frequency of the output Q? Justify your answer. *(5 marks)*

(d) Compare and contrast the JK flip-flop and the Toggle flip-flop. Include a table for clarity. *(5 marks)*

(e) Explain how flip-flops are used in a 4-bit register. Draw a block diagram and describe its application in a digital system. *(5 marks)*

2. Counters and timers are fundamental components in digital electronics used for event counting, time measurement, and control applications in microcontrollers and digital systems.

(a) Define a counter and explain the difference between synchronous and asynchronous counters. *(5 marks)*

(b) Draw the logic diagram of a 3-bit binary asynchronous counter using Toggle flip-flops. Describe its operation. *(5 marks)*

(c) Explain the function of a timer in a microcontroller. What are the typical sources for the timer clock?
(5 marks)

(d) A 4-bit binary counter is used to count clock pulses of 1 kHz. Calculate the time it takes for the counter to overflow (roll over from 1111 to 0000). Show your working.*(5 marks)*

(e) Design a modulo-6 counter using JK flip-flops. Draw the state diagram and truth table, and explain how it resets at count 6.
(5 marks)

3. The PIC16F84 is a classic 8-bit microcontroller with Harvard architecture, on-chip Flash program memory, and a small bank-switched data RAM. Understanding its internal architecture and memory organization is crucial for effective program development.

(a) Define a microcontroller and list three architectural features that distinguish the PIC16F84 from a general-purpose microprocessor.
(5 marks)

(b) Draw the block diagram of the PIC16F84 microcontroller and explain the roles of its main components.
(5 marks)

(c) Describe the memory organization of the PIC16F84, including the distinction between program memory and data memory.
(5 marks)

(d) The PIC16F84 uses a memory banking scheme for data memory. Explain the roles of Bank 0 and Bank 1, and how the bank is selected.
(5 marks)

(e) A program stores temporary variables and control flags in Bank 1 of the data memory. Explain how you would switch to Bank 1, write a value to a location, and switch back to Bank 0 using PIC assembly instructions.
(5 marks)

4. The PIC16F84 microcontroller has a built-in 64-byte EEPROM that allows data to be stored even when power is turned off. Reading from and writing to EEPROM involves interacting with specific registers and control bits.

(a) Explain the purpose of EEPROM in a microcontroller. How does it differ from RAM and program memory (Flash)?
(5 marks)

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(b) List the key EEPROM control and data registers in the PIC16F84. Explain the function of each register. *(5 marks)*

(c) Describe step-by-step how to write a single byte of data to the EEPROM in the PIC16F84. Include the necessary precautions to ensure a successful write. *(5 marks)*

(d) Write an assembly language routine that writes the value 0x5A to EEPROM address 0x10. *(5 marks)*

(e) Explain how to read a byte from EEPROM. Write an assembly routine to read from address 0x10 and store the result in register 0x20. *(5 marks)*

5. The Arduino Uno is based on the ATmega328 microcontroller. Understanding its architecture, features, and programming model is essential for designing embedded systems using the Arduino platform.

(a) Briefly explain the role of the ATmega328P microcontroller in the Arduino Uno board. List four key features of this microcontroller. *(5 marks)*

(b) Draw and label the main hardware components of the Arduino Uno board. Describe the functions of the following components: USB interface, voltage regulator, and reset button. *(5 marks)*

(c) Explain the different types of memory available in the ATmega328P microcontroller. Include their sizes and typical uses. *(5 marks)*

(d) Describe how digital and analog pins are used on the Arduino Uno board. Write code for.

(i) Turn on an LED connected to digital pin 8

(ii) Read an analog voltage from analog pin A1

(5 marks)

(e) Write a complete Arduino sketch that blinks an LED connected to pin 7 with a 1-second ON and 1-second OFF delay using the delay() function. *(5 marks)*

6. Arrays are essential for storing and managing groups of related values, while loops provide an efficient mechanism to execute repetitive tasks. Mastery of these concepts allows for the development of scalable and maintainable embedded applications.

(a) Explain the purpose of using loops in Arduino programming. List the three types of loops commonly used in Arduino with one simple example for each. *(5 marks)*

(b) What is an array in Arduino programming? Describe how arrays can be used together with loops to control multiple hardware components efficiently. Provide a basic example.

(5 marks)

(c) Write an Arduino sketch that uses a for loop and an array to blink 4 LEDs connected to digital pins 3, 4, 5, and 6 one after the other with a 500 ms delay between each ON/OFF cycle. *(5 marks)*

(d) Write a program that uses a while loop to collect 6 analog readings from pin A1 into an array. After collecting, print each reading to the Serial Monitor. *(5 marks)*

(e) Modify the program in part (d) to use a do...while loop instead of while. Also, explain one key difference between the while and do...while loop structures. *(5 marks)*

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