Library

CINEC CAMPUS
Beyond A Graduate

Faculty of Engineering & Technology

Department of Electronics & Telecommunication Engineering

BSc Hons (Eng) Mechatronics Engineering

Semester 4 Second Sit - Final Examination 2026

Module Code	:	**EE2328**
Module Title	:	**Microcontroller Engineering**
Date	:	**4th of June 2026**
Examiners	:	**Mr. Sanath Thilakarathna**
Time Allowed	:	**3 Hours**

Instructions to Candidates:

- This is a closed book examination. No reference materials are allowed.
- This paper consists of five (05) questions. Answer all five questions.
- Use only the provided answer booklet, additional sheets, and graph papers for your answers.
- Write clearly and legibly using a blue or black pen.
- Write your student number on *all* sheets.
- Start each question on a new page in the answer booklet. Clearly indicate the question number at the top of the page.
- If parts of the same question are written discontinuously in different sheets, ensure that each part is appropriately labelled with its corresponding question number.
- Where appropriate, include clear diagrams or sketches. These can aid in calculations and help convey your answers effectively.
- If you are unsure about the wording of a question consult the Supervisor or Invigilator or make reasonable assumptions. Clearly state such assumptions in your answer script.
- Marks will be deducted for missing or incorrect measuring units, and failure to adhere to the above instructions.

Question 1

The ATmega328P is an 8-bit AVR microcontroller widely used in embedded systems such as development boards and small control devices. Its internal organization follows the Harvard architecture, where program instructions and data are stored in separate memory spaces.

i) Compare Harvard architecture and Von Neumann architecture. Clearly explain the key differences between these two architectures and discuss why many modern microcontrollers adopt Harvard architecture. (4 Marks)

ii) Draw a block diagram of the internal architecture of the ATmega328P microcontroller and explain the role of the main components shown in your diagram. Your explanation should include the following units:

- Central Processing Unit (CPU)
- Program Memory (Flash)
- Data Memory (SRAM)
- Electrically Erasable Programmable Read-Only Memory (EEPROM)
- Input/Output (I/O) ports
- Internal data and instruction buses

Describe how these components interact with each other during program execution. (6 Marks)

iii) The CPU of the ATmega328P contains several important registers that control program execution. Explain the purpose and operation of the following registers:

- Program Counter (PC)
- Stack Pointer (SP)
- General-purpose register file (R0–R31)

In your explanation, describe how these registers contribute to instruction execution, data manipulation, and subroutine handling. (6 Marks)

iv) Describe the instruction execution process in a microcontroller. Explain how the fetch–decode–execute cycle occurs in the ATmega328P and how instructions stored in program memory are fetched and executed by the CPU. (4 Marks)

Question 2

The ATmega328P microcontroller contains a 32-register general-purpose register file (R0–R31) and a Status Register (SREG) that plays an important role in the execution of assembly instructions. These registers enable fast data manipulation and allow the processor to make logical decisions during program execution.

i) Explain the purpose of the 32 general-purpose registers (R0–R31) in the ATmega328P architecture. Discuss why using registers instead of memory locations improves execution speed and overall system performance in microcontrollers. (5 Marks)

ii) The Status Register (SREG) contains several flags that indicate the result of arithmetic and logical operations. Explain the purpose of the following flags:

- Zero flag (Z)
- Carry flag (C)
- Negative flag (N)
- Overflow flag (V)

Describe how these flags are affected by arithmetic instructions executed by the CPU. (6 Marks)

iii) Consider the following assembly instructions used in the ATmega328P instruction set:

- ADD
- SUB
- INC
- DEC

Explain the function of each instruction and discuss how they modify register values and affect the status flags. (5 Marks)

iv) Data transfer instructions are commonly used to move data between registers and memory locations. Explain the purpose and operation of the following instructions:

- MOV
- LDI
- LD
- ST

(4 Marks)

Question 3

i) Explain why addressing modes are important for efficient data access in microcontroller systems and compare the following addressing modes used in the ATmega328P instruction set:

- Immediate addressing
- Register addressing
- Direct addressing (4 Marks)

ii) The following instructions are executed in sequence:

LDI R16, 25

LDI R17, 10

ADD R16, R17

Explain what happens during the execution of each instruction and describe the final value stored in register R16 after these instructions are executed. (8 Marks)

iii) The following assembly instructions are executed in sequence in the ATmega328P microcontroller

LDI R16, 0b10110110

LDI R17, 0b00001111

AND R16, R17

Show how the AND operation is performed at the bit level between the two register values. Clearly illustrate how each pair of bits is processed and determine the final value stored in register R16. (8 Marks)

Question 4

The ATmega328P microcontroller contains hardware timers that can be used to generate accurate time delays and periodic interrupts. Assume the system clock frequency is 16 MHz.

i) Explain the purpose of hardware timers in microcontrollers. Why are hardware timers preferred over software delay loops in embedded applications? (4 Marks)

ii) Explain the role of a prescaler in a timer module. Why is a prescaler used, and how does it affect the timer counting speed? (3 Marks)

iii) Timer0 is an 8-bit timer. If Timer0 is configured with a prescaler value of 64, calculate:

- The timer clock frequency

- The time duration of one timer tick

Show all calculation steps. (8 Marks)

iv) Using the same configuration (Timer0 with prescaler = 64), calculate the maximum time before the timer overflows. Assume the timer counts from 0 to 255. (5 Marks)

Question 5

i) Explain the concept of interrupt-driven programming in embedded systems. Why are interrupts more efficient than polling in many real-time applications? (3 Marks)

ii) The ATmega328P uses digital I/O ports to interface with external devices. Explain the function of the following registers in digital I/O operation:

- DDRx
- PORTx
- PINx (6 Marks)

iii) The ATmega328P contains a built-in 10 bit Analog-to-Digital Converter (ADC) used to measure analog signals.

a) If the reference voltage is 5 V, calculate the voltage resolution of the ADC.

b) A sensor produces an analog output of 2.5 V. Calculate the digital value that would be produced by the ADC. (6 Marks)

iv) If you must select one communication protocol among SPI, I2C, and UART for communication between multiple sensors and the microcontroller, which protocol would you choose? Justify your answer. (5 Marks)

End of Question Paper