CHENNAI

Final Assessment Test(FAT) - NOV/DEC 2025

Programme	B.Tech.	Semester	Fall Semester 2025-26
Course Code	BCSE305L	Faculty Name	Prof. Kishor Kisan Ingle
Course Title	Embedded Systems	Slot	C1+TC1
		Class Nbr	CH2025260102119
Time	3 hours	Max. Marks	100

Instructions To Candidates

- Write only your registration number in the designated box on the question paper. Writing anything elsewhere on the question paper will be considered a violation.

Course Outcomes

CO1: Identify the challenges in designing an embedded system using various microcontrollers and interfaces.
CO2: To summaries the functionality of any special purpose computing system, and to propose smart solutions to engineering challenges at the prototype level.
CO3: To examine the working principle and interface of typical embedded system components, create programme models, apply various optimization approaches including simulation environment and demonstration using debugging tools.
CO4: To evaluate the working principle of serial communication protocols and their proper use, as well as to analyze the benefits and drawbacks of real-time scheduling algorithms and to recommend acceptable solutions for specific challenges.

Answer all Questions (10 × 10 Marks)

01. **VarishtRakshak**, a startup for wearable health monitoring devices for elderly patients is aimed at below guidelines:
    - Continuously measure heart rate, blood oxygen and movement
    - Enable wireless communication with a mobile app
    - Be compact and perform real-time trigger alerts
    - Be less expensive and consume less power
    - Perform ECG signal processing and edge-based decisions for fall detection

    a) For the hardware design team, list and explain the differences between microprocessors and microcontrollers in the context of these devices. **(5 marks)**
    b) Also, discuss different microprocessor categories suitable for this application. **(5 marks)**

    [10] (CO1/K2)

02. A small robotic system uses an 8-pin keypad (D0–D7) to select operating modes. Each pin is connected to an 8-to-3 line encoder, whose 3-bit binary output (A, B, C) is read by an Arduino Board.
    a) Draw a block diagram showing the connection between the keypad, the 8-to-3 encoder and the Arduino board. Also, provide a truth table for the encoder output corresponding to each keypad pin. **(5 marks)**
    b) Write an Arduino program that continuously reads the encoder output pins and displays the detected pin number (0–7) on the serial monitor. **(5 marks)**

    [10] (CO3/K2)

03. You are designing a smart air quality monitoring and fan control system using an Arduino Uno board and a MQ-135 gas sensor.
    Proportional to the air pollution level, the sensor outputs an analog voltage in the range 0.4 V (clean air) to 3.2 V (very polluted).
    Write the program and explain for this system to operate as follows:
    a) Read the sensor value from analog pin A1 every 5 seconds. Convert the ADC reading (0 to1023) to pollution level (in percentage) based on the specified voltage range. **(4 marks)**
    b) If pollution exceeds 70 %, turn ON the exhaust fan connected to digital pin 8; otherwise, turn it OFF. Maintain a running average of the last 20 readings to smoothen the sudden changes. For each reading, estimate and display the voltage, pollution percentage, and fan status (ON/OFF). **(6 marks)**

    [10] (CO3/K3)

04. For a low bandwidth environment based multimedia streaming optimization requirement, Diwakar is working as a video compression engineer.
a) Explain in detail, the steps he needs to execute as part of JPEG encoding. **(6 marks)**
b) In a talking-head video he is working on, which types of frames contribute more towards temporal data compression, and why? **(2 marks)**
c) If JPEG spatial compressor in MPEG encoder achieves compression ratio of 15:1 per frame and 70% reduction of redundant frames in temporal compression, what is the final compressed size, Diwakar should expect for the original video of 900MB size. **(2 marks)**

[10] (CO3/K2)

05. Consider the following Code Segment:

```
for (int i = 0; i < n; i++)
{
 int a1 = 12 * 4;
 int b1 = (x + y) * (x + y);
 int c1 = (p * q) + (r * s);
 int d1 = (x + y) * (x + y);
 int e1 = (i * 10) / 2;
 total = total + a1 + b1 + c1 + d1 + e1 + (u * v) - (u * v);
}
```

a) Identify four different types of code optimization techniques that can be applied to this program. **(4 Marks)**
b) Rewrite the current code by applying all optimization techniques. **(4 Marks)**
c) Briefly explain how these optimizations enhance the program's efficiency. **(2 Marks)**

[10] (CO3/K3)

06. Surya is standing on 5th floor and wishes to travel down to the ground floor. He presses the 'floor down' button. The microcontroller enabled elevator controller system, which maintains information such as the elevator's current position, direction and floor ID, determines if the elevator must move upward or downward to reach 5th floor. Under controller supervision, the elevator updates its 'current floor' attribute as it travels upward or downward. When it arrives 5th floor, elevator controller triggers the door to get opened, so that he can get in. When Surya presses the ground floor button in the elevator button system inside the cabin, the door gets closed and starts moving upward or downward. During travel, the elevator button is kept illuminated, indicating the active request. Upon reaching the ground floor, the elevator controller stops the elevator and activates the door to get opened again. Since the journey is completed, the elevator button is no more illuminated and the door gets closed again.
For the given case study,
a) Give two differences between class diagram and state diagram in capturing different aspects under UML context. **(2 marks)**
b) If you use UML's activity diagram, will you just consider the workflow of actions, or also include notations that indicate who triggers and which object performs them? Provide the symbol notations used for fork node, join node and decision node in activity diagram. **(3 marks)**
c) Draw the sequence diagram that shows step-by-step interactions, starting from Surya pressing the 'floor down' button to reaching the ground floor riding the elevator. **(5 marks)**

[10] (CO3/K4)

07. A company is designing a real-time embedded control system for an autonomous drone fleet. The drones must process sensor data, make navigation decisions and respond to obstacles within strict timing constraints.
a) Analyze and classify the type of real-time operating system suitable for this application. Explain your classification and justify the choice based on timing precision, task criticality and failure consequences. **(6 marks)**
b) Discuss the key issues and challenges that engineers face while designing and implementing such real-time operating systems. **(4 marks)**

[10] (CO4/K3)

08. A real-time temperature monitoring system executes three periodic tasks using Earliest Deadline First (EDF) scheduling.

Task	Arrival Time (ms)	Execution Time (ms)	Period (ms)	Deadline (ms)
T_1	0	2	5	5
T_2	1	1	7	7
T_3	2	2	10	10

a) Compute the CPU utilization and verify whether the system is schedulable under EDF using the utilization-based test. **(4 marks)**

b) Construct the EDF scheduling timeline for the first 20 ms along with indications of all pre-emptions of these tasks. **(6 marks)**

[10] (CO4/K3)

09. A student is developing a smart home temperature monitoring system using a microcontroller that communicates with a temperature sensor to collect and display real-time room temperature data. The system sends temperature readings to an LCD display and a Wi-Fi module for remote monitoring. The temperature sensor operates as a slave while the microcontroller functions as the master. The student must establish a reliable communication protocol to retrieve accurate temperature data and display it correctly.

a) Explain the sequence of communication to be followed by the microcontroller in detail, using I²C protocol to successfully request and receive temperature data from the sensor. Include the significance of start/stop conditions, addressing, ACK/NACK bits and data frame structure. **(7 Marks)**

b) Analyze and discuss at least three possible causes for intermittent communication failure or incorrect response by the sensor. **(3 Marks)**

[10] (CO4/K3)

10. A group of students is designing an embedded system architecture for a smart irrigation solution that can automatically water crops based on soil moisture, temperature and weather conditions. The system should optimize water usage and operate efficiently in rural environments with limited power sources.

a) Propose a detailed system architecture showing the interaction between sensors, processing unit, control logic, actuators and communication interfaces. Justify the choice of components and their roles in achieving system objectives. **(6 Marks)**

b) Analyze the key design constraints such as power efficiency, sensor accuracy, and environmental reliability. Suggest strategies to overcome these challenges while maintaining scalability and cost-effectiveness. **(4 Marks)**

[10] (CO2/K4)

BL-Bloom's Taxonomy Levels - (K1-Remembering,K2-Understanding,K3-Applying,K4-Analysing,K5-Evaluating,K6-Creating)

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