

University of Dhaka
 Department of Computer Science and Engineering
 3rd Year 1st Semester Final Examination, 2024
 MATH-3105: Multivariable Calculus and Geometry (3 Credits)

Total Marks: 70

Time: 3 Hours

[Answer any 5 (five) of the following questions]

1. (a) Given a dataset of n observations $\{(x_1, y_1), (x_2, y_2), \dots, (x_n, y_n)\}$, you want to fit a linear model of the form $y = ax + b$ to predict y from x . Now, derive the formula $\beta = (X^T X)^{-1} X^T y$ to obtain the values of a and b that minimize the sum of squared error. Here, [5]

$$X = \begin{bmatrix} x_1 & 1 \\ x_2 & 1 \\ \vdots & \vdots \\ x_n & 1 \end{bmatrix}, \quad y = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix}, \quad \beta = \begin{bmatrix} a \\ b \end{bmatrix}$$

- (b) Suppose you have collected data about houses with two features: (i) x_1 = size of the house in hundreds of square feet, (ii) x_2 = number of bedrooms. And, the corresponding house prices (in thousands of dollars) are given by y . You have the following dataset for 4 houses:

| House | Size (x_1) | Bedrooms (x_2) | Price (y) |
|-------|----------------|--------------------|---------------|
| 1 | 2 | 3 | 50 |
| 2 | 3 | 4 | 65 |
| 3 | 4 | 3 | 70 |
| 4 | 5 | 5 | 85 |

Assuming a linear model, $y = ax_1 + bx_2 + c$, find the values of a , b , and c that minimize the squared error. [5]

- (c) Given a stream of 2D points $(x_1, y_1), (x_2, y_2), \dots, (x_n, y_n)$, design an incremental algorithm to maintain the best-fit line $y = ax + b$ using the least squares method. You must update the slope (a) and intercept (b) in constant time whenever a new point is added. [4]

- (a) Let $L_1(t) = c + ta$ and $L_2(t) = d + tb$ be two parametric line equations. Here, a , b , c , and d be four vectors, and $d - c = b$. The vectors a and b are linearly independent. Find if the lines intersect or not. If yes, find the intersection point. [5]
- (b) Find the parametric equation of a line that passes through the point $P_0 = (2, 4, -1, 0, 3, 5)$ and is orthogonal to the vector $v = (2, 3, 4, 1, -2, 0)$ in 6-dimensional space. [3]
- (c) Find the transformation matrix that rotates a point in 3D by +60 degrees with the point $(2, 3, 4)$ as the center of rotation. [6]
3. (a) Using spherical coordinates, evaluate $\iiint_E xe^{x^2+y^2+z^2} dV$, where E is the portion of the unit ball, $x^2 + y^2 + z^2 \leq 1$, that lies in the first octant. [4]

- (b) The joint probability density function for random variables X , Y , and Z is defined as follows: [5]

$$f(x, y, z) = \begin{cases} Ce^{-(0.5x+0.2y+0.1z)} & x \geq 0, y \geq 0, z \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

- i. Determine the value of constant C .

- ii. Determine $P(X \leq 1, Y \leq 2, Z \geq 7)$.

- (c) An agricultural sprinkler distributes water in a circular pattern of radius 100 ft. It supplies water to a depth of e^{-r} feet per hour at a distance of r feet from the sprinkler. [5]

- i. If $0 < R \leq 100$, find the total amount of water supplied per hour to the region inside the circle of radius R centered at the sprinkler.

- ii. Determine an expression for the average amount of water per hour per square foot supplied to the region inside the circle of radius R .

- (d) Evaluate the line integral $\oint F \cdot dr$, where the vector field $F(x, y, z) = \langle y \cos x - x \sin y, xy + x \cos y \rangle$ and C is a triangle from $(0, 0)$ to $(0, 4)$ to $(2, 0)$ to $(0, 0)$. Solve this problem using both of the following methods. [7]

i. Direct Evaluation: Compute the line integral directly of each segment over each triangular path.

ii. By applying Green's Theorem

- (b) The curl operator allows us to rewrite the equation in Green's Theorem in the vector form as, $\oint F \cdot dr = \iint_D (\operatorname{curl} F) \cdot k dA$, where, $F = \langle P, Q \rangle$ and k is the unit normal vector to the plane (perpendicular to the xy -plane).

Prove this equation when D is a plane region and its boundary curve is C . [4]

- (c) Let $f(x, y, z)$ be a scalar field and $F(x, y, z)$ be a vector field defined over a region in three-dimensional space. Determine whether $\operatorname{div}(\operatorname{curl}(\operatorname{grad} f))$ is a scalar field or a vector field with proper mathematical justifications. [3]

5. (a) Verify that the function $z = \ln(e^x + e^y)$ satisfy the following partial differential equations [4]

$$\frac{\partial z}{\partial x} + \frac{\partial z}{\partial y} = 1 \quad \text{and} \quad \frac{\partial^2 z}{\partial x^2} \frac{\partial^2 z}{\partial y^2} - \frac{\partial^2 z}{\partial x \partial y} = 0$$

- (b) A manufacturing company needs to design a closed cylindrical can (with both top and bottom) to hold a fixed volume V of a liquid product. The cost of material used for the top and bottom of the can is \$2 per unit², while the material for the side (lateral surface) costs \$1 per unit².

Determine the optimal dimensions of the can (radius r and height h) by applying the Lagrange multipliers method that will minimize the total manufacturing cost, subject to the constraint of fixed volume V and the total surface area of the can must not exceed a specified limit of A unit². [5]

- (c) Find the absolute maximum and the absolute minimum values of the function [5]

$$f(x, y) = x^2 + y^2 + x^2 y + 4 \quad \text{where } \{(x, y) | |x| \leq 1, |y| \leq 2\}$$

6. (a) Determine the directional derivative of the function, $f(x, y, z) = xe^y + ye^z + ze^x$, at the point, $(3, 6, -2)$, in the direction of the vector $v = \langle 5, 1, -2 \rangle$. Also, estimate the maximum rate of change of the function f at the given point. [3+2]

- (b) Pollution concentration (C in ppm) depends on Traffic flow (T) (vehicles/hour) and Wind speed (W) (mph). Values of the Pollution concentration function $C(T, W)$ are recorded in the following table.

| Traffic Flow (T) (vehicles/hour) | Wind Speed (W) (mph) | | | | | |
|--------------------------------------|--------------------------|-----|-----|-------|-----|-----|
| | 5 | 10 | 15 | 20 | 25 | 30 |
| 500 | 120 | 100 | 80 | 65 | 55 | 50 |
| 1000 | 180 | 150 | 120 | 100 | 85 | 75 |
| 1500 | 240 | 200 | 160 | 135 | 115 | 100 |
| 2000 | 300 | 250 | 200 | (170) | 145 | 125 |
| 2500 | 360 | 300 | 240 | 205 | 175 | 150 |
| 3000 | 420 | 350 | 280 | 240 | 205 | 175 |

Use the table to find a linear approximation to the function C when T is near 2000 vehicles/hour and W is near 20 hours. Then estimate the pollution level at $T = 1200$ vehicles/hour and $W = 12$ mph. [6]

- (a) A street vendor sells α hamburgers, β hot dogs, and δ soft drinks on a given day. He charges \$2 for a hamburger, \$1.50 for a hot dog, and \$1.1 for a soft drink. If $A = \langle \alpha, \beta, \delta \rangle$ and $P = \langle 2, 1.5, 1.1 \rangle$. Using vector operations, demonstrate how to calculate the vendor's total daily revenue and interpret the mathematical significance of the dot product $A \cdot P$ in this economic context. [3]

- (b) Show that the lines with symmetric equations $x = y = z$ and $x + 1 = y/2 = z/3$ are skew lines. Additionally, find the distance between these lines. [3+2]

- (c) Find the volume of the solid enclosed by the paraboloid $z = 2 + x^2 + (y - 2)^2$ and the planes $z = 1, x = 1, x = -1, y = 0$, and $y = 4$. [4]

- (d) Let, $F(x, y, z) = \langle 2xy^2, 2x^2y + e^z, ye^z \rangle$. Determine whether the vector field F is conservative. If so, find a potential function $f(x, y, z)$. [5]

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3rd Year 1st Semester Final Examination, 2024
CSE-3101: Computer Networking (3 Credits)

Total Marks: 70

Time: 3 Hours

[Answer any 5 (five) of the following questions]

1. (a) A user downloads a 100 MB file from a server. The round-trip time (RTT) is 100 ms, and the data is transferred over a TCP connection with a congestion window of 64 KB. Calculate the approximate throughput in Mbps, assuming the connection is congestion-free and there's no packet loss. [5]
(b) Given a link with a bandwidth of 10 Mbps and an average packet length of 1,500 bytes, what is the maximum packet arrival rate that can be supported without causing congestion? [5]
(c) Consider a 2,000 km link with a propagation speed of $2 \times 10^8 \text{ m/s}$ and a transmission rate of 5 Mbps. If a 1,000-byte packet is sent, what is the propagation delay, transmission delay, and total end-to-end delay when average queuing and processing delays per packet is $10\mu\text{s}$ and 10 ms, respectively? [4]
2. (a) Explain how DASH protocol segments video content and delivers different quality levels. What role do manifest files (MPD) play in this process? [4]
(b) Consider an e-commerce site that wants to keep a purchase record for each of its customers. With the help of a figure, describe how this can be done with cookies. [5]
(c) How does IMAP differ from POP3 in handling email retrieval and storage? Which protocol is more suitable for accessing email from multiple devices? [5]
3. (a) Compare client-server and P2P architectures in terms of performance, scalability, robustness, and trust. Provide examples of applications that use each model effectively. [5]
(b) Explain how the DNS resolution process works when a user enters a website URL into a browser. Include the roles of recursive and authoritative DNS servers. [5]
(c) Suppose host A and B are communicating over a TCP connection, and Host B has already received from A all bytes up through byte 1277. Host A then sends two segments to Host B back-to-back, containing 480 and 540 bytes of data, respectively. In the first segment, the source port number is 3022, and the destination port number is 80. Host B sends an acknowledgment whenever it receives a segment from Host A.
i. In the first segment sent from Host A to B, what are the sequence number, source port number, and destination port number?
ii. If the first segment arrives at B before the second segment, in the acknowledgment of the first arriving segment, what is the acknowledgment number, the source port number, and the destination port number? [4]
4. (a) Compare link-state and distance-vector routing algorithms in terms of convergence speed, message complexity, and robustness to incorrect routing information. In what types of networks would each be more suitable? [3]
(b) Compare the architecture and design goals of ONOS and ODL controllers. How does each controller prioritize scalability, modularity, and application development support? Based on these factors, in what types of deployments (e.g., telco, enterprise, IoT) would each controller be most appropriate? [4]
(c) Compare the header structures of IPv4 and IPv6 and analyze how these differences impact the efficiency of routing and packet forwarding. [3]
(d) Explain the relationship between BGP and OSPF in an enterprise network connected to multiple ISPs. How do these protocols work together? Consider the following issues: the internal routing, the external routing, and the route redistribution. [4]
5. (a) Unlike the IEEE 802.3 Ethernet protocol, the IEEE 802.11 wireless MAC protocol does not implement collision detection. State two reasons for this. [3]
(b) Explain the purpose of RTS/CTS in wireless communication. How does it help mitigate the hidden terminal problem? [4]
(c) Compare the performance of CSMA/CA (as in IEEE 802.11) and TDMA in a high-density environment such as a stadium. Discuss on the following issues: channel utilization efficiency, collision probability, fairness, and throughput. [4]

(d) Describe how a mobile device is identified and authenticated in a 4G LTE network when it connects to a new base station in a visited network. [3]

6. (a) Consider the network graph in Figure: 1, where routers are connected as shown with link costs:

(i) Using the Distance Vector (DV) algorithm, compute the routing table for router 'x' after all routers have exchanged distance vectors and reached convergence. Show all steps. [4]

(ii) Using the Link State Routing algorithm, compute the shortest path tree from router 't'. Provide the final shortest path and cost to each router from 't'. [4]

(iii) Identify and explain one scenario in which Count-to-Infinity could occur in this network if a link fails. Suggest a method to prevent it. [3]

(iv) Discuss how SDN can improve the visibility and control of inter-domain routing. Could SDN replace BGP in the future? Justify your reasoning technically and economically. [3]

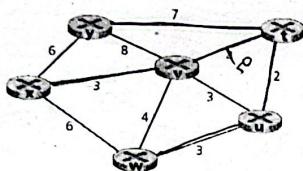


Figure: 1

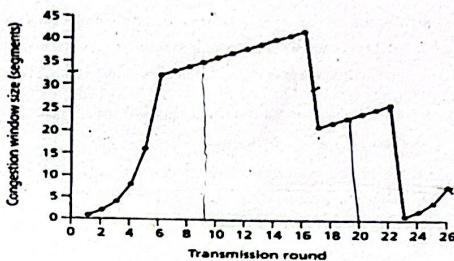


Figure: 2

(a) Consider the graph in Figure: 2, which shows how much the congestion window is changed over time in a TCP connection. [4]

i. Determine whether the above graph represents TCP Tahoe or TCP Reno. Why?

ii. What is the value of ssthresh at the 9th and 20th transmission rounds?

iii. Why do you think that after the 6th transmission round, the congestion window increases linearly rather than exponentially?

iv. During which transmission round is the 65th segment sent? Why?

v. Assuming a packet loss is detected after the 26th round by the receipt of a triple duplicate ACK, what will be the values of the congestion window size and of ssthresh?

(b) TCP uses a sliding window protocol for flow control. Explain how the receiver's advertised window affects the sender's transmission rate. What could cause the advertised window to shrink to zero, and how does TCP handle this scenario? [2]

(c) Consider you are an engineer of a multinational company that has been allocated the public IPv4 block 198.51.100.0/22. The company operates four regional offices, each having a varying number of departments, as shown in the given table, Table: 1. Create four subnets for the regional offices, find (i) subnet address, subnet mask, and valid host address range, and (ii) total number of IP addresses wasted for subnetting and the region-wise number of unused IP addresses for future extension. [5]

| Region | Dept. | Max hosts per dept. |
|---------|-------|---------------------|
| Asia | 2 | 60 |
| Europe | 4 | 120 |
| Africa | 7 | 30 |
| America | 5 | 20 |

Table: 1

(d) Define the "match plus action" operation of a switch. In the case of a destination-based forwarding packet switch, what is matched and what is the action taken? In the case of an SDN, name three fields that can be matched, and three actions that can be taken. [3]

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 CSE-3102: Software Engineering (3 Credits)

Total Marks: 70

Time: 3 Hours

[Answer any 5 (five) of the following questions]

1. (a) Briefly define what a software process model is and explain its importance in software development. [4]
 (b) Differentiate between a generic model and a prescriptive model. Give an example of each. [3+2]
 (c) List two evolutionary models and briefly describe their key characteristics. [5]
- ✓ (a) What is a Rational Unified Process (RUP) model? Explain the four key phases of RUP: (Inception, Elaboration, Construction, Transition). [5]
 (b) Explain how the RUP's disciplines (e.g., Requirements, Design, Implementation) align or conflict with the Agile practices [3]
 (c) What is the difference between the Prototype model and RUP model in terms of deliverables in each iteration? [2]
 (d) Define coupling and cohesion in case of object oriented programs? What degrees of coupling and cohesion are desirable? Explain your answer. [4]
- ✓ (a) Which of the following scenarios represent valid use cases? Explain your answer. [4]
 - i. Negotiate a supplier contract
 - ii. Handle returns
 - iii. Log in
 - iv. Move piece on game Board
- (b) From the use case "Process Sale" below, answer the following questions (should follow the RUP style): [1+3+3]
 - i. Identify the primary actor of this use case.
 - ii. Describe the possible main success scenario.
 - iii. Propose two extensions (failure scenarios) and how the system would handle it (e.g., payment failure).

"Customer arrives at a checkout with items to purchase. The cashier uses the POS system to record each item. The system presents a running total and lineitem details. The customer enters payment information, which the system validates and records. The system updates inventory. The customer receives a receipt from the system and then leaves with the items."
- (c) Identify a reusable subfunction of the use case mentioned in part (iii) of question 3(b), that should be included. Also define the extension point and conditions under which the extended case triggers. [3]
- ✓ (a) From the scenario described below, design a domain model that captures the key entities, their relationships, and critical attributes, while justifying your design choices for clarity and scalability. [7]

"A patient schedules an appointment with a doctor through a clinic's online system. The system checks the doctor's availability and confirms the appointment. On the day of the visit, the receptionist verifies the patient's details and updates their medical record. The doctor examines the patient, diagnoses the condition, and prescribes medication. The system records the diagnosis, updates the treatment history, and generates a prescription. The patient receives the prescription and proceeds to the pharmacy for medication pickup."
- (b) What is the difference between Aggregation and Composition in Class Diagrams? Explain the diagrams in Figure: [5]
 - 1.

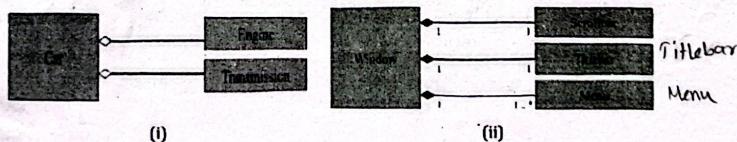


Figure: 1

- (c) Discuss the primary differences between the class diagram and domain model diagram, especially in terms of the level of abstractions. [2]

(a) Draw the sequence diagram from the following code snippet:

[6]

```
public class PaymentSystem {  
    public void processPayment(Order order) {  
        if (order.isValid()) {  
            while (!order.isPaid()) {  
                order.charge();  
            }  
            order.ship();  
        } else {  
            order.reject();  
        }  
    }  
}
```

(b) Briefly explain the difference between black-box and white-box testing.

[2]

(c) Explain the concept of six sigma and its role in software quality management.

[4]

(d) Explain the Figure: 2 in terms of software testing activity.

[2]

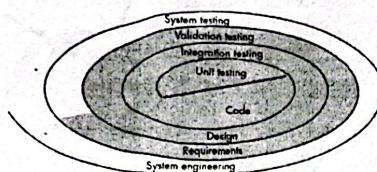


Figure: 2

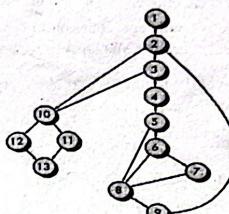


Figure: 3

(a) Explain the primary purpose of using CFGs in program analysis. What does a basic block represent in a CFG? [4]

(b) How are decision points (e.g., if conditions) represented in a CFG? Illustrate with a simple code snippet. [2]

(c) From the flow graph in Figure: 3:

- Determine a basis set of linearly independent paths
- Determine the cyclomatic complexity.

(d) Explain the role of stubs and drivers in case of unit testing. What is the difference between the top-down and bottom-up strategies in case of integration testing? [3]

7. (a) Why software design patterns are necessary? Explain with an example. [3]

(b) From the following code snippet, what changes should be made to make it work as a singleton pattern. Justify your answer. [5]

```
public class SingletonExample {  
    private static SingletonExample ref = null;  
  
    public static SingletonExample getInstance() {  
        if (ref == null) {  
            ref = new SingletonExample();  
        }  
        return ref;  
    }  
    private SingletonExample() { // ... more code }  
}
```

(c) Use the idea of Factory pattern in the following scenarios: [6]

i. A PizzaStore uses a SimplePizzaFactory to create pizzas (CheesePizza, PepperoniPizza, VeggiePizza). Write Java code for SimplePizzaFactory.createPizza(type) that returns the appropriate Pizza subclass.

ii. PizzaStore is now abstract, with subclasses (NYStylePizzaStore, ChicagoStylePizzaStore) overriding createPizza() to produce regional variants. Write the abstract PizzaStore class with the factory method and orderPizza(). Implement createPizza() in NYStylePizzaStore to return NYStyleCheesePizza.

University of Dhaka
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3rd Year 1st Semester Final Examination, 2024
CSE-3103: Microprocessor and Microcontroller (3 Credits)

Total Marks: 70

Time: 3 Hours

[Answer any 5 (five) of the following questions]

1. (a) Briefly describe the features of the Cortex M4 memory model with appropriate diagram. What are the major address ranges? [5]
(b) What will happen if a Cortex-M4 core attempts to access a memory region that is not permitted by the MPU configuration? [2]
(c) Explain bit banding with proper diagram. What will be the bit band alias memory location of the 11th bit of the byte offset of 0x1300 of bit band region in SRAM, where base address of bit band region (in SRAM): 0x20000000 and bit band alias region (in SRAM): 0x22000000 ? [5]
(d) A system developer wants to allow privileged code to access all memory but restrict unprivileged code to only a few memory regions. How should the MPU be configured to achieve this? [2]

2. (a) Consider the set of codes in 2(a) and find the values of R0, R1, R2 and PSR after execution. [3]

2(a)

```
MOVS R0, #0
BEQ Skip
MOV R1, #1
Skip:
MOV R2, #2
```

- 2(b)
- ```
(a) ADD R0, R1, R2 LSL R3
(b) LSL R4, R7, R3
(c) EORGTS R6, R3, #5
```

2(c)

```
(a) MOV R4, [R1]
(b) ADD R5, R3, R5, LSR #2
(c) LDR R2, [R0], #4
(d) STR R2, [R1, -6]!
(e) ADD R3, R8, #12
```

- (b) Convert the ARM assembly code in 2(b) into machine language. Write the instructions in hexadecimal using the tables from the Appendix. [6]  
(c) Consider the ARM assembly language snippet in 2(c). List the addressing mode used at each line of code. Calculate the effective address (EA) and mention the content of register for each instruction. [5]

3. (a) Assume an interrupt IRQ1 with priority 7 is currently executing. During this, another interrupt IRQ2 with priority 4 is generated in the system. Depict the scenario with proper timing diagram where it clearly shows the processor mode, processor operation and interrupt status for such scenario, and also mention the names of the registers associated with each interrupt. [5]  
(b) Why is vector table relocation useful in embedded systems? A bootloader is used to update firmware. Explain how vector table relocation helps when switching from bootloader to main application. [1+2]  
(c) What is the use of ISER and ICER registers in the NVIC? [2]  
(d) What is tail chaining in the context of Cortex-M processors? [2]  
(e) Your program accesses an invalid memory address and triggers a fault. How can you determine whether it was a Memory Management Fault, a Bus Fault, or a HardFault? [2]

4. (a) The high-level function `strcpy` copies the character string `src` to the character string `dst`

```
// C code
void strcpy(char dst[], char src[]) {
 int i = 0;
 do {
 dst[i] = src[i];
 } while (src[i++]);
}
```

i. Implement the `strcpy` function in assembly code. Use register `R0` for `i`. [4]

ii. Draw a picture of the stack before, during, and after the `strcpy` function call. The stack pointer, `sp`, is the special register that points to the top of the stack. You can assume the value of `sp` just before `strcpy` is called. [3]

5. (b) Write an assembly program that calls a function `odd_even` that count the number of 1s in an 32-bit value which is stored in memory. If the value is even, then it stores store 0 (even parity) and if the value is odd, then it stores 1 (odd parity). [7]

5. (a) Compare SPI, I2C and UART communication protocol. [4]

(b) Starting from memory register address 0xA5321000, let an application designed to transfer 100 MB of data from a surveillance system to a security operations center. Let us assume that the communication line speed is 5 Mbaud. After receiving every 1 MB of data, the Receiver sends a positive acknowledgement (one byte) to the sender. By analyzing the performance, overhead, and reliability of the UART, SPI, and I2C, determine which communication protocol is most suitable for transferring data from the surveillance system. [5]

(c) A heavy-weight concrete saw requires 3000 watts for cutting hard rock and 1800 watts for concrete highway. An IGBT transistor running on 1000 DC volts can deliver 6000 Watts of power by applying a continuous 5V at its base, and a 5V for one millisecond can deliver 2000 Watts. Apply PWM and write down the specification of the PWM operation to operate the concrete saw with the correct power. [5]

6. (a) The Dhaka South City Corporation (DSCC) wants to evaluate a signaling system design by a group of CSE third-year students. To evaluate, the Dhaka South City Corporation aims to receive a traffic light status every 10 ms with a 10 MBaud data rate on UART. Your task is to configure the UART for an ARM microcontroller (such as STM32F446RE) to send traffic status stored starting from memory address 0x20005000. It's crucial that the UART is configured to meet these specific requirements. [7]

(b) The DSCC also decides to send commands using the SPI interface. The command instructs the newly developed traffic to send a specific light status and interval. Configure the MCU (STM32F446RE) to receive commands from the DSCC and send a reply using UART (from question 6a). [7]

7. (a) Let a timer be connected to the APB2 bus running at 45 MHz. The timer has a prescaler register (`TIMx_PSC`) to reduce the timer input clock frequency. A 16-bit auto reload register `TIMx_ARR` is used to reload the counter range and a counter register `TIMx_CNT` to hold the current count. The time required to configure the timer using the `TIMx_CR` register is provided in the Appendix. Write a delay function where the argument is a 16-bit integer for a millisecond delay. [7]

(b) Briefly describe the use of `USART_SR` register bits: `TXE`, `TC`, `RXNE`, `NF`, `FE`, and `PE`. [4]

(c) Briefly describe the use of `RCC_APB1ENR` and `RCC_AHB1ENR` registers. [3]

## Appendix

| sh | Instruction | Instruction | Condition Field |
|----|-------------|-------------|-----------------|
| 00 | LSL         | EQ          | 0000            |
| 01 | LSR         | GT          | 1100            |
| 10 | ASR         |             |                 |
| 11 | ROR         |             |                 |

|         |             |          |        |         |         |         |            |          |          |          |          |            |           |           |            |
|---------|-------------|----------|--------|---------|---------|---------|------------|----------|----------|----------|----------|------------|-----------|-----------|------------|
| 31      | 30          | 29       | 28     | 27      | 26      | 25      | 24         | 23       | 22       | 21       | 20       | 19         | 18        | 17        | 16         |
|         |             | DAC EN   | PWR EN | CEC EN  | CAN2 EN | CAN1 EN | FMP12C1 EN | I2C3 EN  | I2C2 EN  | I2C1 EN  | UART5 EN | UART4 EN   | USART3 EN | USART2 EN | SPDIFRX EN |
|         |             | rw       | rw     | rw      | rw      | rw      | rw         | rw       | rw       | rw       | rw       | rw         | rw        | rw        | rw         |
| 15      | 14          | 13       | 12     | 11      | 10      | 9       | 8          | 7        | 6        | 5        | 4        | 3          | 2         | 1         | 0          |
| SPI3 EN | SPI2 EN     |          |        | WWDG EN |         |         | TIM14 EN   | TIM13 EN | TIM12 EN | TIM7 EN  | TIM6 EN  | TIM5 EN    | TIM4 EN   | TIM3 EN   | TIM2 EN    |
| rw      | rw          |          |        | rw      |         |         | rw         | rw       | rw       | rw       | rw       | rw         | rw        | rw        | rw         |
| 31      | 30          | 29       | 28     | 27      | 26      | 25      | 24         | 23       | 22       | 21       | 20       | 19         | 18        | 17        | 16         |
|         | OTGHS ULPEN | OTGHS EN |        |         |         |         |            | DMA2 EN  | DMA1 EN  |          |          | BKP SRAMEN |           |           |            |
|         | rw          | rw       |        |         |         |         |            | rw       | rw       |          |          | rw         |           |           |            |
| 15      | 14          | 13       | 12     | 11      | 10      | 9       | 8          | 7        | 6        | 5        | 4        | 3          | 2         | 1         | 0          |
|         |             | CRC EN   |        |         |         |         |            | GPIOH EN | GPIOG EN | GPIOF EN | GPIOE EN | GPIOD EN   | GPIOC EN  | GPIOB EN  | GPIOA EN   |
|         |             | rw       |        |         |         |         |            | rw       | rw       | rw       | rw       | rw         | rw        | rw        | rw         |

Figure 1: RCC\_APB1ENR & RCC\_AHB1ENR registers

|    |    |    |    |    |    |   |   |      |   |   |     |     |      |     |       |
|----|----|----|----|----|----|---|---|------|---|---|-----|-----|------|-----|-------|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7    | 6 | 5 | 4   | 3   | 2    | 1   | 0     |
|    |    |    |    |    |    |   |   | ARPE |   |   | OPM | URS | UDIS | CEN |       |
|    |    |    |    |    |    |   |   | rw   |   |   | rw  | rw  | rw   | rw  |       |
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7    | 6 | 5 | 4   | 3   | 2    | 1   | 0     |
|    |    |    |    |    |    |   |   | UDE  |   |   |     |     |      |     | UIE   |
|    |    |    |    |    |    |   |   | rw   |   |   |     |     |      |     | rw    |
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7    | 6 | 5 | 4   | 3   | 2    | 1   | 0     |
|    |    |    |    |    |    |   |   |      |   |   |     |     |      |     | UIF   |
|    |    |    |    |    |    |   |   |      |   |   |     |     |      |     | rc_w0 |

Figure 2: Timer registers: CR1, DIER, SR

Table 164. USART register map and reset values

| Offset | Register    | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0                  |                   |
|--------|-------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|---|---|---|---|---|---|---|---|--------------------|-------------------|
| 0x00   | USART_SR    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |                    |                   |
|        | Reset value |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |                    |                   |
| 0x04   | USART_DR    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   | DR(8:0)            |                   |
|        | Reset value |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |                    |                   |
| 0x08   | USART_BRR   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   | DIV_Mantissa[15:4] | DIV_Fraction[3:0] |
|        | Reset value |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |                    |                   |
| 0x0C   | USART_CR1   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   | IDLEIE             | 3                 |
|        | Reset value |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   | TE                 | 2                 |

**Table 26. GPIO register map and reset values**

| Offset | Register                                                 | Reset value | 31            |
|--------|----------------------------------------------------------|-------------|---------------|
| 0x00   | GPIOA_MODER                                              | 1           | MODER[15:0]   |
|        |                                                          | 0           | MODER[15:0]   |
| 0x00   | GPIOB_MODER                                              | 0           | MODER[15:0]   |
|        |                                                          | 0           | MODER[14:0]   |
| 0x00   | GPIO <sub>x</sub> _MODER<br>(where x = C..H)             | 0           | MODER[15:0]   |
|        |                                                          | 0           | MODER[14:0]   |
| 0x04   | GPIO <sub>x</sub> _OTYPER<br>(where x = A..H)            | 0           | MODER[15:0]   |
|        |                                                          | 0           | MODER[14:0]   |
| 0x08   | GPIO <sub>x</sub> _OSPEEDER<br>(where x = A..H except B) | 0           | OSPEEDR[15:0] |
|        |                                                          | 0           | OSPEEDR[14:0] |
| 0x08   | GPIOB_OSPEEDER                                           | 0           | OSPEEDR[15:0] |
|        |                                                          | 0           | OSPEEDR[14:0] |
| 0x20   | GPIO <sub>x</sub> _AFRL<br>(where x = A..H)              | 0           | AFRL7[3:0]    |
|        |                                                          | 0           | AFRL6[3:0]    |
| 0x24   | GPIO <sub>x</sub> _AFRH<br>(where x = A..H)              | 0           | AFRH15[3:0]   |
|        |                                                          | 0           | AFRH14[3:0]   |

Figure 3: SPI Registers

University of Dhaka  
 Department of Computer Science and Engineering  
 3<sup>rd</sup> Year 1<sup>st</sup>. Semester Final Examination, 2024  
 CSE-3104: Database Management Systems-II (3 Credits)

Total Marks: 70

Time: 3 Hours

[ Answer any 5 (five) of the following questions ]

- (a) Consider the following dataset, where *Batman* denotes the class label. Apply the decision tree classification algorithm to construct a decision support system. Also, identify the association rules that can be derived from the classification system. If it can be seen that, for an association rule, not all the tuples fall into the same class, express them as a percentage. For example, if  $X \Rightarrow 70$  of % Times satisfy  $Y$ . [8+2]

| Age Group | Income Group | Behaviour Pattern | Sleep Cycle             | Batman |
|-----------|--------------|-------------------|-------------------------|--------|
| Senior    | High         | Gentle            | Sleeps at Night         | No     |
| Senior    | Average      | Gentle            | Does not sleep at night | Yes    |
| Middle    | Low          | Gentle            | Sleeps at Night         | No     |
| Middle    | High         | Rude              | Sleeps at Night         | Yes    |
| Senior    | Low          | Rude              | Sleeps at Night         | No     |
| Youth     | High         | Rude              | Does not sleep at night | Yes    |
| Youth     | Low          | Gentle            | Sleeps at Night         | No     |
| Middle    | High         | Rude              | Sleeps at Night         | Yes    |
| Senior    | Average      | Gentle            | Does not sleep at night | Yes    |
| Middle    | Low          | Gentle            | Sleeps at Night         | No     |

- (b) Explain the architecture of data warehousing. For the given database schema, explain how the star schema for database warehousing works with the associated terminologies and the "measurement-related" query example. [2+2]

- *Student*(student\_id, age, gender, address\_id)
- *Address*(address\_id, district, area, thana, zip\_code)
- *School*(school\_id, name, address\_id)
- *Performance*(student\_id, school\_id, CGPA, attendance)

- (2) (a) Explain the four fundamental types of parallel database architecture. [4]

- (b) Discuss the algorithms related to the "Partitioned-Join" and "Fragment-and-replicate-Join" in the scenario of intra-operation parallelism. [4]

- (c) You are given the following database *D*. You want to sort this database in ascending order on the date of birth. Apply the "Range-Partitioning based Parallel Sorting Algorithm" to sort this database properly, identifying the state. Analyze the complexity of the computation in detail. Please consider these given constraints: Currently, *D* resides in a centralized database. You need to use two processors to distribute the workload and to process in parallel. [4+2]

| Name | Date of Birth | Name | Date of Birth  |
|------|---------------|------|----------------|
| A    | Feb 14, 2017  | F    | Feb 02, 2012   |
| B    | Jan 03, 2015  | G    | Sep 12, 1990   |
| C    | Mar 05, 1999  | H    | April 01, 1887 |
| D    | May 06, 2001  | I    | Mar 07, 1996   |
| E    | Aug 10, 1980  | J    | Jan 01, 2020   |

1920 - 2020  
 87 90 96 99  
 01 02 03 04  
 15 17

3. (d) Consider the following information:

**Database Schema:**

- *MatchStatistics*(match\_id, player\_id, num\_of\_goals)
- *PlayerInfo*(player\_id, team\_id, player\_name, player\_country, player\_height, player\_specialization)
- *TeamInfo*(team\_id, name, origin, budget, coach\_id)
- *CoachInfo*(coach\_id, name, origin, salary)

**Considerable Premises:**

- The *MatchStatistics* relation is at Site *S1*
- The *PlayerInfo* relation has been horizontally distributed at Site *S2* and *S3*, respectively
- The *TeamInfo* relation has been kept at Site *S4*
- The final output of the query has to be at Site *S1*.

Given the premise, outline the steps of the Semijoin strategy to resolve the query - "Name of the players of Team name *Y* with their total number of goals" [4]

- (b) Explain the processes related to Transaction System Processing. [4]

- (c) Explain the concept of the Two-Phase Commit Protocol (2PC) in ensuring atomicity in Distributed Processing. Additionally, discuss strategies for handling failures and recovery mechanisms in 2PC. [2+2+2]

- (a) Explain the joining of two relations using hashing on join attribute? [4]
- (b) With example differentiate between materialized evaluation and pipelined evaluation of a query? [3]
- (c) Consider the following relations of the *university* database. Then, design the best possible query evaluation plan for the query: "Find the names of all instructors in the CSE department, along with the titles of the courses that they teach in 2nd Semester in 2023". [4]
- *instructor*(ID, name, dept\_name, salary)
  - *teaches*(ID, course\_id, sec\_id, semester, year)
  - *course*(course\_id, title, dept\_name, credits)
- (d) Mention the steps in the typical heuristic optimization of a query. [3]
5. (a) Explain the algorithm of Merge Sort based on External Sorting. [4]
- (b) You are given the following two relations: Movie and Actors. Apply Natural Join over these two relations using "Nested Loop Join" and "Hash-Join". For "Hash-Join", you need to choose the first character as the hash function criterion to determine the bucket. For each join operation, simulate the algorithms, present the theoretical and actual costs. [3+3]

| Relations: Movie |          |          |          |
|------------------|----------|----------|----------|
| Movie_id         | Actor_id | Movie_id | Actor_id |
| 1                | AA       | 5        | AA       |
| 2                | BA       | 6        | CA       |
| 3                | BB       | 7        | BB       |
| 4                | CA       | 8        | BA       |

| Relations: Actors |            |
|-------------------|------------|
| Actor_id          | Actor_Name |
| AA                | Arnold     |
| BA                | Beethoven  |
| AB                | Nolan      |
| BB                | Farhad     |
| CA                | David      |

- (c) Explain the concept of Materialized Evaluation for the query:  $\Pi(\sigma(Movie) \bowtie \Pi(\sigma(Actor)))$  You can assume that proper conditioning and projection attributes have been set to successfully execute the query. [4]
- (a) What are the approaches of the data fragmentation in distributed database? What advantage you may gain by these approaches? [4]
- (b) Find the limitations of heterogeneous distributed databases. [3]
- (c) Differentiate 'Transaction Processing System' and 'Decision Support System'. [3]
- (d) What do you understand by multitable clustering file organization? Explain the advantages and disadvantages of this type of file organization. [4]
7. (a) Explain the concept of Dense and Sparse Indexing. [2]
- (b) Explain the use case of Column Oriented Data Representation in optimizing the cost of query execution. [2]
- (c) Explain the strategy of "Least Recently Used" in terms of Buffer Block Replacement policies. [2]
- (d) You are given the following Tabular Relation. If you create a secondary index on the Artist's Name attribute using a B+ Tree and Hash indexing, respectively, what would be the final representations of the relation? For each strategy, outline your steps in detail and present the final representations. Discuss the complexity of resolving range queries for each. As constraints, for the B+ Tree, each node can hold at most three key values, and for Hashing, there cannot be more than three buckets. [4+4]

| UID | Artist' Name | Song Name                  | Like Count  |
|-----|--------------|----------------------------|-------------|
| 101 | Elvis        | Can't Help Falling in Love | 1.7 million |
| 107 | Chris        | Scientist                  | 10 million  |
| 104 | Taylor       | Delicate                   | 3.5 million |
| 109 | Eric         | Wonderful Tonight          | 2 million   |
| 111 | Rose         | Apate                      | 11 million  |
| 110 | Bruno        | Uptown Funk                | 21 million  |
| 102 | Daniel       | Demons                     | 13 million  |
| 106 | Harry        | Story of Our Life          | 10 million  |
| 108 | Adele        | Rolling in the Deep        | 19 million  |
| 103 | Ed           | All of the Stars           | 2.7 million |