University of Dhaka
Department of Computer Science and Engineering
3rd Year 1st Semester Final Examination, 2023
CSE 3103– Microprocessor and Microcontroller (3 Credits)

Time: 3 Hours **Total Marks: 70**

Answer any five (5) out of the following seven (7) questions. Marks are given in the right margin.

1. (a) Identify the differences between Cortex-M3 and Cortex-M4 processor. Discuss the differences and improvements. (4)

   (b) What are instruction sets? Discuss the format of the instruction relevant to the Cortex-M3 architecture. (6)

   (c) Discuss the privileged and unprivileged modes of the Cortex-M4 architecture in the context of operation modes. (4)

2. (a) Register $R1$ has the value $0x80008001$, what is its value of $R1$ after the following operations are performed independently:
   (a) LSR R1,R1,#3
   (b) LSL R1,R1,#4
   (c) ASR R1,R1,#1 (3)

   (b) Convert the following ARM assembly code into machine language. Write the instructions in hexadecimal.
   (a) MOV R10, #68
   (b) STR R4, [R11, R8]
   (c) ASR R6, R7, R3 (6)

   (c) Consider the following ARM assembly language snippet. List the addressing mode used at each line of code. Calculate the effective address (EA) and mention the content of register for each instruction.
   (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 (5)

3. (a) Assume an interrupt with priority 12 is currently executing. During this, another interrupt with priority 5 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 draws diagrams of the resulting stack structure while handling both interrupts. (6)

   (b) What are the main causes to trigger a bus fault exception in Cortex M4 processor? Introduce all the associated registers with their functionality which will represent the fault status in such scenario. (3)

   (c) How does Cortex M4 handle "late arrival" exception behavior? Describe with a proper diagram. (3)

   (d) Describe different states of exception with proper example. (2)

4. (a) Identify the differences between Cortex-M3 and Intel x86 architecture. (7)

   (b) Describe the concept of paging in the Intel x86 architecture. Explain how paging facilitates virtual memory management and memory protection in x86-based systems. Also, discuss the flags relevant to Segmentation and Paging in x86-based architecture. (7)

5. (a) You are required to translate the following C statements into an equivalent sequence of ARM instructions (a and b are integer variables).

```
while (a - b > 0) {
if (a < -b) {
b = b - a;
a = -a;
} else {
b = a * b;
a = 2 - b;
}
}
```

(4)

(b) There are some optimizations that you can make e.g. keeping variables in registers, or using special instructions available on the ARM Cortex M4. For each optimization that you can apply to this example (answer of Q. 5(a)), illustrate it by explaining the changes that would have to be made to your original answer. In particular, you should discuss the use of conditional arithmetic instructions, and whether they would be an improvement in this example. (2)

(c) What literal is moved to R2 by the instruction: MVN R2, #0xff,6 ? (2)

(d) Write an assembly language program to implement the function which in a high-level language is **int find42(int array[], int size)**. **size** specifies the number of elements in **array**, and **array** specifies the base address of the array. The function should return the index number of the first array entry that holds the value 42. If no array entry is 42, it should return the value -1. (6)

6. About clock and timer configuration.

(a) The microcontroller connects an 8MHz external crystal, and its system clock configuration utilizes a clock generated from the microcontroller's PLLCLK module. The microcontroller has AHB1, APB1, and APB2 buses for connecting peripherals. The peripherals connected to the AHB1 bus require a 100MHz clock, while the APB2 and APB1 require 50MHz and 25MHz, respectively. Determine the prescaler values as provided in the following table. (4)

Sequence	Prescaler	Possible values
1	PLLM, PLLN, PLLP	$2 \leq$ PLLM ≤ 63, $50 \leq$ PLLN ≤ 432, PLLP $\in$ [2, 4, 6, *or* 8]
2	System Clock Mask	HSI, HSE, PLLCLK or PLLR
3	AHB Prescaler	HPRE $\in [2, 4, 8, 16, \cdots, 512]$
4	APB1 Prescaler	PPRE1 $\in [2, 4, 8, 16]$
4	APB2 Prescaler	PPRE2 $\in [2, 4, 8, 16]$

(b) The timer is an independent peripheral and is not influenced by the code running on the microprocessor unless the code modifies its configuration. A timer can generate PWM signals as needed by any application. One application lets 'AppX' need a PWM signal that comprises five pulses with duty cycles 20%, 25%, 35%, 40% and 50% accordingly. Determine the CCR1, Prescaler, and ARR registers values for the up counter setting of a timer to generate the PWM signal with the given pattern. Note that an MCU GPIO pin changes polarity (low to high or high to low) whenever the CNT register matches the CCR1 register value. Assume that the input clock of the timer is 90MHz, and the generated target pulses (five altogether) take exactly five microseconds. (5)

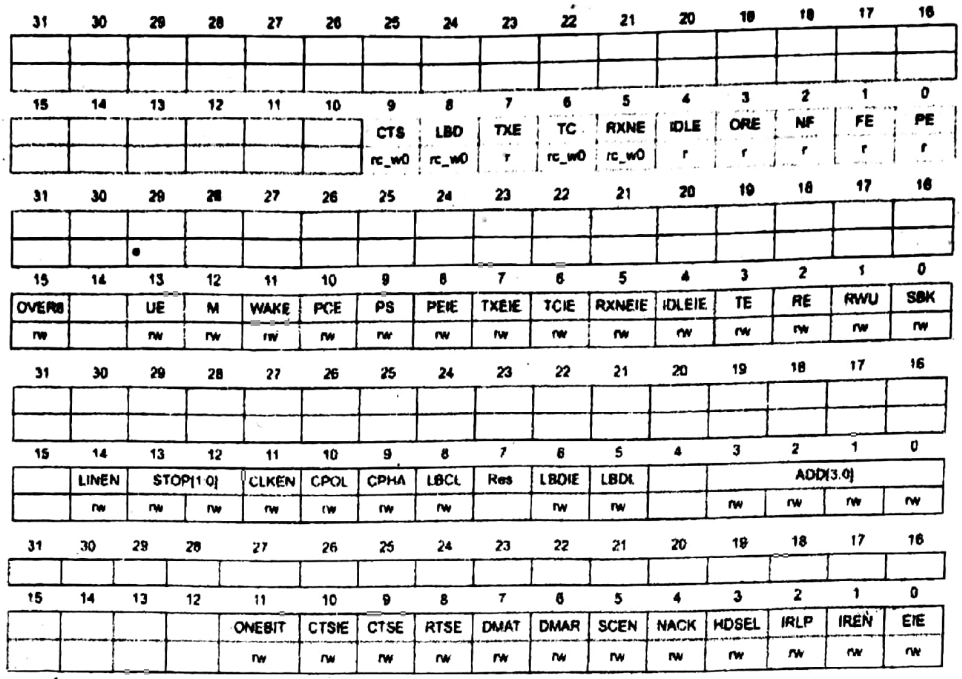
(c) Two pushdown switches (down represents '1') are connected to pin PA7 and PA9. Four LEDs are connected to GPIO port C (PC1, PC2, PC3, and PC4). Determine the values of RCC_AHB1ENR, GPIOx_MODER, GPIOx_OTYPER, GPIOx_OSPEEDR registers. Write a segment of code to recognize the input switches combinations, such as to light on LEDs following the conditions given in the following table. Assume that bit-'0' to bit-7 must be configured to enable GPIOA to GPIOH on APBxENR. Starting from bit-'0' to bit-31 (2-bit for each pin) of GPIOx_SPEEDR and GPIO_MODER registers represent pin '0' to '15'. However, bit-'0' to bit-'15' needs to configure for pin-'0' to pin-'15' of GPIOx_OTYPER register. In addition, bit-'0' to '15' for set and '16' to '31' reset the 16 GPIO pins on register BSRR. Note: LED ready for connect will glow when MCU pulldown the pin, which means other side of LED connected to the +VCC. (5)

Input (PA5 PA6)	LED Status (PB1 PB2 PB3 PB4)
00	on off off off
01	off on off off
10	off off on off
11	off off off on

7. Answer the following questions based on UART deployment in the STM32F446re microcontroller.

(a) A UART slave device is connected to the MCU, and MCU can read from and write values to the device registers. MCU writes value to the register of the slave device primarily to configure the device and reads a register value from the device (such as sensing the speed of the jet engine of an aircraft). However, the device only accepts a baud rate of exactly 1MBps. Determine the mantissa and fractional values for the USARTx_BRR register to set the baud rate. Assume that the register accepts 12-bits for mantissa and only 4-bits for the fractional value. (3)

(b) Write a program to set up UART communication with the Aircraft Engine at a baud rate of 1 Mbps. When the Aircraft Engine receives 0x5C, it should send 3 KBytes of consecutive data to the MCU. This data should include the engine's speed (in rpm), engine-health information, angle to the ground, flight time, height from the sea level, and GPS position. The MCU uses USART6 with PC6 for Tx and PC7 for Rx, and the alternate function for PC6 and PC7 is AF8 (0x08). The registers for the alternate function are GPIOx_AFRL for pins 0 to 7 and GPIOx_AFRH for pins 8 to 15. Additionally, please note that RCC_APB2ENR bits 4 and 5 should be enabled for USART1 and 6 clocks. The USART registers are as follows: SR, CR1, CR2, CR3. (8)



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
						CTS	LBD	TXE	TC	RXNE	IDLE	ORE	NF	FE	PE
						rc_w0	rc_w0	r	rc_w0	rc_w0	r	r	r	r	r

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
OVERS		UE	M	WAKE	PCE	PS	PEIE	TXEIE	TCIE	RXNEIE	IDLEIE	TE	RE	RWU	SBK
rw		rw	rw	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

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	LINEN	STOP[1:0]		CLKEN	CPOL	CPHA	LBCL	Res	LBDIE	LBDL		ADD[3:0]			
	rw	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

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
				ONEBIT	CTSIE	CTSE	RTSE	DMAT	DMAR	SCEN	NACK	HDSEL	IRLP	IREN	EIE
				rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw

(c) Write the consequence while the Aircraft sends the 3KBytes in one UART frame. Explain the action the Aircraft should take in this circumstance. (3)

Data processing immediate shift	*(cond)* [1] 0 0 0 *(opcode)* S R(n) R(d) *(shift amount)* *(shift)* 0 R(m)
Miscellaneous instructions	*(cond)* [1] 0 0 0 1 0 x x 0 x x x x x x x x x x x x 0 x x x x
Data processing register shift [2]	*(cond)* [1] 0 0 0 *(opcode)* S R(n) R(d) R(s) 0 *(shift)* 1 R(m)
Miscellaneous Instructions	*(cond)* [1] 0 0 0 1 0 x x 0 x x x x x x x x x x x x 0 x x 1 x x x x
Multiplies, extra load/stores	*(cond)* [1] 0 0 0 x x x x x x x x x x x x x x x x 1 x x 1 x x x x
Data processing immediate [2]	*(cond)* [1] 0 0 1 *(opcode)* S R(n) R(d) *(rotate)* *(immediate)*
Undefined instruction [3]	*(cond)* [1] 0 0 1 1 0 x 0 0 x x x x x x x x x x x x x x x x x x x x
Move immediate to status register	*(cond)* [1] 0 0 1 1 0 R 1 0 *(Mask)* *(SBO)* *(rotate)* *(immediate)*
Load/store immediate offset	*(cond)* [1] 0 1 0 P U B W L R(n) R(d) *(immediate)*
Load/store register offset	*(cond)* [1] 0 1 1 P U B W L R(n) R(d) *(shift amount)* *(shift)* 0 R(m)
Undefined instruction	*(cond)* [1] 0 1 1 x x x x x x x x x x x x x x x x x x x x 1 x x x x
Undefined instruction [4,7]	1 1 1 1 x x x x x x x x x x x x x x x x x x x x x x x x
Load/store multiple	*(cond)* [1] 1 0 0 P U S W L R(n) *(register list)*
Undefined instruction [4]	1 1 1 1 1 0 0 x x x x x x x x x x x x x x x x x x x x x x x x
Branch and branch with link	*(cond)* [1] 1 0 1 L *(24-bit offset)*
Branch and change to Thumb [4]	1 1 1 1 1 0 1 H *(24-bit offset)*
Copro load/store [6]	*(cond)* [5] 1 1 0 P U N W L R(n) CR(d) *(cp_num)* *(8-bit offset)*
Copro data processing	*(cond)* [5] 1 1 1 0 *(opcode1)* CR(n) CR(d) *(cp_num)* *(opcode2)* 0 CR(m)
Copro register transfer	*(cond)* [5] 1 1 1 0 *(opcode1)* L CR(n) R(d) *(cp_num)* *(opcode2)* 1 CR(m)
Software interrupt	*(cond)* [1] 1 1 1 1 *(sw number)*
Undefined [4]	1 1 1 1 1 1 1 1 x x x x x x x x x x x x x x x x x x x x x x x x

Figure 3-1 The ARM Instruction Set Summary

Figure 1:

Opcode	Instruction
0000	AND
0001	EOR
0010	SUB
0100	ADD
0101	ADC
0110	SBC
1010	CMP
1100	ORR
1101	MOV /Shift
1110	BIC

sh	Instruction
00	LSL
01	LSR
10	ASR
11	ROR

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
DIV_Mantissa[11:0]												DIV_Fraction[3:0]			
rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw

USART BRR

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
OVER8		UE	M	WAKE	PCE	PS	PEIE	TXEIE	TCIE	RXNEIE	IDLEIE	TE	RE	RWU	SBK
rw		rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw

USART CR1

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
	LINEN	STOP[1:0]		CLKEN	CPOL	CPHA	LBCL	Res.	LBDIE	LBDL		ADD[3:0]			
	rw	rw	rw	rw	rw	rw	rw		rw	rw		rw	rw	rw	rw

USART CR2

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
				ONEBIT	CTSIE	CTSE	RTSE	DMAT	DMAR	SCEN	NACK	HDSEL	IRLP	IREN	EIE
				rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw

USART CR3

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
						CTS	LBD	TXE	TC	RXNE	IDLE	ORE	NF	FE	PE
						rc_w0	rc_w0	r	rc_w0	rc_w0	r	r	r	r	r

USARTX SR

Data processing immediate shift	⟨*cond*⟩[1] 0 0 0 ⟨*opcode*⟩ S R(*n*) R(*d*) ⟨*shift amount*⟩ ⟨*shift*⟩ **0** R(*m*)
Miscellaneous instructions	⟨*cond*⟩[1] 0 0 0 **1 0** x x **0** x x x x x x x x x x x x x x **0** x x x x
Data processing register shift [2]	⟨*cond*⟩[1] 0 0 0 ⟨*opcode*⟩ S R(*n*) R(*d*) R(*s*) 0 ⟨*shift*⟩ 1 R(*m*)
Miscellaneous Instructions	⟨*cond*⟩[1] 0 0 0 **1 0** x x **0** x x x x x x x x x x x **0** x x **1** x x x x
Multiplies, extra load/stores	⟨*cond*⟩[1] 0 0 0 x x x x x x x x x x x x x x x x **1** x x **1** x x x x
Data processing immediate [2]	⟨*cond*⟩[1] 0 0 1 ⟨*opcode*⟩ S R(*n*) R(*d*) ⟨*rotate*⟩ ⟨*immediate*⟩
Undefined instruction [3]	⟨*cond*⟩[1] 0 0 1 **1 0** x **0 0** x x x x x x x x x x x x x x x x
Move immediate to status register	⟨*cond*⟩[1] 0 0 1 **1 0** R **1 0** ⟨*Mask*⟩ ⟨*SBO*⟩ ⟨*rotate*⟩ ⟨*immediate*⟩
Load/store immediate offset	⟨*cond*⟩[1] 0 1 0 P U B W L R(*n*) R(*d*) ⟨*immediate*⟩
Load/store register offset	⟨*cond*⟩[1] 0 1 1 P U B W L R(*n*) R(*d*) ⟨*shift amount*⟩ ⟨*shift*⟩ **0** R(*m*)
Undefined instruction	⟨*cond*⟩[1] 0 1 1 x x x x x x x x x x x x x x x x x x x **1** x x x x
Undefined instruction [4,7]	1 1 1 1 0 x x x x x x x x x x x x x x x x x x x x x x x x
Load/store multiple	⟨*cond*⟩[1] 1 0 0 P U S W L R(*n*) ⟨*register list*⟩
Undefined instruction [4]	1 1 1 1 1 0 0 x x x x x x x x x x x x x x x x x x x x x x x
Branch and branch with link	⟨*cond*⟩[1] 1 0 1 L ⟨*24-bit offset*⟩
Branch and change to Thumb [4]	1 1 1 1 1 0 1 H ⟨*24-bit offset*⟩
Copro load/store [6]	⟨*cond*⟩[5] 1 1 0 P U N W L R(*n*) CR(*d*) ⟨*cp_num*⟩ ⟨*8-bit offset*⟩
Copro data processing	⟨*cond*⟩[5] 1 1 1 0 ⟨*opcode1*⟩ CR(*n*) CR(*d*) ⟨*cp_num*⟩ ⟨*opcode2*⟩ 0 CR(*m*)
Copro register transfer	⟨*cond*⟩[5] 1 1 1 0 ⟨*opcode1*⟩ L CR(*n*) R(*d*) ⟨*cp_num*⟩ ⟨*opcode2*⟩ 1 CR(*m*)
Software interrupt	⟨*cond*⟩[1] 1 1 1 1 ⟨*swi number*⟩
Undefined [4]	1 1 1 1 1 1 1 1 x x x x x x x x x x x x x x x x x x x x x x x x

Figure 3-1 The ARM Instruction Set Summary

University of Dhaka
Department of Computer Science and Engineering
3rd Year 1st Semester Final Examination, 2023
CSE3102: Software Engineering (3 Credits)

Time: 3 hours **Total Marks: 70**

Answer any five (5) out of the following seven (7) questions. Marks are given in the right margin.

1 (a) Describe two disadvantages with the traditional Waterfall Life-Cycle Model. For each of these disadvantages, explain how a project using evolutionary model can avoid them. [5]

(b) Draw spiral model as a UML activity diagram. Compare the readability of the original figure of spiral model with the activity diagram. [4]

(c) Describe how testing activities can be initiated well before implementation activities. Explain why this is desirable. [5]

2 (a) Write formal use case description for the activity "*reading message in a voice mail system*". [4]

(b) Consider the normal operation of an ATM machine. The typical scenarios are: a customer inserts the card, enters his/her PIN, enters the amount, takes the card, takes/deposits/transfers the money etc. Identify the main actors and give four use-cases. [6]

(c) Develop a state/swim-lane diagram based on the following narrative. The purpose of the Open Access Insurance System is to provide automotive insurance to car owners. Initially, prospective customers fill out an insurance application, which provides information about the customer and his or her vehicles. This information is sent to an agent, who sends it to various insurance companies to get quotes for insurance. When the responses return, the agent then determines the best policy for the type and level of coverage desired and gives the customer a copy of the insurance policy proposal and a quote. [4]

3 (a) Write one functional and one non-functional requirement of a mail management client, for instance, MS Outlook. Give two reasons as to why it is a good idea to classify and separate functional requirements and non-functional requirements in a requirements specification document. [4]

(b) A supermarket needs to develop a software to encourage regular customers. For this, the customer needs to supply his name, address and telephone number. A customer is assigned a unique customer number (CN) by the computer. When a customer makes a purchase, the value of the purchase is credited against his CN. At the end of each year, surprise gifts to 10 customers who have made the highest purchase are given. In addition, gold coin is given to every customer who has made a purchase over Taka 80,000/- a month on an average. [6]

Identify functional and non-functional requirements of the above system.

(c) Maintaining traceability during requirements and subsequent activities is expensive, because the additional information that must be captured and maintained. What are the benefits of traceability that outweigh this overhead? [4]

4 (a) What is wrong with the following design from the perspective of cohesion, and what could be done to improve them? [6]

In an electronic commerce application, a module is created to add books to the '~~shipping~~ shopping basket' and perform such operation as computing the total amount the customer owes. A second module adds '*special reward*' merchandise to the shopping basket: this module also display the contents of the shopping basket on the screen and sends an email to the user telling him or her what he or she bought.

(b) Explain why content coupling is more undesirable than data coupling. [3]

(c) Assuming one of your design goals is to *enable future developers to substitute the planning algorithm that decides on the next move with a better one*. Which design pattern would you consider to satisfy the goal and why? [5]

5 (a) Suppose we want to develop software for a graphic package and we are given the task to implement *circle* class. The *circle* class has to be translatable from its origin. It should also be able to give perimeter and area of the circle. Identify the data and method requirements for the class. Give the data flow of *translation* method. [5]

(b) A company consists of departments. Departments are located in one or more offices. One office acts as headquarter. Each department has a manager who is recruited from the set of employees. Draw a class diagram with the classes in your system their attributes, operations and relationships. [5]

(c) Explain three different advantages and/or disadvantages of a layered architecture. [4]

6 (a) Below is a graph defined by the set of nodes, initial nodes, final nodes, edges, and *defs* and *uses*. The graph also contains a collection of test paths. List a minimal test set that satisfies *all-defs* coverage with respect to x. Use the given test paths. [4]

$N = \{1, 2, 3, 4, 5, 6\}$
$N_0 = \{1\}$
$N_f = \{6\}$
$E = \{(1, 2), (2, 3), (3, 4), (3, 5), (4, 5), (5, 2), (2, 6)\}$
$def(x) = \{1, 4\}$
$use(x) = \{3, 5, 6\}$
Test Paths:
$t_1 = [1, 2, 3, 5, 2, 6]$
$t_2 = [1, 2, 3, 4, 5, 2, 6]$

For questions from *b* to *d*, use the following program fragment.

```
w = x; // node 1
if (m > 0) {
   w++; // node 2
}
else {
   w=2*w; // node 3
}
// node 4 (no executable statement)
if (y <= 10) {
   x = 5*y; // node 5
}
else {
   x = 3*y+5; // node 6
}
z = w + x; // node 7
```

(b) Draw a control flow graph for this program fragment. Use the node numbers as given. [2]

(c) Which nodes have *defs* for variable w? Which nodes have *uses* for variable w? [2+2]

(d) Are there any *du-paths* with respect to variable w from node 1 to node 7? If not, explain why. If any exists, show one. [4]

7 (a) What are the main components considered when creating a project schedule? Explain their importance. [3]

(b) How to calculate unadjusted function point using different function types? Explain the associated weight factors. [4]

(c) Describe three deployment strategies that can be used to introduce a new software application. [5]

(d) What are the problems of general COCOMO model? [2]

University of Dhaka
Department of Computer Science and Engineering
3rd Year 1st Semester Final Examination 2023
CSE 3101 - Computer Networking (3 Credits)

Time: 3 Hours **Total Marks: 70**

Answer any five (5) out of the following seven (7) questions.

1. (a) (6 points) Define traffic intensity. Suppose N packets arrive at a router simultaneously every $(L/R)N$ seconds. Identify the queuing delay for the first packet in this burst. Express the queuing delay for the n^{th} packet.

   (b) (4 points) Illustrate, with the help of an example, the differences between 'throughput' and 'goodput' of a transmission link.

   (c) (4 points) When a file is transferred between two computers, two acknowledgement strategies are possible. In the first one, the file is chopped up into packets, which are individually acknowledged by the receiver. In the second one, the packets are not acknowledged individually, but the entire file is acknowledged when it arrives. Compare and contrast these two approaches.

2. (a) (4 points) Most major commercial websites use cookies today. Identify four key components of cookie technology and state their functional purposes.

   (b) (5 points) "Although web caching can reduce user-perceived response times, it introduces a new problem — the copy of an object residing in the cache may be stale." - Explain the problem and its effect. Describe in detail a process to mitigate the problem.

   (c) (5 points) "A feature of HTTP/2 is the ability for a server to send multiple responses for a single request from a client." - Do you support this statement? If no, justify your answer. If yes, explain its detailed operational process.

3. (a) (5 points) In HTTP streaming, the video is simply stored at an HTTP server as an ordinary file with a specific URL. When a user wants to see the video, the client establishes a TCP connection with the server and issues an HTTP GET request for that URL. State the key limitation of this process in transferring multimedia content. How can it be addressed by using the DASH protocol? Describe in your own words.

   (b) (5 points) Consider a packet of length L that begins at router A and travels over three links to a destination router B. Suppose the packet is 1500 bytes. The propagation speed on all three links is 2.5×10^8 m/s and the transmission rates of all three links are 2.5 Mbps. The packet switch processing delay of all the routers is 3 ms. If the lengths of the first, second, and third links are 5000 km, 4000 km, and 1000 km respectively, analyze the scenario and calculate the end-to-end delay.

   (c) (4 points) What is the basis of classification for the four types of links defined by OSPF? Why do OSPF messages propagate faster than RIP messages?

4. (a) (4 points) Suppose Host A sends two TCP segments back to back to Host B over a TCP connection. The first segment has sequence number 2048; the second has sequence number 2560. How much data is in the first segment? Suppose that the first segment is lost but the second one arrives at B. In the acknowledgment that Host B sends to Host A, what will be the acknowledgment number? [Consider default headers in each case]

   (b) (3 points) Write down the process of calculating 'Timeout' period for a TCP sender using EWMA formula.

   (c) (4 points) Find the topology of the network if the following table is the routing table for router R1.

Mask	Network Address	Next-Hop Address	Interface
/27	202.14.17.224	–	m1
/18	145.23.192.0	–	m0
Default	Default	130.56.12.4	m2

   (d) (3 points) Referring to the above routing table, is it possible to receive a packet with destination address 140.24.7.194? Please justify your answer.

5. (a) (4 points) Compare and contrast the IPv4 and the IPv6 header fields. State the reasons of eliminating or updating the fields 'Segmentation and Reassembly', 'IP header checksum', and 'Source and Destination addresses' of IPv4.

   (b) (4 points) Suppose an application generates chunks of 40 bytes of data every 20 ms, and each chunk gets encapsulated in a TCP segment and then an IP datagram. What percentage of each datagram will be overhead, and what percentage will be application data?

(c) (6 points) The BGP protocol uses an extended version of hot-potato routing. For any given destination prefix, the input into BGP's route-selection algorithm is the set of all routes to that prefix that have been learned and accepted by the router. If there is only one such route, then BGP selects that route. If there are two or more routes to the same prefix, then a set of elimination rules is applied. List down them sequentially.

6. (a) (4 points) Consider a three-node topology with the link costs $c(x, y) = 3$, $c(y, z) = 6$, and $c(z, x) = 4$. Compute the distance vector tables after the initialization step and after each iteration of a synchronous version of the distance-vector algorithm.

(b) (4 points) Suppose that your organization purchased a large network 200.100.0.0/16 and eight organizations named A through H request approximately 1000 IP addresses each. For these organizations, calculate the network addresses, first IP address assigned and the subnet mask in w.x.y.z/s notation.

(c) (4 points) "A Software Defined Network (SDN) represents a significant 'unbundling' of network functionality - data plane switches, SDN controllers, and network-control applications are now separate entities that may each be provided by different vendors and organizations." Explain the above statement and contrast SDN and the traditional model of data routing.

(d) (2 points) What types of messages flow across an SDN controller's northbound and southbound APIs? Who is the recipient of these messages sent from the controller across the southbound interface, and who sends messages to the controller across the northbound interface?

7. (a) (4 points) Describe the similarities and differences in tunnel configuration when a mobile device is resident in its home network, versus when roaming in a visited network.

(b) (3 points) Suppose an IEEE 802.11b station (operating at 11Mbps channel) is configured to always reserve the channel with the RTS/CTS sequence. Suppose that this station suddenly wants to transmit 1500 bytes of data and all other stations are idle at this time. As a function of SIFS ($10\mu s$) and DIFS ($30\mu s$), and ignoring propagation delay and assuming no bit errors, calculate the time required to transmit the frame.

(c) (4 points) What is the role of the Mobility Management Entity (MME) in 4G/5G cellular architecture? With which other 4G/5G network elements (mobile device, base station, HSS, Serving Gateway Router, PDN Gateway Router) does it directly communicate with in the control plane? In the data plane? State purposes.

(d) (3 points) State the differences between direct and indirect routing of datagrams to and from a roaming mobile host.

University of Dhaka
Department of Computer Science and Engineering
3rd Year 1st Semester Final Examination, 2023
MATH3105: Multivariable Calculus and Geometry (3 Credits)

Time: 3 hou s **Total Marks: 70**

Answer any five (5) out of the following seven (7) questions. Marks are given in the right margin.

1 (a) Green's Theorem states that — **[5]**
Let C be a positively oriented, piecewise-smooth, simple closed curve in the plane and let D be the region bounded by C. If P and Q have continuous partial derivatives on an open region that contains D, then

$$\int_C P\,dx + Q\,dy = \int \int_D \left(\frac{\partial Q}{\partial x} - \frac{\partial P}{\partial y}\right) dA$$

Proof this equation when D is a simple region.

(b) The position of an object with mass m at time t is $< at^2, bt^3, 0 >$ when $0 \le t \le 1$. **[5]**
I. What is the force acting on the object at time t?
II. What is the work done by the force during the time interval $0 \le t \le 1$?

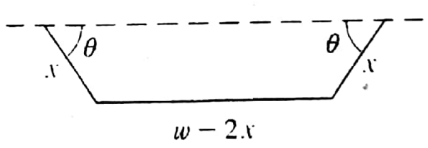
(c) If $F(x, y, z) = < y^2, 2xy + e^{3z}, 3ye^{3z} >$, find a function f such that $\nabla f = F$. **[4]**

2 (a) A metal plate is situated in the xy-plane and occupies the rectangle $0 \le x \le 10, 0 \le y \le 8$, where x and y are measured in meters. The temperature at the point (x,y) in the plate is $T(x,y)$, where T is measured in degrees Celsius. Temperatures at equally spaced points were measured and recorded in the table. **[6]**

x \ y	0	2	4	6	8
0	30	38	45	51	55
2	52	56	60	62	61
4	78	74	72	68	66
6	98	87	80	75	71
8	96	90	86	80	75
10	92	92	91	87	78

Find a linear approximation to the temperature function near the point (6,4). Then use it to estimate the temperature at the point (5, 3.8).

(b) A long piece of galvanized sheet metal with width w is to be bent into a symmetric form with three straight sides to make a rain gutter. A cross-section is shown in the figure. **[8]**



I. Determine the dimensions that allow the maximum possible flow; that is, find the dimensions that give the maximum possible cross-sectional area.
II. Would it be better to bend the metal into a gutter with a semicircular cross-section?

3 (a) A lamp has three bulbs, each of a type with an average lifetime of 800 hours. If we model the probability of failure of the bulbs by an exponential density function with mean 800, find the probability that all three bulbs fail within a total of 1000 hours. **[6]**

(b) If $\boldsymbol{a}$, $\boldsymbol{b}$, and $\boldsymbol{c}$ are constant vectors, $\boldsymbol{r}$ is the position vector $x\boldsymbol{i} + y\boldsymbol{j} + z\boldsymbol{k}$, and $\boldsymbol{E}$ is given by the inequalities $0 \le \boldsymbol{a}.\boldsymbol{r} \le \alpha, 0 \le \boldsymbol{b}.\boldsymbol{r} \le \beta, 0 \le \boldsymbol{c}.\boldsymbol{r} \le \gamma$, show that **[8]**

$$\int \int \int_E (\boldsymbol{a}.\boldsymbol{r})(\boldsymbol{b}.\boldsymbol{r})(\boldsymbol{c}.\boldsymbol{r})dV = \frac{(\alpha\beta\gamma)^2}{8|\boldsymbol{a}.(\boldsymbol{b}\times\boldsymbol{c})|}$$

4 (a) Find the volume of the solid enclosed by the hyperboloid $-x^2 - y^2 + z^2 = 1$ and the plane $z = 2$. [4]

(b) Find the average value of the function $f(x, y, z) = xyz$ over the cube with side length that lies in the first octant with one vertex at the origin and edges parallel to the coordinate axes. [5]

(c) The ellipsoid $4x^2 + 2y^2 + z^2 = 16$ intersects the plane $y = 2$ in an ellipse. Find the parametric equations for the tangent line to this ellipse at the point (1, 2, 2). [5]

5 (a) The length x of a side of a triangle is increasing at a rate of 3 m/s, the length y of another side is decreasing at a rate of 2 m/s, and the contained angle θ is increasing at a rate of 0.05 radian/s. How fast is the area of the triangle changing when $x = 40$m, $y = 50$m and $\theta = \pi/6$? [6]

(b) A boatman wants to cross a canal that is 3 km wide and wants to land at a point 2 km upstream from his starting point. The current in the canal flows at 3.5 km/hour and the speed of his boat is 13km/hour. [5]

I. In what direction should he steer?

II. How long will the trip take?

(c) Find the angle between the diagonal of a cube and one of its edges using the concept of vector dot product. [3]

6 (a) Consider a lamina that occupies the region D bounded by the parabola $x = 1 - y^2$ and the coordinate axes in the first quadrant with density function $\rho(x, y) = y$. [8]

I. Find the mass of the lamina.

II. Find the center of mass.

III. Find the moments of inertia and radii of gyration about the x- and y-axes.

(b) The double integral $\int_0^1 \int_0^1 \frac{1}{1-xy} dxdy$ is an improper integral and could be defined as the limit of double integrals over the rectangle $[0, t] \times [0, t]$ as $t \to 1^-$. But if we expand the integrand as a geometric series, we can express the integral as the sum of an infinite series. Show that [6]

$$\int_0^1 \int_0^1 \frac{1}{1-xy} dxdy = \sum_{n-1}^{\infty} \frac{1}{n^2}$$

7 (a) A surface consists of all points P such that the distance from P to the plane $y = 1$ is twice the distance from P to the point $(0, -1, 0)$. Find an equation for this surface and identify it. [5]

(b) Find an equation of the largest sphere that passes through the point (-1,1,4) and is such that each of the points (x, y, z) inside the sphere satisfies the condition: [5]

$$x^2 + y^2 + z^2 < 136 + 2(x + 2y + 3z)$$

(c) Find a unit vector perpendicular to the plane that passes through the points P(1, -1, 1), Q(-2, 5, -1) and R(1, 4, 6). [4]