University of Dhaka
Department of Computer Science and Engineering
3rd Year 1st Semester Final Examination, 2022
CSE-3101: Computer Networking (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) "Circuit switching pre-allocates transmission link capacity regardless of user demand, with allocated but unneeded link time going unused". Explain this statement and justify the effectiveness of packet switching to overcome this problem. [3]

(b) In the Internet architecture, access ISPs provide connections to the end system users in residential and office areas. Each access ISP typically gets connected to the outer world through one or more global transit ISPs. Do you think introducing the concept of multi-homing for connecting access ISPs to global transit ISPs would be beneficial for the users? Explain the reasons behind your answer. [3]

(c) Consider two hosts, A and B, connected by a single link of rate R bps. Suppose that the two hosts are separated by m meters, and suppose the propagation speed along the link is s meters/sec. Host A is to send a packet of size L bits to Host B. [4]
   (i)   Ignoring processing and queuing delays, obtain an expression for the end-to-end delay.
   (ii) Suppose Host A begins to transmit the packet at time $t = 0$. At time $t = d_{trans}$, where is the last bit of the packet?
   (iii) Suppose d_{prop} is greater than d_{trans}. At time $t = d_{trans}$, where is the first bit of the packet?
   (iv) Suppose $s = 2.5 \times 10^8$, $L = 1500$ bytes, and $R = 10$ Mbps. Find the distance m so that d_{prop} equals d_{trans}.

(d) A socket is an Application Programming Interface (API). An application developer controls everything on the socket's application-layer side but has little control of its transport-layer side. Draw a figure representing this interface, identify the parameters involved on both sides, and explain the principle of client-server communication using sockets. [4]

2 (a) Consider an HTML-based web page in a server containing a large video clip near the top of the page and many small objects below the video. Suppose a single TCP connection of HTTP/1.0 has been established to transfer the contents from the server to a client. [5]
   (i)   Describe the problem that will be encountered by the small objects.
   (ii) Does HTTP/1.1 support addressing this problem by opening multiple parallel TCP connections? Explain.
   (iii) Describe how frame-interleaving of HTTP/2.0 can help to solve this problem.

(b) Suppose Afsana is connected with the mail server mail.cse.du.ac.bd and she wants to send an email to her friend Barira who is attached to mail.egineering.mit.edu. Discuss the operation principles of the protocols involved in this communication with the help of necessary figures. [5]

(c) Is FTP a stateful protocol? Justify your answer. [2]

(d) How can CNAME records of the DNS system help to distribute loads among many servers of Gmail? Briefly explain. [2]

3 (a) The key limitation of traditional HTTP streaming protocol is that it does not care about the amount of bandwidth available to a client, both across different clients and also over time with the same client. This observation has given birth to a new protocol, namely DASH (Dynamic Adaptive Streaming Over HTTP Protocol). Describe the working principle of DASH protocol and its advantages. [4]

(b) Suppose Host B receives two TCP segments back-to-back from Host A over a TCP connection. The first segment has the sequence number 1580 and the second has the sequence number 3760. [4]
   (i)   Investigate the amount of data sent in the first segment.
   (ii) Suppose the first segment is lost but the second segment arrives at B. In the acknowledgement that Host B sends to Host A, analyze the acknowledgement number in the second segment with proper justifications and a suitable diagram.

(c) Suppose that five measured *SampleRTT* values are 106 ms, 120 ms, 140 ms, 90 ms, and 115 ms. Compute the *EstimatedRTT* after each of these *SampleRTT* values is obtained, using a value of $\alpha = 0.125$ and assuming that the initial value of *EstimatedRTT* was 100 ms. Compute also the *DevRTT* after each sample is obtained, assuming a value of $\beta = 0.25$ and assuming the initial value of *DevRTT* was 5 ms. Last, compute the TCP *TimeoutInterval* after each of these samples is obtained. [3]

(d) TCP and UDP use 1's complement scheme for computing checksum. With this scheme, is it possible that a 1-bit error will go undetected? How about a 2-bit error? Analyze with proper examples. [3]

4 (a) The network layer activities can be broadly divided into the data plane and control plane. List down their specific functionalities. **[2]**

(b) Suppose you purchase a wireless router and connect it to your cable modem. Also, suppose that your ISP dynamically assigns your wireless router one IP address and you have five hosts at home that use 802.11 to wirelessly connect to your wireless router. How are IP addresses assigned to the devices? Does the wireless router use NAT? Why or why not? **[3]**

(c) Compare and contrast the Ipv4 and the Ipv6 header fields. Discuss the effectiveness of the new fields in the Ipv6 header. **[3]**

(d) Define generalized forwarding adopted by Software-Defined Networking. How does this differ from destination-based forwarding? Explain. **[3]**

(e) Write down the differences between RR and WFQ packet scheduling. Is there any case where RR and WFQ will behave exactly the same? Explain with the help of an example. **[3]**

5 (a) Compare and contrast link state and distance vector routing algorithms. **[3]**

(b) Define an Autonomous System (AS) of the Internet. Does it reduce the route computation complexity of the Internet? Justify your answer. **[3]**

(c) In BGP, a prefix along with its attributes is called a route. In determining the best route, the BGP of a router exploits a set of attributes including AS-PATH, NEXT-HOP, and LOCAL PREFERENCE. For any given destination prefix, the input to BGP's route selection algorithm is the set of all routes to that prefix that have been learned and accepted by the router. Given that there are two or more routes to the same prefix, write down the four steps that are followed to find out the best one. **[4]**

(d) Figure 1 shows six interconnected ASs, where W, X, and Y are access ISPs and A, B, and C are backbone provider networks. All traffic entering an ISP access network must be destined for that network, and all traffic leaving an ISP access network must have originated in that network. **[4]**
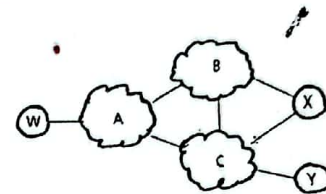

Figure-1

  (i) When implementing BGP routing policy, how will X be preventing from forwarding traffic between B and C?
  (ii) How does B implement its routing policy so that it forwards traffic from X toward W and restricts the same from C?

6 (a) Define the hidden terminal problem. List down its major causes. Discuss one way to address it. **[4]**

(b) With the help of the necessary figure(s), illustrate the role of binary exponential backoff in reducing collision in the CSMA/CA wireless networks. **[3]**

(c) Describe the two possible sleep modes of a 4G/5G mobile device. In each of these sleep modes, will the mobile device remain associated with the same base station between the time it goes to sleep and the time it wakes up and first sends/receives a new datagram? **[4]**

(d) State role of the Mobility Management Entity (MME) in 4G/5G cellular architecture. With which other 4G/5G network elements does it directly communicate with in the control plane? Describe. **[3]**

7 (a) Suppose Alice has a message that she is ready to send to anyone who asks, but each wants to be sure of the integrity of the message. In this context, do you think a MAC based or a digital-signature-based integrity scheme is more suitable? Why? **[3]**

(b) Suppose Bob initiates a TCP connection to Trudy who is pretending to be Alice. During the handshake, Trudy sends Bob Alice's certificate. In what step of the TLS handshake algorithm will Bob discover that he is not communicating with Alice? Briefly explain. **[3]**

(c) Consider RSA with $p = 5$ and $q = 11$. Find n and z. Let e be 3. Why is this an acceptable choice for e? Find d such that $de = 1 \pmod z$ and $d < 160$. Encrypt the message $m = 8$ using the key (n, e). **[4]**

(d) In the *BitTorrent* P2P file distribution protocol, the seed breaks the file into blocks, and the peers redistribute the blocks to each other. Without any protection, an attacker can easily wreak havoc in a torrent by masquerading as a benevolent peer and sending bogus blocks to a small subset of peers in the torrent. These unsuspecting peers then redistribute the bogus blocks to other peers, which in turn redistribute the bogus blocks to even more peers. Thus, it is critical for BitTorrent to have a mechanism that allows a peer to verify the integrity of a block, so that it doesn't redistribute bogus blocks. Assume that when a peer joins a torrent, it initially gets a *.torrent* file from a fully trusted source. Describe a simple scheme that allows peers to verify the integrity of blocks. **[4]**

University of Dhaka
Department of Computer Science and Engineering
3rd Year 1st Semester Final Examination, 2022
CSE-3102: 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) There are two major views of software development lifecycle: activity-oriented view and entity-oriented view. Give the combined view and show how the activities are related with the deliverables. **[5]**

(b) Briefly describe the fundamental distinctions between the spiral model and the waterfall model. **[4]**

(c) When is evolutionary model preferred to waterfall model? Explain. **[5]**

2 (a) Justify the statement with proper reasoning *"The requirement analysis document serves as a contract between development team and the customer"*. **[4]**

(b) Give two reasons of why it is a good idea to classify and separate functional requirements and non-functional requirements in a requirements specification document. **[3]**

(c) For the following description of a system, identify functional and non-functional requirements of the system: **[7]**

Suppose you want to develop software for an alarm clock. The clock shows the time of day. Using buttons, the user can set the hours and minutes fields individually, and choose between 12 and 24-hour display. It is possible to set one or two alarms. When an alarm fires, it will sound some noise. The user can turn it off, or choose to 'snooze'. If the user does not respond at all, the alarm will turn off itself after 2 minutes. 'Snoozing' means to turn off the sound, but the alarm will fire again after some minutes of delay. This 'snoozing time' is pre-adjustable.

3 (a) Assume, you are going to implement an application that will handle the process of assigning the driving license to the people. Two types of people will use this application, the admins and the general people. The features from the general people's side will require logging credentials, account authentication, a basic information-providing panel with an update feature, the ability to give online exams, a panel to apply for the license, a panel to receive important notifications, and many more. **[5+5]**

Similarly, the admins will have features to verify an account with his/her national id, will have features to set questionnaires for an online exam alongside marking assistance. The admins will also be able to send notifications regarding many aspects to the people who applied for the license and finally a panel to update different attributes of the database.
(i) You need to draw a use-case diagram of the above-assumed application.
(ii) You also need to draw two state chart diagrams representing various states of the general people and the admins.
The listed features are only a bare minimum of the expected features of the application. You are welcome to incorporate other features as well.

(b) Suggest two different readers of a requirements specification. Explain what they will look for in the specification. **[4]**

4 (a) Coupling is a measure of the interdependence among components in software. Explain content coupling, control coupling and data coupling with examples. **[5]**

(b) Partitioning and layering are techniques to achieve low coupling. Explain how low coupling is achieved through partitioning and layering. **[5]**

(c) Which one of functional cohesion and procedural cohesion is more desirable and why? **[4]**

5 (a) A group of diary and time management system is intended to support the timetabling of meetings and appointments across a group of co-workers. When an appointment is to be made that involves a number of people, the system finds a common slot in each of their diaries and arranges the appointment for that time. If no common slots are available, it interacts with the user to rearrange his or her personal diary to make room for the appointment. **[8]**

Identify possible entity, boundary and control objects including attributes and operations in the above system.

(b) A book is composed of a number of parts, which in turn are composed of a number of chapters. Chapters are composed of sections. A book includes a publisher, publication date, and an ISB number. A part includes a title and a number. A chapter includes a title, a number, and an abstract. A section includes a title and a number. **[6]**

Draw a class diagram representing a book defined by the above statements.

6 (a) The essence of software testing is to determine a set of test cases for the item to be tested. Identify all the components of a test case. **[4]**

(b) In white box testing, correct working of code is tested. Explain branch coverage and path coverage with respect to white box testing with an example. **[6]**

(c) Differentiate between white box testing, grey box testing, and black box testing. **[4]**

7 (a) A project organization defines the relationships among resources, in particular the participants. Give communication structure among participants of a project. **[3]**

(b) Show associations between tasks, activities, roles, work products, and work packages. **[3]**

(c) A project consists of 5 activities. Let us consider the following table for starting finishing week for each activity of the project: **[8]**

Activity	Latest Start (LS)	Latest Finish (LF)	Earliest Start (ES)	Earliest Finish (EF)
A1	Start of week 1	End of week 5	Start of week 1	End of week 5
A2	Start of week 7	End of week 7	Start of week 6	End of week 6
A3	Start of week 2	End of week 2	Start of week 1	End of week 1
A4	Start of week 3	End of week 5	Start of week 2	End of week 4
A5	Start of week 6	End of week 7	Start of week 6	End of week 7

Find the critical path of the project and slack time of each activity.
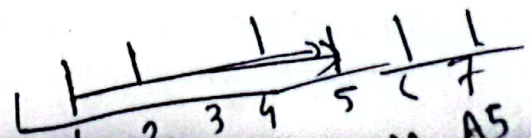
University of Dhaka
Computer Science and Engineering
3rd Year 1st Semester B.Sc. Final Examination, 2021
CSE3103– Microprocessor and Microcontroller (3 Credits)

Time: 3 Hours   Total marks: 70

Answer any five [At least two(2) from each group] out of 7 questions.

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1. (a) (4 points) Briefly describe the features of the Cortex M4 memory model with appropriate diagram. What are the major address ranges?

   (b) (4 points) 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 ?

   (c) (4 points) Describe briefly about different operating modes of ARM architecture.

   (d) (2 points) Explain the usability of Control register with different context.

2. (a) (3 points) What are the leading causes to trigger a bus fault exception in the Cortex M4 processor?

   (b) (5 points) Mention the scenario when both the Bus Fault and Hard Fault exceptions enable simultaneously. Introduce all the associated registers with their functionality which will represent the fault status in such a scenario.

   (c) (2 points) What is the purpose of Cortex M4's feature " lazy stacking"? Explain.

   (d) (4 points) Mention and describe the instructions required to call and to return from an exception. Also, list the name and functionality of different general and system registers to handle the exception.

3. (a) (4 points) Write a subroutine that checks the character in register R0 to see if it is alphabetic (upper- or lower-case). It should set the Zero flag if the character is alphabetic, and reset the flag if it is not.
   Sample Problems:

		Test A	Test B	Test C
Input	R0	47 'G'	36 '6'	6A 'j'
Output	Z	FF	00	FF

   (b) (4 points) Write down the equivalent ARM assembly code of the following C code :

   ```
   int main(int argc, char *argv[])
   {
   int x,y;
   x = 1;
   switch(x)
   {
   case 0:
   y = 10;
   ```

1

```
        break:
        case 1:
        y = 11:
        break:
        default:
        y = 13:
        }
        return y;
        }
```

(c) (6 points) The following method returns a random number from 1 to n, where n is stored in r1.

```
    # Calculate a random number
    # arguments: r0 - seed (if seed is 0, get next random value)
    # r1 - range (from 1 to r1). If r1 is 0 or negative, range is all ints)
    #
    Random:
    SUB sp, sp, #8
    # Save return to os on stack

    STR lr, [sp, #0]  Prompt For An Input
    STR r4, [sp, #4]
    #
    MOV r3, #0
    CMP r0, r3
    BNE Reset
    LDR r0, =seed  get the seed
    LDR r0, [r0, #0]
    Reset:
    ADD r0, r0, #137  get the next seed
    EOR r0, r0, r0, ror #13
    LSR r0, r0, #1  make sure it is positive
    MOV r4, r0  save the value to r4
    # Get the remainder
    MOV r3, #0
    CMP r1, r3
    BLE NoRange
    BL __aeabi_idiv
    MUL r1, r0, r1
    SUB r4, r4, r1
    NoRange:
    # Save the seed to memory
    LDR r0,=seed
    STR r4,[r0, #0]
    # Return to the OS
    MOV r0, r4
    LDR lr, [sp, #0]
    LDR r4, [sp, #4]
    ADD sp, sp, #8
    MOV pc, lr
    .data
    seed: .word 25
    #end Random
```

1. Create an array of 100 values, and populate it with 100 random numbers.
2. Using the array in previous part, find the minimum and average of all values in the array.

4. (a) (4 points) Convert the following ARM assembly code into machine language. Write the instruction in hexadecimal.
   - MOV R10, #63488
   - LSL R9, R6, #7
   - STR R4, [R11, R8]
   - ASR R6, R7, R3

   (b) (2 points) Translate the following machine code into equivalent ARM assembly code.
   - 0xE5902004
   - 0xE1A04638

   (c) (4 points) Describe different addressing modes used in ARM processor with proper example.

   (d) (2 points) All instructions in the ARM instruction set may be conditionally executed. Discuss the advantages and disadvantages of this feature.

   (e) (2 points) First, write down the ARM instruction to multiply the content of register $r0$ by nine and store the product in $r7$. Later, write the equivalent single instruction to perform the same operation without using any multiplication instruction.

5. GPIO and UART Configuration questions.

   (a) (6 points) Configure GPIOA PIN 0-3 for input traffic density at the crossroad and 4-7 as output to control 4-traffic lights. Assume that each pulse changes the light status, such as RED to GREEN or GREEN to YELLOW, and so on. Where MODER, SPEEDER, TYPER, and PUPDR registers have two-bit allocated for each PIN.

   (b) (4 points) Describe the steps to set a GPIO pin as input and output. Let the GPIO pin-X's speed set to 160 MHz and another GPIO pin-Y's speed set to 50 MHz. Now, to identify a real-time sensor event which pin will result best?

   (c) (4 points) A UART agent is connected to an MCU, and the MCU can read from and write values to the agent registers. MCU writes a value to the agent's register primarily to configure the device and read a register value from the agent (such as sensing the speed of a motor). However, the agent only accepts a baud rate of exactly 2MBps. Determine the mantissa and fractional values for the USARTx_BRR register to set the baud rate. Assume the register accepts 22 bits for mantissa and only 8 bits for the fractional value.

6. Answer the following questions based on I2C deployment in the ARM-M microcontroller.

   (a) (3 points) How could an I2C slave identify the start and stop conditions of an I2C transmission? Write the steps sequentially to transfer 1MB of data using I2C.

   (b) (6 points) A temperature sensor has four registers, register-1 address 0x0AH and register-2 address 0x0BH for temperature (F/C) and pressure (p/kp) unit. Write to 0x0CH to 0x0AH set Centigrade and 0x0FH Farenthite accordingly. Writing 0xA0H or 0xB0H to 0x0BH sets the pressure unit to p (pascal) or Kp (kilopascal). Register-3 and Register-4 obtain the current temperature and pressure value. How can we set the temperature and pressure unit F and Kp in a single I2C frame? Similarly, read the temperature and pressure values from the sensor using an I2C frame. The address of the sensor is 0x41H. Addresses of register-3 and 4 are 0x0CH and 0x0DH repectively.

CamScanner

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	SPI_CR1																	BIDIMODE	BIDIOE	CRCEN	CRCNEXT	DFF	RXONLY	SSM	SSI	LSBF/RST	SPE	BR[2:0]			MSTR	CPOL	CPHA
	Reset value																	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x04	SPI_CR2																									TXEIE	RXNEIE	ERRIE	FRF		SSOE	TXDMAEN	RXDMAEN
	Reset value																									0	0	0	0		0	0	0
0x08	SPI_SR																								FRE	BSY	OVR	MODF	CRCERR	UDR	CHSIDE	TXE	RXNE
	Reset value																								0	0	0	0	0	0	0	1	0
0x0C	SPI_DR																	DR[15:0]															
	Reset value																	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 1: SPI Essential Registers

(c) (5 points) Many I2C devices do clock stretching to adjust the speed of the clock. However master has a timer to set the limit slave clock stretching duration. If it exceeds I2C Hang, it needs to reset. However, it is not very pleasant in real applications, and resetting may not be a suitable solution. A reset-i2c function may take the place of a hard reset. Write down the reset-i2c function with a suitable explanation.

7. Answer the following questions on SPI. Let the SPI slave contains two arrays at 0xA00H and 0xF00H to host the configuration and monitor data of crossroad traffic lights. Each configuration needs a 4-byte (uint32_t). The registers are (i) Traffic Light 1, (ii) Traffic Light 2, (iii) Traffic Density in a north-south direction, and (iv) Traffic Density in the east-west direction. Whereas 0xF00H has eight 32-bit registers to store the last two monitoring data sets (each contains four pieces of information -- lights, traffic density). Fig. 1 demostrate the SPI essential registers.

(a) (6 points) Write a program to configure two-MCU as master and slave SPI. Figure 1 shows the SPI registers.

(b) (4 points) Write two functions to read monitoring data and set traffic light configuration for the Bijoy-Sarani crossroad. The address bit must clearly indicates the salve to identify read and write command. Hints: send data with the starting address.

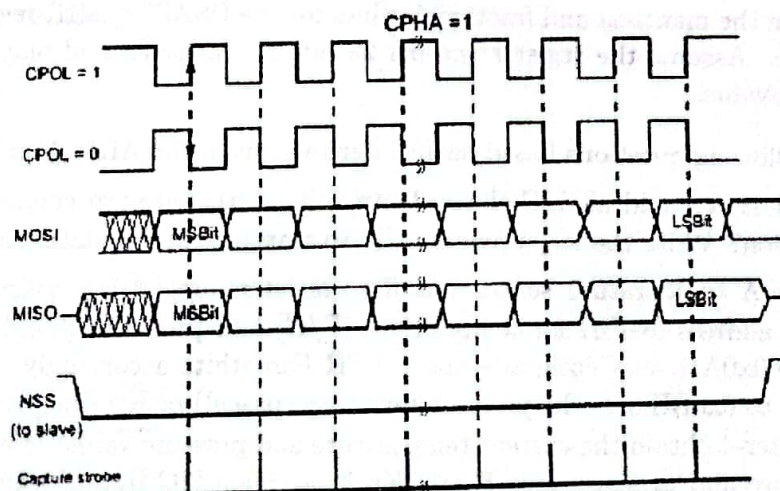(c) (4 points) Explain the following figure 2 for a typical SPI communication.

Figure 2: SPI Signaling

Instruction	Opcode
AND	0000
ORR	1100
ADD	0100
SUB	0010
ADC	0101
CMP	1010
MOV	1101
Shift	1101
GT	1100
EOR	0001
LT	1011
LE	1101
LSL	sh=00
LSR	sh=01
ASR	sh=10
ROR	sh=11

University of Dhaka
Department of Computer Science and Engineering
3rd Year 1st Semester Final Examination, 2022
CSE-3104: Database Management Systems - II (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) Define RAID. Explain the necessity of RAID with examples. [4]

(b) What do you understand about P+Q Redundancy? Write notes on the RAID Level 5 with suitable examples. [5]

(c) Explain different performance measures of disks. [5]

2 (a) Define indexing. Discuss the evaluation factors of an index structure. [5]

(b) Make a B+ tree inserting the following values according to the given sequence. Consider the fanout value as 4. [Show only the tree after inserting each value] [5]
$23 \rightarrow 11 \rightarrow 67 \rightarrow 34 \rightarrow 97 \rightarrow 13 \rightarrow 42 \rightarrow 53 \rightarrow 7 \rightarrow 1 \rightarrow 100 \rightarrow 99 \rightarrow 90 \rightarrow 3 \rightarrow 77$

(c) "To make a primary index, one must choose the primary key as the search key" – explain with proper logic. [4]

3 (a) Explain the distinction between closed and open hashing. Discuss the relative merits of each technique in database applications. [3]

(b) Suppose that we are using extendable hashing on a file that contains records with the following search-key values: 2, 3, 5, 7, 11, 17, 19, 23, 29, 31, 35, 44, 47, 49, 52, 59, 63. Show the extendable (dynamic) hash structure for this file if the hash function is $h(x) = x$ mod 8 and buckets can hold three records. [6]

(c) What are the causes of bucket overflow in a hash file organization? What can be done to reduce the occurrence of bucket overflows? [5]

4 (a) What do you understand by 'query processing' and 'query optimization'? Why is it not desirable to force users to make an explicit choice of a query processing strategy? [4]

(b) Assume (for simplicity in this exercise) that only one tuple fits in a block and memory holds at most three blocks. Show the runs created on each pass of the sort-merge algorithm when applied to sort the following tuples on the first attribute: (kangaroo, 17), (wallaby, 21), (emu, 1), (wombat, 13), (platypus, 3), (lion, 8), (warthog, 4), (zebra, 11), (meerkat, 6), (hyena, 9), (hornbill, 2), (baboon, 12) [6]

(c) Explain how you can apply the following equivalence rules to improve the efficiency of certain queries: [4]
i) $E_1 \bowtie_\theta (E_2 - E_3) \equiv (E_1 \bowtie_\theta E_2 - E_1 \bowtie_\theta E_3)$
ii) $\sigma_\theta (_A\gamma_F(E)) \equiv {}_A\gamma_F(\sigma_\theta(E))$, where θ uses only attributes from A

5 (a) Compare different partitioning techniques for I/O parallelism with respect to: [5]
i) sequential search ii) point query iii) range query

(b) Histograms are good for avoiding data distribution skew but are not very useful for avoiding execution skew. Explain why. How virtual node portioning technique is used to handle skew created by I/O partitioning? [2+3]

(c) Explain the following forms of parallelism mentioning advantages and disadvantages: [4]
i) Pipelined Parallelism
ii) Independent Parallelism

6 (a) What do you understand by data analytics? What are the common steps in doing data analytics? **[4]**

(b) How can you differentiate the following schemas used in data warehouse? Give examples. **[4]**
i) Star ii) Snowflake iii) Fact-constellation

(c) The cube operation computes union of **group by's** on every subset of the specified attributes. **[2]** Now consider the following cube operation on a multidimensional schema *sales (item_name, color, size, number)*:

select *item_name, color, size,* **sum**(*number*)
from *sales*
group by cube(*item_name, color, size*)

Convert the above SQL using only **rollup** operation that will produce the same output.

(d) Define the terms with respect the data mining: **[4]**
i) Classification ii) Regression

7 (a) What motivates you using object-based databases rather than relational database? **[3]**

(b) Consider a schema for instructor. Each instructor has: **[2+4]**
- *ID*
- *name* with sub-field *first_name* and *last_name* (composite attribute)
- a list of *children* (multivalued attribute)
- a list of *degree* achieved (multivalued attribute)
- a set of *phone_nos* (multivalued attribute)
- *age* (derived attribute of date attribute)

i) Create 2 tuples for the nested relation based on above schema.
ii) Show the 4NF decomposition of the nested relation mentioned in 7.b.i)

(c) Suppose that you have been hired as a consultant to choose a database system for your client's application. For each of the following applications, state what type of database system (relational, persistent programming language–based OODB, object relational; do not specify a commercial product) you would recommend. Justify your recommendation. **[5]**
i) A computer-aided design system for a manufacturer of airplanes.
ii) A system to track contributions made to candidates for public office.
iii) An information system to support the making of movies.

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) Given two vectors v and w, proof that $\| v + w \| <= \|v\| + \|w\|$. [4]

    (b) Let there be a supershop that sells three items pen, pencil, and bottle. John is a buyer who bought two [5]
    pens and two pencils. We represent the items bought by a person using a three dimensional vector where
    the values represent the number of pen, pencil, and bottles bought, respectively. The items bought by
    John are represented as [2, 2, 0]. Analyze why Cosine Similarity will be more suitable than Euclidean
    Distance to define similarity between the buying patterns of two persons.

    (c) Let the vector representation items bought by three persons John, Bob and Alice be [1, 1, 0], [2, 2, 0] and [5]
    [100, 100, 0], respectively. In case of cosine similarity, similarity between John and Bob is equal to the
    similarity between John and Alice. But Bob is more similar to John than Alice. Define a new similarity
    measure modifying cosine similarity that incorporate such differences.

2. (a) Let $L_1(t) = c + ta$ and $L_2(t) = c + tb$ be two parametric line equations. Here, a, b, and c be three vectors. [6]
    I.   Find if the lines intersect or not.
    II.   If a.b < 0, what can we infer about the angle between the lines?

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

    (c) Find vector equations of the lines passing through the pairs of points listed below. [4]
    • (5, 2, 1, 3) and (1, 3, 4, 2)
    • (1, 1, 0) and (2, 4, 2)

3. (a) Let L_1 and L_2 be two lines lying on a plane 2x + 3y - 4z = 22. Let the angle between L_1 and L_2 be 30 [4]
    degrees. Proof that the lines intersect with each other.

    (b) Find an equation of the plane that passes through point (2, 4, -1) and is parallel to the vector (2, 3, 4). [5]

    (c) Find the shortest distance between the plane $x_1 + x_2 + x_3 - 1 = 0$ and point (2, 2, 3). [3]

    (d) Find the shortest distance between the lines $L_1(t) = (t, 0, 0)$ and $L_2(t) = (0, 1+t, 1)$. [2]

4. (a) Find the unit tangent vector for the vector equation $r(t) = (1+t^3, te-t, \cos 2t)$ at t = 0. [4]

    (b) Find the arc length L for the curve $r(t) = (\cos t, \sin t, t)$ for $0 \leq t \leq 2\pi$. [3]

    (c) Professor Mosby wanted to find the arc length L for the curve $r(t) = (t^2, t^3, t^4)$ from point (0, 0, 0) to (4, [3]
    8, 32) but failed to do so. Explain why.

    (d) Calculate the volume under the surface $z = 1 - x^2 - y^2$ over the region D defined by $0 \leq x \leq 1$ and $0 \leq y \leq 1$. [4]

5. (a) Let $T: R^5 \to R^4$ be defined by $T(x) = A(x)$, where x is R^5 and **[6]**

$$A = \begin{bmatrix} 1 & 2 & 0 & 1 & -1 \\ 2 & 1 & 3 & 1 & 0 \\ -1 & 0 & -2 & 0 & 1 \\ 0 & 0 & 0 & 2 & 8 \end{bmatrix}$$

Find a basis for the range of T.

(b) Let $f(x, y)$ be a function. Discuss the points where $f_x(a, b) = 0$ and $f_y(a, b) = 0$. **[4]**

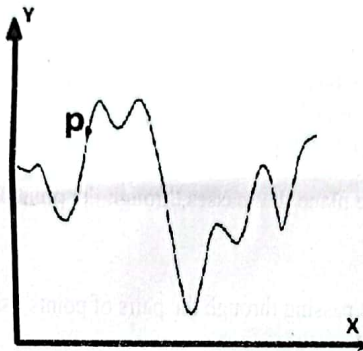(c) Find the maximum value of $f(x, y) = x^4 + y^4 - 4xy + 1$. **[4]**

6. (a) Let $f(x, y) = x^2y + xy^2 + x^2y^2$. Starting at $(x, y) = (3, 5)$, demonstrate how gradient descent algorithm **[6]** maximizes $f(x, y)$ with learning rate, $\alpha = 0.002$. You must report the values of x, y, and $f(x, y)$ after each iteration for the first four iterations. Show one iteration with $\alpha = 1.0$ and comment on the choice of learning rate.

(b) Let $y = f(x)$ be a function plotted in the graph below. Is the point P a good choice as starting point for **[3]** minimizing using gradient descent algorithm? What about in case of maximizing?

(c) Find the maximum and minimum values of $f(x,y,z)=xyz$ subject to the constraint $x + y + z = 1$. Assume **[5]** that $x,y,z >= 0$.

7. (a) Find $\dfrac{dY}{dX}$ where $Y = [x^5, x^6, x^7]$ and $X = [x, x^2]$. **[4]**

(b) Let f be a function. Explain the difference between df and Δf. **[2]**

(c) Find the tangent plane of surface $z = 2x^2 + y^2$ at point $(1, 1, 3)$. **[4]**

(d) Find the area inside the ellipse $(\frac{x}{a})^2 + (\frac{y}{b})^2 = 1$ using double integral. **[4]**