

1. "If X then Y unless Z" is represented by which of the following formula in propositional logic? (" \neg ", is negation, " \wedge ", is conjunction, and " \rightarrow " is implication)

A. $(X \wedge \neg Z) \rightarrow Y$

☒ B. $(X \wedge Y) \rightarrow \neg Z$

C. $X \rightarrow (Y \wedge \neg Z)$

D. $(X \rightarrow Y) \wedge \neg Z$

$Z \rightarrow (X \rightarrow Y)$

$\neg (X \rightarrow Y) \wedge Z$

$\neg (\neg Y \wedge X) \wedge Z$

2. Consider the following relations:

R1 (a,b) iff (a+b) is even over the set of integers

R2 (a,b) iff (a+b) is odd over the set of integers

R3 (a,b) iff $a.b > 0$ over the set of non-zero rational numbers

R4 (a,b) iff $|a - b| \leq 2$ over the set of natural numbers

Which of the following statement is correct?

A. R1 and R2 are equivalence relations. R3 and R4 are not

B. R1 and R3 are equivalence relations. R2 and R4 are not

☒ C. R1 and R4 are equivalence relations. R2 and R3 are not

D. R1, R2, R3 and R4 are all equivalence relations

3. How many 4-digit even numbers have all 4 digits distinct?

A. 2240

☒ B. 2296

C. 2620

D. 4536

$\frac{10}{90}$

ABC D

$\frac{720 \times 7}{5040}$

$10 \times 9 \times 8 \times 7$

$10 \times 9 \times 8$

4. Consider the following formula and its two interpretations I_1 and I_2 .

$\alpha: (\forall x)[Px \Leftrightarrow (\forall y)[Qxy \Leftrightarrow \neg Qyy]] \Rightarrow (\forall x)[\neg Px]$

I_1 : Domain: the set of natural numbers

$P_x =$ 'x is a prime number'

$Q_{xy} =$ 'y divides x'

I_2 : same as I_1 except that $P_x =$ 'x is a composite number'.

Which of the following statements is true?

☒ A. I_1 satisfies α , I_2 does not

B. I_2 satisfies α , I_1 does not

C. Neither I_1 nor I_2 satisfies α

D. Both I_1 and I_2 satisfies α

5. The binary relation $S = \phi$ (empty set) on set $A = \{1,2,3\}$ is

A. Neither reflexive nor symmetric

☒ B. Symmetric and reflexive

C. Reflexive and transitive

D. Transitive and symmetric

6. Let G be a simple connected planar graph with 13 vertices and 19 edges. Then, the number of faces in the planar embedding of the graph is:

A. 6

B. 8

☒ C. 9

D. 13

7. The inclusion of which of the following sets into

$S = \{\{1,2\}, \{1,2,3\}, \{1,3,5\}, \{1,2,4\}, \{1,2,3,4,5\}\}$ is necessary and sufficient to make S a complete lattice under the partial order defined by set containment?

A. $\{1\}$

B. $\{1\}, \{2,3\}$

☒ C. $\{1\}, \{1,3\}$

D. $\{1\}, \{1,3\}, \{1,2,3,4\}, \{1,2,3,5\}$

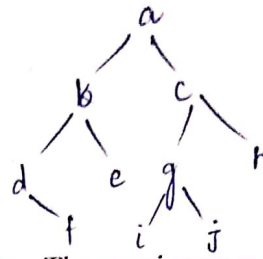
8. Consider the In-order and Post-order traversals of a tree as given below :

In-order : j | e | n | k | o | p | b | f | a | c | l | g | m | d | h | i

Post-order : j | n | o | p | k | e | f | b | c | l | m | g | h | i | d | a

The Pre-order traversal of the tree shall be:

- A. a b f e j k n o p e d g l m h i
 B. a b c d e f j k n o p g l m h i
 C. a b e j k n o p f c d g l m h i
 D. j e n o p k f b c l m g h i d a



d f b e a i g j c h in-order
j n o p k e f b c l m g h i d a post-order

9. Consider an undirected graph G with 100 nodes. The maximum number of edges to be included in G so that the graph is not connected is:

- A. 2451
 B. 4950
 C. 4851
 D. 9900

10. The 2's complement representation of the decimal value - 15 is:

- A. 11111
 B. 10111
 C. 10011
 D. 10001

11111
 00000

 10001

11. In the worst case, the number of comparisons needed to search a singly linked list of length n for a given element is:

- A. $\log_2 n$
 B. $n/2$
 C. $\log_2 n - 1$
 D. n

12. Which of the following scheduling algorithms is non-preemptive?

- A. Round Robin
 B. First-In First-Out
 C. Multilevel Queue Scheduling
 D. Multilevel Queue Scheduling with Feedback

13. Consider the following two statements:

S1: $\{0^{2n} | n \geq 1\}$ is a regular language 0, 0000, 000000, 00000000

S2: $\{0^m 1^n 0^{m-n} | m \geq 1 \text{ and } n \geq 1\}$ is a regular language 0100, 011000, 00110000

- A. Only S1 is correct
 B. Only S2 is correct
 C. Both S1 and S2 are correct
 D. None of S1 and S2 is correct

14. Which of the following statement is false?

- A. Virtual memory implements the translation of a program's address space into physical memory address space.
 B. Virtual memory allows each program to exceed the size of the primary memory.
 C. Virtual memory increases the degree of multiprogramming.
 D. Virtual memory reduces the context switching overhead

15. Consider an undirected un-weighted graph G. Let a breadth-first traversal of G be done starting from a node r. Let $d(r, u)$ and $d(r, v)$ be the lengths of the shortest paths from r to u and v respectively in G. If u is visited before v during the breadth-first traversal, which of the following statements is correct?

- A. $d(r, u) < d(r, v)$
 B. $d(r, u) > d(r, v)$

- ☒ C. $d(r,u) \leq (r,v)$
 D. $d(r,u) \geq (r,v)$
16. Given an arbitrary non-deterministic finite automaton (NFA) with N states, the maximum number of states in an equivalent minimized DFA is at least:
- A. N^2
☒ B. 2^N
 C. $2N$
 D. $N!$
17. Consider a B+-tree in which the maximum number of keys in a node is 5. What is the minimum number of keys in any non-root node?
- A. 1
 B. 2
 C. 3
☒ D. 4
18. A low memory can be connected to 8085 by using:
- A. INTR
☒ B. RESET IN
 C. HOLD
 D. READY
19. What is the minimum number of stacks of size n required to implement a queue of size n ?
- A. One
☒ B. Two
 C. Three
 D. Four
20. The order of a leaf node in a B+ tree is the maximum number of (value, data record pointer) pairs it can hold. Given that the block size is 1K bytes, data record pointer is 7 bytes long, the value field is 9 bytes long and a block pointer is 6 bytes long, what is the order of the leaf node?
- ☒ A. 63
 B. 64
 C. 67
 D. 68
21. The following postfix expression with single digit operands is evaluated using a stack: $8\ 2\ 3\ ^\wedge / 2\ 3\ * + 5\ 1\ * -$.
 Note that $^\wedge$ is the exponentiation operator. The top two elements of the stack after the first $*$ is evaluated are:
- ☒ A. 6, 1
 B. 5, 7
 C. 3, 2
 D. 1, 5
22. Consider the grammar with the following translation rules and E as the start symbol.
- $E \rightarrow E1 \# T \{ E.value = E1.value * T.value \} \mid T \{ E.value = T.value \}$
 $T \rightarrow T1 \& F \{ T.value = T1.value + F.value \} \mid F \{ T.value = F.value \}$
 $F \rightarrow num \{ F.value = num.value \}$
- Compute $E.value$ for the root of the parse tree for the expression: $2 \# 3 \& 5 \# 6 \& 4$.
- A. 200
 B. 180
☒ C. 160
 D. 40

$$N \rightarrow 2^N$$

$$8\ 8 / 23 * + 51 * -$$

$$1\ 23 * + 51 * -$$

$$E \rightarrow E1 \# T1 \& E1 \# T1 \& num$$

$$E \rightarrow 2 \# 3 \&$$

$$E \rightarrow E1 \#$$

$$((4+6)*5+3)*2$$

$$50 \quad \frac{53*2}{106}$$

23. The minimum number of page frames that must be allocated to a running process in a virtual memory environment is determined by:

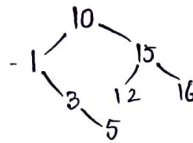
A. The instruction set architecture
☒ B. Page size
 C. Physical memory size
 D. Number of processes in memory

24. The best data structure to check whether an arithmetic expression has balanced parentheses is a:

A. queue
☒ B. stack
 C. tree
 D. list

25. The following numbers are inserted into an empty binary search tree in the given order: 10, 1, 3, 5, 15, 12, 16. What is the height of the binary search tree (the height is the maximum distance of a leaf node from the root)?

A. 2
☒ B. 3
 C. 4
 D. 6



26. Let $G = (\{S\}, \{a, b\}, R, S)$ be a context free grammar where the rule set R is $S \rightarrow a S b \mid SS \mid \epsilon$

Which of the following statements is true?

A. G is not ambiguous
 B. There exist $x, y \in L(G)$ such that $xy \notin L(G)$
☒ C. There is a deterministic pushdown automaton that accepts $L(G)$
 D. We can find a deterministic finite state automaton that accepts $L(G)$

27. The regular expression $0^*(10^*)^*$ denotes the same set as:

A. $(1^*0)^*1^*$
 B. $0 + (0 + 10)^*$
 C. $(0 + 1)^* 10(0 + 1)^*$
☒ D. $(0^*1)^*1^*$

28. Let G be an arbitrary graph with n nodes and k components. If a vertex is removed from G , the number of components in the resultant graph must necessarily lie between:

A. k and n
 B. $k - 1$ and $k + 1$
 C. $k - 1$ and $n - 1$
☒ D. $k + 1$ and $n - k$

29. Which one of the following expressions does NOT represent exclusive NOR of x and y ?

A. $xy + x'y'$
☒ B. $x \wedge y$ where \wedge is XOR
 C. $x \oplus y$ where \oplus is XOR
☒ D. $x \wedge y$ where \wedge is XOR

30. Consider two strings $A = "qpqrr"$ and $B = "pqprrrp"$. Let x be the length of the longest common subsequence (not necessarily contiguous) between A and B and let y be the number of such longest common subsequences between A and B . Then $x + 10y = \text{-----}$.

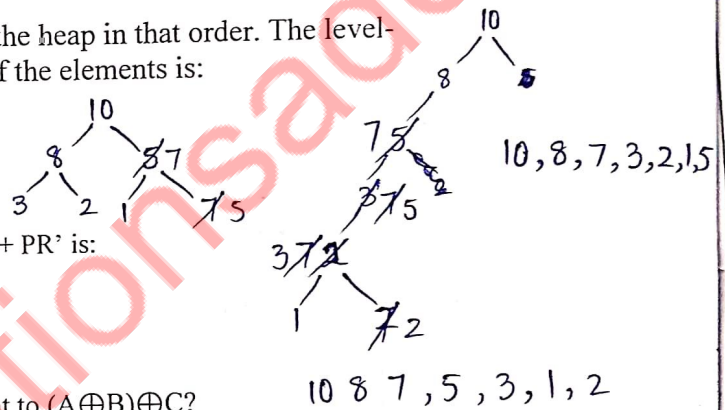
☒ A. 33
 B. 23
 C. 43
 D. 34

1111
 3221
 122

19

$3 + (1 \times 10)$

31. Which of the following standard algorithms is not Dynamic Programming based.
- ☒ A. Prim's Minimum Spanning Tree
 - ☒ B. Floyd Warshall Algorithm for all pairs shortest paths
 - C. 0-1 Knapsack problem
 - D. Bellman-Ford Algorithm for single source shortest path
32. Let X be a problem that belongs to the class NP. Then which one of the following is TRUE?
- A. There is no polynomial time algorithm for X
 - ☒ B. If X can be solved deterministically in polynomial time, then $P = NP$.
 - C. If X is NP-hard, then it is NP-complete.
 - D. X may be undecidable.
33. Which of the following is not $O(n^2)$?
- A. $(15^{10}) * n + 120$
 - B. $n^{1.98}$
 - ☒ C. $n^3 / (\sqrt{n})$
 - D. $(2^{20}) * n$
34. A Priority-Queue is implemented as a Max-Heap. Initially, it has 5 elements. The level-order traversal of the heap is given below:
10, 8, 5, 3, 2
Two new elements "1" and "7" are inserted in the heap in that order. The level-order traversal of the heap after the insertion of the elements is:
- A. 10, 8, 7, 5, 3, 2, 1
B. 10, 8, 7, 2, 3, 1, 5
C. 10, 8, 7, 1, 2, 3, 5
☒ D. 10, 8, 7, 3, 2, 1, 5
35. The minterm expansion of $f(P, Q, R) = PQ + QR' + PR'$ is:
- A. $m_2 + m_4 + m_6 + m_7$
 - ☒ B. $m_0 + m_1 + m_3 + m_5$
 - C. $m_0 + m_1 + m_6 + m_7$
 - D. $m_2 + m_3 + m_4 + m_5$
36. Which of the following expressions is equivalent to $(A \oplus B) \oplus C$?
- ☒ A. $(A+B+C)(A^-+B^-+C^-)$
 - B. $(A+B+C)(A^-+B^-+C)$
 - C. $ABC+A^-(B \oplus C)+B^-(A \oplus C)$
 - D. $(A \oplus B \oplus C)(A^-+B^-+C)$
37. A processor that has carry, overflow and sign flag bits as part of its program status word (PSW) performs addition of the following two 2's complement numbers 01001101 and 11101001. After the execution of this addition operation, the status of the carry, overflow and sign flags, respectively will be:
- A. 1, 1, 0
 - ☒ B. 1, 0, 0
 - C. 0, 1, 0
 - D. 1, 0, 1
38. Increasing the RAM of a computer typically improves performance because:
- A. Virtual memory increases
 - B. Larger RAMs are faster
 - ☒ C. Fewer page faults occur
 - D. Fewer segmentation faults occur



39. Thrashing occurs when:
 A. When a page fault occurs
☒ B. Processes on system frequently access pages not memory
 C. Processes on system are in running state
 D. Processes on system are in waiting state
40. Which of the following is true about constructors?
 1) They cannot be virtual.
 2) They cannot be private.
 3) They are automatically called by new operator.
☒ A. All 1, 2, and 3
 B. Only 1 and 3
 C. Only 1 and 2
 D. Only 2 and 3
41. How can we restrict dynamic allocation of objects of a class using new?
☒ B. By making an empty private new operator.
 C. By making an empty private new and new[] operators
 D. By overloading new operator and new[] operators
42. Which of the following in Object Oriented Programming is supported by Function overloading and default arguments features of C++?
☒ B. Polymorphism
 C. Encapsulation
 D. Abstraction
43. Which of the following scenarios may lead to an irrecoverable error in a database system?
☒ D. A transaction reads a data item after it is written by an uncommitted transaction
 A. A transaction writes a data item after it is read by an uncommitted transaction
 B. A transaction reads a data item after it is read by an uncommitted transaction
 C. A transaction reads a data item after it is written by a committed transaction
44. Consider the following transaction involving two bank accounts x and y.
 read(x); x := x - 50; write(x); read(y); y := y + 50; write(y)
 The constraint that the sum of the accounts x and y should remain constant is that of:
☒ A. Atomicity
 B. Consistency
 C. Isolation
 D. Durability
45. Match the following:
 (P) SMTP (1) Application layer
 (Q) BGP (2) Transport layer
☒ (R) TCP (3) Data link layer
 (S) PPP (4) Network layer
 (5) Physical layer
☒ A. P - 2 Q - 1 R - 3 S - 5 -
 B. P - 1 Q - 4 R - 2 S - 3
 C. P - 1 Q - 4 R - 2 S - 5 -
 D. P - 2 Q - 4 R - 1 S - 3

46. Host A sends a UDP datagram containing 8880 bytes of user data to host B over an Ethernet LAN. Ethernet frames may carry data up to 1500 bytes (i.e. MTU = 1500 bytes). Size of UDP header is 8 bytes and size of IP header is 20 bytes. There is no option field in IP header. How many total number of IP fragments will be transmitted and what will be the contents of offset field in the last fragment?
- 6 and 925
 - 6 and 7400
 - 7 and 1110
 - 7 and 8880
47. Which one of the following protocols is NOT used to resolve one form of address to another one?
- ✓ A. DHCP
 - B. DNS
 - C. ARP
 - D. RARP
48. Which of the following are used to generate a message digest by the network security protocols?
- (P) RSA
 - (Q) SHA-1
 - (R) DES
 - (S) MD5
- ✓ A. Q and S only
 - B. Q and R only
 - C. P and R only
 - D. Q and R only
49. Which software designers tool helps to design the block structure of the software, that may further be broken down into smaller modules using refinement techniques?
- A. Analysis tools
 - ✓ B. Design tools
 - C. Configuration management tools
 - D. Documentation tools
50. Which of the following techniques is not a White box technique?
- A. Statement Testing and coverage
 - B. Decision Testing and coverage
 - ✓ C. Condition Coverage
 - D. Boundary value analysis

PART – II(B)

Maximum Marks=50

Attempt any five questions. All questions carry equal marks.

- Q1. (a) Let w_n denote the number of words of length n , formed using the Italian alphabet $\{a, b, c, \dots, u, v, z\}$, which do not contain the substrings "aa", "ee", "ii", "oo", "uu". Find a recursion and an explicit formula for w_n .
- (b) Find the 18 th term of the Arithmetic sequence, if its 6 th term is 19 and 9 th term is 31.

- Q2. (a) Arrange the list of elements in ascending order using quick sort:
44,33,11,55,77,90,40,60,99,22,88, 66.
After each step write the value of left pointer l , right pointer r and LOC and also draw the current scenario after each step?

- (b) Consider the following arithmetic expression P , written in postfix notation:
 $P: 12, 7, 3, -, /, 2, 1, 5, +, *, +$
i. Translate P into equivalent infix expression.
ii. Evaluate the infix expression.

- Q3. (a) Find the average waiting time (A.W.T) and average turnaround time (A.T.A.T) for executing the following process using:
(i) Preemptive short-job first
(ii) Non-preemptive short-job first?

Process	P1	P2	P3	P4	P5
Burst time	5	13	8	4	10
Arrival time	2	3	0	5	1

- (b) Suppose we have five processes and three resources. A, B, and C. A has 2 instances, B has 5 instances and C has 4 instances. Can the system execute the following processes with or without deadlock occurring. Justify your answer.

Process	Maximum need			Allocation		
	A	B	C	A	B	C
P1	1	2	3	0	1	1
P2	2	2	0	0	1	0
P3	0	1	1	0	0	1
P4	3	5	3	1	2	1
P5	1	1	2	1	0	1

- Q4 (a) Consider a 16-way set-associative cache with the following detail:
- Data words are 64 bits long
 - Words are addressed to the half-word
 - The cache holds 2 Mbytes of data
 - Each block holds 16 data words
 - Physical addresses are 64 bits long.

How many bits of tag, index, and offset are needed to support references to this cache?

- (b) Assuming that N instructions are executed, and all N instructions are add instructions, what is the speedup of a pipelined implementation when compared to a multi-cycle implementation? Answer should be an expression that is a function of N .

- Q5 (a) Solve the following equations to find the value of x , y and z .
- $$3x + 5y + 7z \equiv 3 \pmod{16}$$
- $$x + 4y + 13z \equiv 5 \pmod{16}$$
- $$2x + 7y + 3z \equiv 4 \pmod{16}.$$

- (b) An IP datagram has arrived with the following information in the Header (in Hex.)
0x4500005400035850200600007C4E0302B40E0F02
- Is the packet fragmented?
 - What is the size of the data?
 - How many more routers can the packet travel to?
 - What is the identification number of the packet?
 - What is the type of service?

Q6. Consider the entries in the following table:

Entry A	Entry B	Entry C
<T, BEGIN>	<T, BEGIN>	<T, BEGIN>
<T1, A, 500, 395>	<T1, A, 500, 395>	<T1, A, 500, 395>
<T1, B, 800, 950>	<T1, B, 800, 950>	<T1, B, 800, 950>
	<T1, COMMIT>	<T1, COMMIT>
	T2, BEGIN>	<T2, BEGIN>
	<T2, C, 320, 419>	<T2, C, 320, 419>
		<T1, COMMIT>

- (a) Assume a deferred update log, describe for each case (A, B, C) what recovery actions are necessary and why? Indicate what are the values for the given attributes after the recovery actions are completed?
- (b) Assuming an immediate update log, describe for each case (A, B, C) what recovery actions are necessary and why? Indicate what are the values for the given attributes after the recovery actions are completed?

- Q7 (a) How does software configuration management facilitate the changes that may occur during various stages of a system development life cycle? Illustrate your explanation with all examples at each stage.
- (b) Consider a program for determining the previous date. Its input is a triple of day, month and year with the values in the range $1 \leq \text{month} \leq 12$, $1 \leq \text{day} \leq 31$, $1990 \leq \text{year} \leq 2017$. The possible outputs would be previous date or invalid input date. Design the boundary value test cases.

- Q8 (a)** Draw a top-down predictive parser using the following parser table.
 Grammar of given language is defined as:
 $S \rightarrow (L)/a$
 $L \rightarrow SL'$
 $L' \rightarrow \epsilon / , SL'$
 String $w = (a, a, a)$

A	,	()	\$
S $S \rightarrow A$		$S \rightarrow (L)$		
L $L \rightarrow SL'$		$L \rightarrow SL'$		
L'	$L' \rightarrow , SL'$		$L' \rightarrow \epsilon$	

- (b)** Find the first and follow sets for the given grammar:
 $E \rightarrow TE'$
 $E' \rightarrow \epsilon / + TE'$
 $T \rightarrow FT'$
 $T' \rightarrow \epsilon / * FT'$
 $F \rightarrow ID/(E)$

- Q9 (a)** Consider the following details in a table with Knapsack size = 20 and Number of objects = 3. Find the total knapsack value and proof that it is optimal or not.

Object	Obj1	Obj2	Obj3
Profit	25	24	15
Weight	18	15	10

- (b)** For what purpose Bellman –Ford Algorithm is used? Write the Pseudo-code for Bellman –Ford Algorithm and explain it with suitable example.
- Q10 (a)** What are wrapper classes used in oops? Explain the wrapper classes with suitable example.
- (b)** What is constructor? Explain the types of constructor with a suitable example. Write a program to overload = operator using constructor. Assign values of data members of one object to another object of the same type.