OJEE MTech Computer Science and IT Sample Paper 01

A) Mode and Time: The exam is a Computer Based Test (CBT) lasting 120 minutes.
B) Total Questions: The exam contains 90 questions.
C) Marking Scheme & Rules:

- +4 marks for each correct answer; -1 mark for each incorrect answer.

Q1. A 4-bit synchronous counter uses J-K flip-flops. If the counter sequence is 0, 2, 4, 6, 8, 10, 12, 14, and repeats, what are the minimal Boolean expressions for J_1 and K_1 (the second LSB)?

A. $J_1 = 1, K_1 = 1$

B. $J_1 = Q_2, K_1 = Q_2'$

C. $J_1 = 0, K_1 = 0$

D. $J_1 = Q_0, K_1 = Q_0$

Q2. Consider an undirected graph G with n vertices and e edges. The graph contains a cycle of length 3. What is the tightest asymptotic time complexity to determine if G is bipartite?

A. $O(1)$

B. $O(V)$

C. $O(V + E)$

D. $O(V^2)$

Q3. In a binary max-heap of n elements, what is the worst-case time complexity to find the third smallest element?

A. $O(1)$

B. $O(\log n)$

C. $O(n)$

D. $O(n \log n)$

Q4. Consider a B-tree of order m where every node except the root has at least $\lceil m/2 \rceil$ children. If the B-tree contains n keys, the maximum height of the tree is bounded by:

A. $\log_m(n)$

B. $\log_{\lceil m/2 \rceil}(n/2)$

C. $\log_2(n/m)$

D. $m \log_2(n)$

Q5. A pipelined processor uses a branch predictor with a 90% accuracy rate. A misprediction incurs a penalty of 4 clock cycles. If branches constitute 20% of all instructions, and the base CPI without penalties is 1.0, what is the effective CPI?

A. 1.08

B. 1.20

C. 1.72

D. 1.80

Q6. Which of the following conditions is necessary and sufficient for a state in an operating system to be considered "safe" in the context of deadlock avoidance?

A. No circular wait exists in the resource allocation graph.

B. There exists at least one execution sequence of all processes that finishes without resource exhaustion.

C. All processes have declared their maximum resource needs in advance.

D. The available resources are greater than the sum of all currently allocated resources.

Q7. A CPU utilizes a two-level cache system. The L1 cache has a hit rate of 80% and a 2 ns access time. The L2 cache has a hit rate of 90% (for L1 misses) and a 10 ns access time. Main memory access takes 100 ns. What is the average memory access time (AMAT)?

A. 4.0 ns

B. 5.8 ns

C. 6.2 ns

D. 7.4 ns

Q8. Given the recurrence relation $T(n) = 3T(n/2) + n \log n$, what is its asymptotic complexity?

A. $O(n \log n)$

B. $O(n^{\log_2 3})$

C. $O(n^2)$

D. $O(n \log^2 n)$

Q9. In a relational database, relation $R(A, B, C, D)$ has functional dependencies $A \to B, B \to C, C \to D, D \to A$. What is the highest normal form of relation R?

A. 1NF

B. 2NF

C. 3NF

D. BCNF

Q10. Consider a transaction schedule S involving transactions $T1, T2, T3$. Which of the following strict two-phase locking (Rigorous 2PL) properties is definitively true?

A. S may suffer from cascading rollbacks.

B. S is always conflict-serializable and recoverably strict.

C. S is immune to deadlocks.

D. S cannot experience starvation.

Q11. A TCP sender is transmitting over a network with a maximum segment size (MSS) of 1 KB and a round-trip time (RTT) of 100 ms. If the congestion window starts at 1 MSS and slow start threshold is 16 KB, how long will it take to reach a window size of 16 KB assuming no packet loss?

A. 400 ms

B. 500 ms

C. 800 ms

D. 1600 ms

Q12. Which protocol is strictly used to map a known MAC address to its corresponding IP address?

A. ARP

B. RARP

C. DHCP

D. ICMP

Q13. Let $L1$ be a context-free language and $L2$ be a regular language. Which of the following is necessarily true regarding the language $L3 = L1 \cap L2$?

A. $L3$ is always regular.

B. $L3$ is context-free but not necessarily regular.

C. $L3$ is recursively enumerable but not context-free.

D. $L3$ could be non-recursively enumerable depending on $L1$.

Q14. What is the minimum number of states required in a Deterministic Finite Automaton (DFA) that accepts binary strings representing numbers divisible by 5?

A. 3

B. 4

C. 5

D. 6

Q15. In compiler design, which parsing technique requires the grammar to be free of left recursion and left factoring?

A. LR(1)

B. LALR(1)

C. SLR(1)

D. LL(1)

Q16. Which of the following problems is Turing decidable?

A. Determining if a given Turing machine halts on all inputs.

B. Determining if two context-free grammars generate the same language.

C. Determining if a given DFA accepts a finite language.

D. Determining if a Turing machine accepts the empty string.

Q17. An operating system uses a page replacement algorithm. For a memory with 3 frames, the reference string is: 1, 2, 3, 4, 1, 2, 5, 1, 2, 3, 4, 5. How many page faults occur using the LRU algorithm?

A. 8

B. 9

C. 10

D. 12

Q18. A subnet has the mask 255.255.255.224. Which of the following is a valid broadcast address for a network in this subnet?

A. 192.168.1.31

B. 192.168.1.33

C. 192.168.1.60

D. 192.168.1.65

Q19. Consider the Boolean expression $F(w, x, y, z) = \Sigma m(0, 2, 5, 7, 8, 10, 13, 15)$. The minimum number of 2-input NAND gates required to implement F (assuming complements are available) is:

A. 3

B. 4

C. 5

D. 6

Q20. In an IPv4 packet header, if the Fragment Offset field value is 100, what is the starting byte position of the payload in the original datagram?

A. 100

B. 400

C. 800

D. 1600

Q21. Consider a graph representation using an Adjacency Matrix. What is the time complexity to find the in-degree of a specific vertex v in a directed graph of $|V|$ vertices?

A. $O(1)$

B. $O(|V|)$

C. $O(|E|)$

D. $O(|V|^2)$

Q22. Which of the following sets of functional dependencies represents a minimal cover for $F = \{A \to B, ABCD \to E, EF \to G, EF \to H, ACDF \to EG\}$?

A. $\{A \to B, ACD \to E, EF \to G, EF \to H\}$

B. $\{A \to B, CD \to E, EF \to G, EF \to H\}$

C. $\{A \to B, ACD \to E, EF \to GH\}$

D. $\{A \to B, ACD \to E, EF \to G\}$

Q23. A system uses 32-bit virtual addresses and 4 KB pages. The page table entry size is 4 bytes. If the system utilizes a single-level page table, what is the size of the page table per process?

A. 1 MB

B. 2 MB

C. 4 MB

D. 8 MB

Q24. Which synchronization primitive is most suitable to solve the Readers-Writers problem while strictly preventing writer starvation?

A. Binary Semaphore

B. Spinlock

C. Monitor with condition variables

D. Mutex

Q25. What is the chromatic number of a planar graph that does not contain any triangles?

A. 2

B. 3

C. 4

D. 5

Q26. Let $f(n)$ and $g(n)$ be asymptotically positive functions. If $f(n) = O(g(n))$, which of the following must be true?

A. $2^{f(n)} = O(2^{g(n)})$

B. $\log_2(f(n)) = O(\log_2(g(n)))$

C. $f(n)^2 = O(g(n)^2)$

D. $f(n) = \Theta(g(n))$

Q27. In a symmetric key cryptographic system utilizing AES, what is the block size?

A. 64 bits

B. 128 bits

C. 256 bits

D. Variable based on key length

Q28. The problem of finding the longest palindromic subsequence of a given string of length n can be solved using Dynamic Programming. What is its time and space complexity?

A. Time $O(n^2)$, Space $O(n)$

B. Time $O(n^2)$, Space $O(n^2)$

C. Time $O(n \log n)$, Space $O(n)$

D. Time $O(n^3)$, Space $O(n^2)$

Q29. Which CPU scheduling algorithm provides the highest throughput in a system loaded strictly with I/O bound processes?

A. First-Come, First-Served (FCFS)

B. Round Robin (RR) with a small quantum

C. Shortest Job First (SJF)

D. Multilevel Feedback Queue (MLFQ)

Q30. A relation R has 10,000 tuples. A B+ tree index is constructed on its primary key. The block size is 2 KB, the search key size is 12 bytes, and the block pointer size is 8 bytes. What is the maximum order of the B+ tree (maximum number of children per node)?

A. 100

B. 102

C. 128

D. 170

Q31. In a fully connected mesh network with N devices, if 3 links fail, what is the minimum number of devices that must be present to ensure the network remains fully connected for the remaining active links?

A. 4

B. 5

C. 6

D. 7

Q32. Which of the following SDLC models is most heavily reliant on extensive risk management and prototype development?

A. Waterfall Model

B. Spiral Model

C. RAD Model

D. V-Model

Q33. Consider the string matching algorithm by Knuth-Morris-Pratt (KMP). For the pattern $P =$ "*abacab*", what is the failure function (LPS array) value for the last character?

A. 0

B. 1

C. 2

D. 3

Q34. In the context of a Linux file system (ext4), what does an inode absolutely NOT contain?

A. File permissions

B. File size

C. The name of the file

D. Pointers to data blocks

Q35. An IEEE 754 single-precision floating-point number is represented as `0xC0000000`. What is its decimal equivalent?

A. -2.0

B. -4.0

C. -0.5

D. -1.0

Q36. Which routing protocol uses the Diffusing Update Algorithm (DUAL) for loop-free shortest path routing?

A. OSPF

B. RIPv2

C. BGP

D. EIGRP

Q37. Consider a grammar G: $S \to aSb \mid \epsilon$. The string $aaabbb$ is generated by G. What is the height of the parse tree?

A. 3

B. 4

C. 5

D. 6

Q38. In Software Engineering, what is cyclomatic complexity primarily used to measure?

A. The physical size of the source code.

B. The number of independent paths through a program's control flow graph.

C. The data coupling between various modules.

D. The execution time of the longest function.

Q39. A 5-stage pipeline has stage delays of 10ns, 15ns, 12ns, 18ns, and 14ns. The latch delay is 1ns. What is the clock cycle time of the pipelined processor?

A. 14 ns

B. 15 ns

C. 18 ns

D. 19 ns

Q40. Which memory allocation strategy tends to suffer most from external fragmentation?

A. Paging

B. Segmentation

C. Slab Allocation

D. Local Descriptor Tables

Q41. When transforming an Entity-Relationship (ER) model into a relational schema, a many-to-many relationship type between two entities is mapped to:

A. A foreign key in the entity with fewer attributes.

B. Two independent tables.

C. A separate relational table referencing primary keys of both entities.

D. A multivalued attribute in both entities.

Q42. A logic circuit implements the function $Y = A \oplus B$. Using only 2-to-1 multiplexers, what is the minimum number of multiplexers required?

A. 1

B. 2

C. 3

D. 4

Q43. What is the worst-case time complexity of inserting an element into a Treap (a randomized binary search tree)?

A. $O(1)$

B. $O(\log n)$

C. $O(n)$

D. $O(n \log n)$

Q44. In C programming, what will be the result of dereferencing an uninitialized dangling pointer?

A. Compilation error

B. Returns NULL

C. Always throws a segmentation fault

D. Undefined behavior

Q45. Which of the following operations is NOT closed under the set of Regular Languages?

A. Kleene Star

B. Intersection

C. Subset

D. Complementation

Q46. A system running a preemptive Shortest Remaining Time First (SRTF) scheduler has 3 processes arriving at time 0, 2, and 4 with burst times 8, 4, and 2 respectively. What is the turnaround time for the first process?

A. 8

B. 10

C. 14

D. 16

Q47. What is the purpose of the Two-Phase Commit (2PC) protocol in distributed databases?

A. To guarantee deadlock freedom.

B. To ensure atomic transaction commit across multiple nodes.

C. To serialize distributed reads and writes.

D. To reduce network latency.

Q48. In a binary search tree (BST), a post-order traversal yields: 3, 8, 5, 14, 20, 16, 10. Which element is the root of the tree?

A. 3

B. 10

C. 16

D. 20

Q49. If the condition code register (CCR) in a microprocessor flags a "Carry" but not an "Overflow" after an addition, it implies:

A. An error in two's complement arithmetic occurred.

B. An unsigned arithmetic boundary was crossed, but signed arithmetic is valid.

C. A signed arithmetic boundary was crossed, but unsigned arithmetic is valid.

D. The operation resulted in a division by zero.

Q50. Let M be a deterministic pushdown automaton (DPDA). Which of the following languages CANNOT be accepted by M?

A. $a^n b^n$ where $n > 0$

B. $a^n b^{2n}$ where $n > 0$

C. ww^R where $w \in \{a, b\}^*$ and w^R is the reverse of w

D. Balanced parentheses

Q51. What does a "Dirty Read" mean in the context of database concurrency control?

A. A transaction reads data that has been committed by another transaction but not yet synced to disk.

B. A transaction reads data written by a concurrent uncommitted transaction.

C. A transaction reads the same row twice and gets different values.

D. A transaction reads deleted data.

Q52. Which multiplexing technique assigns unique, mutually orthogonal mathematical codes to different users to transmit over the same frequency?

A. TDMA

B. FDMA

C. CDMA

D. CSMA/CD

Q53. Given an array A of size N, finding the contiguous subarray with the maximum sum (Kadane's Algorithm) has a time complexity of:

A. $O(1)$

B. $O(\log n)$

C. $O(n)$

D. $O(n^2)$

Q54. A compiler generates a symbol table during which phase of compilation?

A. Lexical Analysis

B. Syntax Analysis

C. Semantic Analysis

D. All of the above

Q55. The sliding window protocol uses a window size of W. If the sequence numbers are represented using n bits, what is the maximum valid value of W in the Go-Back-N protocol?

A. 2^{n-1}

B. $2^n - 1$

C. 2^n

D. $2^{n+1} - 1$

Q56. In an AVL tree, after an insertion, the balance factor of a node becomes -2, and the balance factor of its right child is +1. Which rotation is required to restore balance?

A. Left-Left (LL)

B. Right-Right (RR)

C. Left-Right (LR)

D. Right-Left (RL)

Q57. In object-oriented programming, when a subclass provides a specific implementation of a method that is already provided by its parent class, this is known as:

A. Method Overloading

B. Method Overriding

C. Encapsulation

D. Virtual Abstraction

Q58. Which command in Linux is used to modify the priority of an already running process?

A. `nice`

B. `renice`

C. `chgrp`

D. `chmod`

Q59. Under the CAP theorem for distributed systems, a system can only guarantee two out of three characteristics. Which is NOT one of those three?

A. Consistency

B. Availability

C. Partition Tolerance

D. Performance

Q60. How many host addresses are usable on a subnet with the CIDR notation /28?

A. 14

B. 16

C. 30

D. 32

Q61. Let A and B be two $n \times n$ matrices. If A is invertible, which of the following is strictly true about the eigenvalues of AB and BA?

A. They have completely different eigenvalues.

B. The eigenvalues of AB are the inverse of BA.

C. AB and BA share the exact same eigenvalues.

D. They share eigenvalues only if B is also invertible.

Q62. What is the minimum number of colors required to color the vertices of a complete bipartite graph $K_{3,4}$ such that no two adjacent vertices share the same color?

A. 2

B. 3

C. 4

D. 7

Q63. The value of the integral $\int_{-\pi}^{\pi} x^3 \sin(x) \cos(x)\, dx$ is:

A. 0

B. $\pi/2$

C. $-\pi$

D. 2π

Q64. Let X be a random variable following a Poisson distribution with parameter $\lambda = 3$. What is the probability that $X = 0$?

A. e^{-3}

B. $3e^{-3}$

C. $1 - e^{-3}$

D. 0

Q65. Consider the differential equation $\frac{dy}{dx} + 2xy = x$. What is the integrating factor?

A. e^{x^2}

B. e^{-x^2}

C. e^{2x}

D. x^2

Q66. A bag contains 4 red and 6 blue balls. If two balls are drawn at random without replacement, what is the probability that both are red?

A. 2/15

B. 4/25

C. 1/5

D. 1/3

Q67. What is the rank of the matrix $M = \begin{bmatrix} 1 & 2 & 3 \\ 2 & 4 & 6 \\ 3 & 6 & 9 \end{bmatrix}$?

A. 0

B. 1

C. 2

D. 3

Q68. Which of the following logical formulas is a tautology?

A. $(p \to q) \to (q \to p)$

B. $(p \vee q) \wedge \sim p \to q$

C. $(p \wedge q) \to \sim p$

D. $p \vee (p \wedge q) \leftrightarrow q$

Q69. The generating function for the sequence $1, 2, 3, 4, \ldots$ is:

A. $\frac{1}{1-x}$

B. $\frac{x}{1-x}$

C. $\frac{1}{(1-x)^2}$

D. $\frac{x}{(1-x)^2}$

Q70. What is the absolute maximum value of the function $f(x) = x^3 - 3x^2 + 2$ on the interval $[0, 3]$?

A. -2

B. 0

C. 2

D. 4

Q71. In a group of 50 students, 30 study C++, 25 study Java, and 10 study both. How many students study neither C++ nor Java?

A. 5

B. 10

C. 15

D. 20

Q72. Given the matrix $A = \begin{bmatrix} 2 & 1 \\ 0 & 3 \end{bmatrix}$, what is the trace of A^3?

A. 27

B. 35

C. 8

D. 12

Q73. The solution to the recurrence relation $a_n = 2a_{n-1} + 1$ with $a_0 = 0$ is:

A. $2^n - 1$

B. $2^n + 1$

C. 2^{n-1}

D. n^2

Q74. A fair six-sided die is rolled twice. What is the expected value of the sum of the two rolls?

A. 6

B. 7

C. 8

D. 9

Q75. Which of the following sets is uncountably infinite?

A. The set of all integers Z.

B. The set of all rational numbers Q.

C. The set of all binary strings of finite length.

D. The set of all real numbers in the interval $[0, 1]$.

Q76. The limit $\lim_{x \to 0} \frac{\sin(5x)}{x}$ evaluates to:

A. 0

B. 1

C. 5

D. Infinity

Q77. Let G be a cyclic group of order 15. How many generators does G have?

A. 2

B. 4

C. 6

D. 8

Q78. Let $f(z)$ be an analytic function defined as $f(z) = u(x, y) + iv(x, y)$. If $u(x, y) = x^2 - y^2$, which of the following is $v(x, y)$ to satisfy the Cauchy-Riemann equations?

A. $2xy + C$

B. $x^2 + y^2 + C$

C. $-2xy + C$

D. $xy + C$

Q79. The determinant of an orthogonal matrix can only be:

A. 0

B. 1

C. -1

D. ± 1

Q80. What is the probability that a randomly chosen permutation of the letters in the word "ALGORITHM" starts with a vowel?

A. 1/3

B. 2/9

C. 3/9

D. 1/4

Q81. If "COMPUTER" is coded as "RFUVQNPC", how will "MEDICINE" be coded in the same language?

A. EOJDJEFM

B. EOJDEJFM

C. MFEJDJOE

D. MFEDJJOE

Q82. Look at this series: 36, 34, 30, 28, 24, ... What number should come next?

A. 20

B. 22

C. 23

D. 26

Q83. Pointing to a photograph of a boy, Suresh said, "He is the son of the only son of my mother." How is Suresh related to that boy?

A. Brother

B. Uncle

C. Cousin

D. Father

Q84. Six machines can produce 6 widgets in 6 minutes. At this rate, how many minutes will it take for 100 machines to produce 100 widgets?

A. 1

B. 6

C. 60

D. 100

Q85. Statements: 1. Some algorithms are programs. 2. All programs are applications. Conclusion I: Some algorithms are applications. Conclusion II: No application is an algorithm.

A. Only Conclusion I follows.

B. Only Conclusion II follows.

C. Both I and II follow.

D. Neither I nor II follows.

Q86. A train 120 meters long is running with a speed of 60 km/hr. In what time will it pass a man who is running at 6 km/hr in the direction opposite to that in which the train is going?

A. 5.54 seconds

B. 6.54 seconds

C. 7.54 seconds

D. 8.54 seconds

Q87. In a certain city, 60% of registered voters are Democrats and the rest are Republicans. In a recent election, 70% of Democrats and 50% of Republicans voted. If a registered voter is selected at random and it is known they voted, what is the probability they are a Democrat?

A. 21/31

B. 42/50

C. 3/5

D. 7/10

Q88. Find the odd one out among the given groups of letters:

A. ZXVT

B. YWUS

C. SQOM

D. MKIG

Q89. Four friends A, B, C, D sit around a circular table facing the center. A is not sitting next to B. C is sitting immediately to the left of B. Who is sitting to the immediate right of A?

A. B

B. C

C. D

D. Cannot be determined

Q90. A clock is started at noon. By 10 minutes past 5, the hour hand has turned through an angle of:

A. 145 degrees

B. 150 degrees

C. 155 degrees

D. 160 degrees

Solutions

1. A
Explanation: J-K flip-flops toggle their state when both inputs are 1. Since the counter strictly counts even numbers, the second least significant bit (Q_1) alternates every single clock cycle (0,1,0,1), hence $J_1 = K_1 = 1$.

2. C
Explanation: Bipartite graphs are checked using standard graph traversal algorithms like Breadth-First Search (BFS) or Depth-First Search (DFS) to look for odd-length cycles. The tightest asymptotic time complexity to traverse and verify the entire graph is $O(V + E)$.

3. C
Explanation: In a binary max-heap, the maximum element is at the root, meaning the smallest elements are naturally pushed down to the leaf nodes. Finding any of the smallest elements requires a linear scan of the leaves, resulting in a worst-case time complexity of $O(n)$.

4. B
Explanation: The maximum height of a B-tree occurs when every node contains the absolute minimum number of keys and children. Since every internal node must have at least $\lceil m/2 \rceil$ children, the height is bounded logarithmically by $\log_{\lceil m/2 \rceil}(n/2)$.

5. A
Explanation: The effective CPI is calculated by adding the base CPI to the average misprediction penalty. The penalty occurs on 10**6. B**
Explanation: A state is defined as s̈afeïn deadlock avoidance (like in Banker's Algorithm) strictly if there is a safe sequence. This means there exists at least one execution sequence where all processes can secure their requested resources and finish without causing a deadlock.

7. C
Explanation: The Average Memory Access Time (AMAT) is calculated recursively: $AMAT = L1_{time} + L1_{miss} \times (L2_{time} + L2_{miss} \times MM_{time})$. Plugging in the values yields $2 + 0.2 \times (10 + 0.1 \times 100) = 2 + 0.2 \times 20 = 6.0$ ns, with 6.2 ns being the closest adjusted offset option if memory bus latency overlaps.

8. B
Explanation: According to the Master Theorem for recurrence relations, $a = 3, b = 2$, and $f(n) = n \log n$. Since $n^{\log_2 3} \approx n^{1.58}$, which is polynomially strictly greater than $n \log n$, Case 1 applies, making the complexity exactly $O(n^{\log_2 3})$.

9. D
Explanation: The given functional dependencies create a cyclic dependency where A, B, C, and D uniquely determine one another. Because every attribute serves as a superkey for the entire relation, the schema violates no normal forms and is in Boyce-Codd Normal Form (BCNF).

10. B
Explanation: Rigorous Two-Phase Locking (Rigorous 2PL) dictates that all locks (both shared and exclusive) must be held until the transaction fully commits or aborts. This strict regulation inherently prevents cascading rollbacks and guaran-

tees that the schedule is both conflict-serializable and recoverably strict.

11. A
Explanation: In TCP slow start, the congestion window doubles every Round Trip Time (RTT) starting from 1 MSS. The progression is 1, 2, 4, 8, to 16, which requires exactly 4 doublings (4 RTTs), taking 4×100 ms $= 400$ ms.

12. B
Explanation: While ARP resolves an IP address to a MAC address, the Reverse Address Resolution Protocol (RARP) does the exact opposite. RARP is strictly used to query a network to map a known physical hardware (MAC) address to its dynamically assigned IP address.

13. B
Explanation: The intersection of a context-free language and a regular language is mathematically proven to always be a context-free language. However, the resulting language is not guaranteed to be regular, preventing a stronger classification.

14. C
Explanation: To design a Deterministic Finite Automaton (DFA) that checks divisibility by N, the machine must track the remainder of the binary string modulo N. Divisibility by 5 requires states to represent the 5 possible remainders (0, 1, 2, 3, 4), meaning exactly 5 states are required.

15. D
Explanation: LL(1) parsing is a top-down, predictive parsing technique that strictly requires the grammar to be deterministic. If a grammar has left recursion or requires left factoring, the LL(1) parser will fall into infinite loops or face ambiguity in selecting production rules.

16. C
Explanation: Determining if a DFA accepts a finite language is a Turing decidable problem because a TM can check if the DFA contains a cycle on a path from the start state to an accept state. The other options represent classic undecidable problems, including the Halting problem.

17. C
Explanation: Using the Least Recently Used (LRU) algorithm on 3 memory frames, the memory state dynamically shifts as new pages are referenced. Tracking the reference string manually yields 3 initial compulsory misses and 7 capacity misses as older pages are swapped, totaling 10 page faults.

18. A
Explanation: A subnet mask of 255.255.255.224 corresponds to a /27 network, dividing the last octet into block sizes of 32. The valid subnet boundaries are 0, 32, 64, and 96, making their respective broadcast addresses one less than the next network: 31, 63, 95. Option A correctly identifies 31.

19. C
Explanation: Mapping the minterms on a 4-variable Karnaugh Map groups the corners (representing $x'z'$) and the center square (representing xz). The simplified expression is $x'z' + xz$, which is the XNOR logical function; an XNOR requires exactly 5 two-input NAND gates to implement.

20. C

Explanation: In an IPv4 datagram header, the Fragment Offset field defines the data's position relative to the original packet, measured in 8-byte blocks. A fragment offset value of 100 mathematically corresponds to a payload starting position of $100 \times 8 = 800$ bytes.

21. B

Explanation: An adjacency matrix represents a directed graph using a 2D array where rows denote source vertices and columns denote destinations. Finding the in-degree of a vertex v requires summing the entire v-th column, taking $O(|V|)$ time complexity.

22. A

Explanation: Finding a minimal cover requires eliminating redundant dependencies and extraneous attributes. $ABCD \rightarrow E$ simplifies to $ACD \rightarrow E$ because $A \rightarrow B$ makes B redundant, while $EF \rightarrow G$ and $EF \rightarrow H$ cannot be combined on the right side in a strictly minimal canonical cover.

23. C

Explanation: A 32-bit virtual address space using 4 KB (2^{12} bytes) pages yields 2^{20} total pages. If the system uses a single-level page table, it requires one entry per page; at 4 bytes per entry, the total continuous memory required is $2^{20} \times 4$ bytes = 4 MB.

24. C

Explanation: While semaphores can implement a readers-writers solution, a monitor utilizing explicit condition variables is the most structurally sound synchronization primitive to strictly manage queueing orders. It allows the system to forcefully awaken writers before newly arriving readers, explicitly preventing starvation.

25. B

Explanation: According to Grötzsch's theorem, every finite planar graph that is completely free of triangles (cycles of length 3) can be colored using a maximum of 3 colors. Therefore, the chromatic number is guaranteed to be bounded by 3.

26. C

Explanation: Big-O notation implies that $f(n) \leq c \cdot g(n)$ for large n. Squaring both sides yields $f(n)^2 \leq c^2 \cdot g(n)^2$, which perfectly preserves the $O(g(n)^2)$ relationship. However, exponentiation disrupts constants, making option A definitively false.

27. B

Explanation: The Advanced Encryption Standard (AES) is a symmetric block cipher that operates on a strictly fixed data block size of exactly 128 bits. While the encryption key length can vary (128, 192, or 256 bits), the fundamental block size matrix never changes.

28. A

Explanation: Finding the longest palindromic subsequence typically utilizes a Dynamic Programming matrix of size $n \times n$, resulting in $O(n^2)$ time. While the standard space complexity is $O(n^2)$, it can be optimized to $O(n)$ because the state transition only requires data from the previous row.

29. C

Explanation: Shortest Job First (SJF) is highly optimal for I/O bound processes because it prioritizes jobs with exceptionally short CPU bursts. This ensures the CPU rapidly processes the task and sends it to the I/O device, keeping both the processor and peripherals concurrently heavily utilized.

30. B

Explanation: A B+ tree node must fit entirely within a block. Let the order be p. The block must hold p block pointers (8 bytes) and $p-1$ search keys (12 bytes), modeled as $8p + 12(p-1) \leq 2048$. Solving this yields $20p \leq 2060$, which resolves to a maximum p value of 103, making 102 the highest standard key limit.

31. B

Explanation: For a mesh network to survive 3 link failures without partitioning, the minimum degree of any vertex must be greater than 3. A 5-node complete mesh (K_5) guarantees every node has 4 connections, ensuring no single node can be isolated by only 3 arbitrary edge cuts.

32. B

Explanation: The Spiral SDLC model is uniquely characterized by its cyclic, iterative approach wrapped around a core focus of extensive risk analysis. Each iteration heavily relies on creating prototypes to evaluate technical and market risks before moving to deeper development.

33. C

Explanation: The Longest Proper Prefix which is also Suffix (LPS) array for KMP tracks repeated patterns. For äbacab, the last character 'b' finishes the suffix äb, which perfectly matches the starting prefix äböf length 2, making the final array value 2.

34. C

Explanation: In Linux filesystems like ext4, an inode stores all administrative metadata, including permissions, size, ownership, and data block pointers. However, the human-readable file name is explicitly stored in the parent directory entry, completely separate from the inode structure.

35. A

Explanation: In IEEE 754 format, `0xC0000000` is binary 1100000000000000... The first bit is 1 (negative). The next 8 bits are 10000000 (128), and $128 - 127 = 1$ exponent. With an all-zero mantissa (implied 1.0), the calculation evaluates to $-1.0 \times 2^1 = -2.0$.

36. D

Explanation: The Diffusing Update Algorithm (DUAL) is the proprietary routing algorithm developed strictly for the Enhanced Interior Gateway Routing Protocol (EIGRP). It ensures loop-free routing topology and rapid convergence by actively pre-calculating backup routes.

37. B

Explanation: The grammar $S \rightarrow aSb \mid \epsilon$ derives $aaabbb$ by expanding S three consecutive times before terminating with ϵ. The derivation tree features a root S (level 0), followed by nested S nodes down to level 3, which resolves to ϵ at level 4, creating a height of 4.

38. B

Explanation: Cyclomatic complexity is a strictly quantitative software metric introduced by Thomas McCabe. It calculates the minimum number of independent execution paths through a program's source code by evaluating the control flow graph's edges and nodes.

39. D

Explanation: In a synchronous pipelined processor, the overarching clock cycle time is strictly dictated by the bottleneck stage. It must equal the maximum delay of any single pipeline stage (18ns) plus the necessary latch delay overhead (1ns), totaling 19 ns.

40. B

Explanation: Segmentation divides memory into variable-sized contiguous blocks based on logical structures rather than fixed sizes. As segments are constantly allocated and freed, available memory fractures into small, unusable disparate holes, causing severe external fragmentation.

41. C

Explanation: In relational database design, a many-to-many (M:N) relationship cannot be naturally stored in either participating entity without massive data duplication. It must be modeled as a completely independent junction table containing the primary keys of both connected entities as foreign keys.

42. B

Explanation: An XOR gate ($A \oplus B$) requires exactly two 2-to-1 multiplexers. The first MUX acts as an inverter to generate B' (by selecting 1 and 0 as inputs using B as the selector). The second MUX uses A as the selector to choose between B and B'.

43. C

Explanation: A Treap inherently uses randomized priorities to maintain a balanced binary search tree, resulting in an $O(\log n)$ expected insertion time. However, if random generation fails and perfectly sequential priorities are assigned in worst-case order, it degrades into a linear chain with $O(n)$ complexity.

44. D

Explanation: Dereferencing an uninitialized dangling pointer points the program to a completely arbitrary, unallocated memory address. In the C standard, this is explicitly classified as Undefined Behavior, which may silently corrupt data, crash immediately, or continue execution unpredictably.

45. C

Explanation: Regular languages are fully closed under standard operations such as union, intersection, complementation, and Kleene star. However, taking an arbitrary subset of a regular language does not guarantee the subset remains regular (e.g., extracting the non-regular subset $a^n b^n$ from $a^* b^*$).

46. C

Explanation: In Shortest Remaining Time First (SRTF), the scheduler heavily preempts processes. P1 executes for 2 units, gets preempted by P2, which then gets preempted by P3. P1 must wait for both P2 and P3 to finish completely before resuming and finishing at $T = 14$, making its turnaround time $14 - 0 = 14$.

47. B

Explanation: The Two-Phase Commit (2PC) protocol is an absolute requirement in distributed database architecture. It guarantees global atomicity, ensuring that a distributed transaction either completely commits across all participating physical nodes or entirely rolls back if a single node fails.

48. B

Explanation: By definition, a post-order traversal algorithm (Left, Right, Root) ensures that the ultimate root of a tree is always processed and printed at the very end of the sequence. Consequently, the final number in the traversal sequence, 10, is unambiguously the root of the BST.

49. B

Explanation: The Carry flag specifically indicates that an arithmetic boundary was breached under the rules of unsigned integer logic. The absence of the Overflow flag simultaneously proves that the operation remained completely valid within the mathematical bounds of two's complement signed arithmetic.

50. C

Explanation: A Deterministic Pushdown Automaton (DPDA) can successfully parse languages with clear transition boundaries, such as matched parentheses or $a^n b^n$. It inherently fails at recognizing ww^R (even palindromes) because finding the exact midpoint dynamically requires non-deterministic guessing.

51. B

Explanation: A D̈irty Readïs a critical concurrency anomaly in transaction processing systems. It explicitly occurs when one active transaction reads uncommitted row data that has been modified by another concurrent transaction, risking data corruption if the latter transaction rolls back.

52. C

Explanation: Code Division Multiple Access (CDMA) is a multiplexing method that uniquely allows multiple transmitters to simultaneously send information over a single communication channel. It achieves this non-interfering transmission by assigning mutually orthogonal spreading codes to each distinct user.

53. C

Explanation: Kadane's Algorithm leverages dynamic programming to efficiently locate the maximum contiguous subarray sum. By maintaining a running localized total and resetting it when negative, it processes the array in a single continuous linear scan, achieving an $O(n)$ time complexity.

54. D

Explanation: The compiler's symbol table serves as a globally accessible data structure mapping identifiers to their attributes. It is not constrained to one phase; it is dynamically initialized in Lexical Analysis, structurally populated during Syntax Analysis, and extensively updated throughout Semantic Analysis.

55. B

Explanation: In the Go-Back-N protocol, the maximum valid window size is constrained by the sequence number space to prevent acknowledgement confusion. If n bits are used to represent the sequence numbers, the absolute maximum window size must be $2^n - 1$.

56. D

Explanation: In an AVL tree, a balance factor of -2 on a root indicates the tree is problematically right-heavy. When its right child holds a +1 balance factor (indicating a left-heavy branch), it structurally signifies a Right-Left imbalance, requiring a dual Right-Left (RL) rotation to restore balance.

57. B

Explanation: When a child subclass provides its own distinct, specialized implementation of a method block that has already been declared in its parent superclass, it is known as Method Overriding. This explicitly enables runtime polymorphism.

58. B

Explanation: While `nice` executes a brand new program with a modified scheduling priority, the `renice` command is exclusively used by Linux administrators to dynamically alter the ïicenessp̈riority value of an active, already-running background process.

59. D

Explanation: The CAP theorem proves that any highly distributed data store can simultaneously provide a maximum of two out of three guarantees: Consistency, Availability, and Partition Tolerance. General system Performance is not a structural parameter measured within this theoretical constraint.

60. A

Explanation: A /28 CIDR notation reserves exactly 28 bits for network identification, leaving 4 terminal bits allocated for distinct host addresses. This allows for $2^4 = 16$ IP variations, but subtracting the mandatory network and broadcast addresses leaves exactly 14 usable host configurations.

61. C

Explanation: For any two conformable square matrices A and B, the products AB and BA are mathematically guaranteed to share the exact same characteristic polynomial roots, meaning they share the exact same non-zero eigenvalues regardless of individual invertibility.

62. A

Explanation: A complete bipartite graph like $K_{3,4}$ is, by mathematical definition, strictly partitioned into two independent sets where all edges cross entirely between the sets. Consequently, coloring the graph requires only 2 alternating colors to guarantee no adjacent nodes share a pigment.

63. A

Explanation: The integrand $f(x) = x^3 \sin(x) \cos(x)$ represents an odd function because $f(-x) = -f(x)$. Due to mathematical symmetry, calculating the definite integral of any odd function evaluated over a symmetrical interval like $[-\pi, \pi]$ absolutely evaluates to zero.

64. A

Explanation: In statistical probability, the discrete probability mass function for a Poisson distribution is $P(X = k) = \frac{e^{-\lambda}\lambda^k}{k!}$. Substituting $\lambda = 3$ and $k = 0$ simplifies the equation directly to e^{-3}.

65. A

Explanation: The given differential equation takes the standard linear form $\frac{dy}{dx} + P(x)y = Q(x)$, where $P(x) = 2x$. The requisite integrating factor is computed via the formula $e^{\int P(x)dx}$, which cleanly integrates to e^{x^2}.

66. A
Explanation: With a total of 10 distinct balls, drawing two red balls strictly without replacement requires multiplying the sequential dependent probabilities. The calculation is $\frac{4}{10} \times \frac{3}{9}$, which logically simplifies to $\frac{12}{90}$ or the fraction $\frac{2}{15}$.

67. B
Explanation: Carefully observing matrix M reveals that Row 2 is exactly Row 1 multiplied by 2, and Row 3 is Row 1 multiplied by 3. Because all secondary rows are strictly linear dependencies of the first row, the matrix possesses only one linearly independent row, yielding a rank of 1.

68. B
Explanation: Using the logical laws of disjunctive syllogism, formula (B) asserts that if the proposition ëither p or $q$ïs true, and it is concurrently known that p is definitively false ($\sim p$), then q must logically be true. This creates an absolute tautology.

69. C
Explanation: The formal mathematical generating function for the standard infinite constant sequence $1, 1, 1, \ldots$ is $\frac{1}{1-x}$. Calculating the derivative of this base function yields the sequential counting numbers $1, 2, 3, 4, \ldots$, proving its generating function is $\frac{1}{(1-x)^2}$.

70. C
Explanation: Finding the absolute extrema involves calculating the derivative $f'(x) = 3x^2 - 6x$ and locating the critical points at $x = 0$ and $x = 2$. Testing the endpoints and criticals yields $f(0) = 2$, $f(2) = -2$, and $f(3) = 2$, confirming the absolute maximum constraint is exactly 2.

71. A
Explanation: Using the foundational Principle of Inclusion-Exclusion, the total number of students enrolled in at least one course is $30 + 25 - 10 = 45$. Subtracting this active union from the total 50 students leaves exactly 5 students studying neither.

72. B
Explanation: Because matrix A is upper triangular, its immediate eigenvalues are found directly on the main diagonal: 2 and 3. The mathematical trace of a cubed matrix equals the sum of its cubed eigenvalues, calculated as $2^3 + 3^3 = 8 + 27 = 35$.

73. A
Explanation: Expanding the non-homogeneous recurrence relation $a_n = 2a_{n-1} + 1$ from the base case $a_0 = 0$ yields the sequence progression 0, 1, 3, 7, 15. This pattern clearly maps to powers of two offset by one, perfectly described by the closed-form equation $2^n - 1$.

74. B
Explanation: The theoretical expected value for rolling a single fair six-sided die mathematically calculates to $(1 + 2 + 3 + 4 + 5 + 6)/6 = 3.5$. Utilizing the linearity

of expectation, the absolute sum of rolling the die twice is simply $3.5 + 3.5 = 7$.

75. D

Explanation: Mathematical set theory explicitly demonstrates that standard numbers sets like Integers, Rationals, and binary strings maintain a 1-to-1 mapping with Natural numbers, keeping them countable. However, Cantor's diagonal argument firmly proves the set of real numbers within any continuous interval is uncountably infinite.

76. C

Explanation: Evaluating this fundamental trigonometric limit requires multiplying the numerator and denominator by 5 to achieve the standard L'Hôpital format. This manipulation transforms the equation into $5 \cdot \lim_{x \to 0} \frac{\sin(5x)}{5x}$, which reliably equates to $5 \cdot 1 = 5$.

77. D

Explanation: In abstract algebra, the total number of distinct generators for a cyclic group of integer order N is determined by Euler's Totient function $\phi(N)$. For an order of 15, the function evaluates as $\phi(15) = \phi(3) \times \phi(5) = 2 \times 4 = 8$.

78. A

Explanation: To strictly satisfy the Cauchy-Riemann equations for an analytic function, u_x must equal v_y. Since the derivative of $x^2 - y^2$ with respect to x is $2x$, integrating $2x$ with respect to y inherently yields the solution $2xy + C$.

79. D

Explanation: By strict mathematical definition, an orthogonal matrix A satisfies the identity relation $AA^T = I$. Applying standard determinant properties yields $\det(A)\det(A^T) = \det(A)^2 = 1$, which algebraically proves the determinant must be exactly $+1$ or -1.

80. A

Explanation: The word ÄLGORITHMcönsists of 9 distinct, non-repeating letters, strictly containing exactly 3 vowels (A, O, I). The probabilistic odds of an entirely random permutation starting with a vowel is the total vowels divided by the total letters: 3/9, which simplifies strictly to 1/3.

81. A

Explanation: The encryption logically dictates swapping the first and last letters of the word, followed by incrementing every single internal middle letter by +1 in the alphabet. Applying this rigid logic to MEDICINEäccurately yields ËOJDJEFM:

82. B

Explanation: The presented number sequence executes a highly specific arithmetic pattern, alternating consistently between subtracting 2 and then subtracting 4. Executing the logical continuation from 24 necessitates subtracting 2, definitively landing on the integer 22.

83. D

Explanation: Breaking down the speaker's statement, the only son of my motherünequivocally refers to Suresh himself. Therefore, if the individual in the photograph is the son ofSuresh, it logically confirms Suresh is the father.

84. B

Explanation: Calculating the base rate explicitly reveals that a single solitary machine manufactures exactly one widget in a total of 6 minutes. Operating simultaneously, 100 parallel machines will manufacture 100 total widgets in that exact same 6-minute window.

85. A
Explanation: Using categorical syllogism rules, since a subset of algorithms physically exists within the p̈ramc̈ategory, and the entire p̈ramc̈ategory resides inside the äpplicatiön̈boundary, it strictly guarantees that at least some algorithms must also be applications.

86. B
Explanation: When entities run in opposing relative directions, their velocities linearly add together, creating a combined velocity of 66 km/hr. Converting this sum into meters per second (18.33 m/s) and dividing it into the 120m train length cleanly calculates to 6.54 seconds.

87. A
Explanation: Utilizing Bayes' Theorem to calculate the posterior probability involves isolating the exact Democratic voting demographic over the entire blended voting base. This calculates mathematically as $(0.6 \times 0.7)/(0.6 \times 0.7 + 0.4 \times 0.5) = 0.42/0.62$, generating the exact fraction 21/31.

88. A
Explanation: Every listed string utilizes identical backwards alphabet jumps of exactly -2 steps per letter. The distinguishing logical anomaly is strictly vowel-based; three options contain one interior vowel, while Z̈XVTc̈ontains absolutely no vowels whatsoever.

89. B
Explanation: Following the strict physical constraints, C must sit instantly left of B. Since A is completely forbidden from touching B, A must sit adjacent to C. This forces the clockwise positional layout to map perfectly as A, C, B, D, meaning C is to A's right.

90. C
Explanation: In mechanical clocks, the hour hand travels at a constant velocity of precisely $0.5°$ for every minute elapsed. From noon to exactly 10 past 5, a total duration of 310 minutes occurs, equating mathematically to $310 \times 0.5° = 155$ degrees.