

## COMPUTER SCIENCE

1. Which of the following is the general solution of the recurrence relation:  
 $a_n = 2a_{n-1} + 3a_{n-2}$ , when  $c_1$  and  $c_2$  are constants?
  - a)  $a_n = c_1 3^n + c_2 (-1)^n$
  - b)  $a_n = c_1 (-3)^n + c_2 (1)^n$
  - c)  $a_n = c_1 (-3)^n + c_2 (-1)^n$
  - d)  $a_n = c_1 3^n + c_2 2^n$
  
2. In a multiplicative group  $G$  with identity element  $e$ , it is given that  $a^5 = e$ ,  $aba^{-1} = b^2$  for  $a, b \in G$ . Then, the order of  $b (\neq e)$  is :
  - a) 12
  - b) 11
  - c) 31
  - d) 21
  
3. Which one of the following is not correct?
  - a) A finite connected graph is Eulerian if and only if each vertex has even degree.
  - b) Let  $G$  be a connected planar graph with  $p$  vertices and  $q$  edges, where  $p \geq 3$ . Then  $q \geq 3p - 6$ .
  - c) The relation among number  $V$  of vertices, the number  $E$  of edges, and the number  $R$  of regions of any connected map is given by  $V + E - R = 2$ .
  - d) The sum of the degrees of the vertices in a graph is always equal to twice the number of edges.
  
4. The number of ways in which a tree of six vertices can be properly coloured with at most 3 colours is:
  - a) 16
  - b) 32
  - c) 48
  - d) 96
  
5. The statement  $p \wedge (\sim q \vee r) \wedge (\sim r \vee q)$  is
  - a) a contradiction
  - b) a contingency
  - c) a tautology
  - d) None of these

6. Consider the following system of equations in unknowns  $x, y$  and  $z$ :

$$\begin{aligned}x + 2y - 3z &= a \\2x + 6y - 11z &= b \\x - 2y + 7z &= c.\end{aligned}$$

If the above system of equations has no solution, then the condition satisfied by the constants  $a, b$  and  $c$  is

- a)  $5a = 5b + 2c$
- b)  $5a \neq c + 2b$
- c)  $5a = -c + 2b$
- d)  $a - b + c = 0$

7. If the matrix  $P = \begin{bmatrix} 4 \\ 3 \\ 2 \end{bmatrix} \begin{bmatrix} 3 & -2 & 1 \end{bmatrix}$ , then determinant of  $P$  is equal to

- a) 18
- b) 12
- c) 11
- d) 0

8. The  $LU$  decomposition of the matrix  $M$  is given by  $M = LU$ , where

$$M = \begin{bmatrix} 2 & -1 & 3 \\ 4 & 2 & 1 \\ -6 & -1 & 2 \end{bmatrix}, L = \begin{bmatrix} 1 & 0 & 0 \\ l_{21} & 1 & 0 \\ l_{31} & l_{32} & 1 \end{bmatrix} \text{ and } U = \begin{bmatrix} u_{11} & u_{12} & u_{13} \\ 0 & u_{22} & u_{23} \\ 0 & 0 & u_{31} \end{bmatrix},$$

then  $U$  is given by

- a)  $\begin{bmatrix} 2 & -1 & 3 \\ 0 & 4 & 5 \\ 0 & 0 & 6 \end{bmatrix}$
- b)  $\begin{bmatrix} 2 & -1 & 3 \\ 0 & 4 & -5 \\ 0 & 0 & 6 \end{bmatrix}$
- c)  $\begin{bmatrix} 2 & -1 & 3 \\ 0 & 4 & 5 \\ 0 & 0 & -6 \end{bmatrix}$
- d)  $\begin{bmatrix} 2 & -1 & 3 \\ 0 & 4 & -5 \\ 0 & 0 & -6 \end{bmatrix}$

9. If the Eigen-vectors of the matrix  $\begin{bmatrix} 1 & 2 \\ 0 & 2 \end{bmatrix}$  are given by vectors  $\begin{bmatrix} 1 \\ l \end{bmatrix}$  and  $\begin{bmatrix} 1 \\ m \end{bmatrix}$ , then the value of  $l + m$  is \_\_\_\_\_

- a) 2
- b) 0
- c)  $1/2$
- d) None of the option

10. If  $P = \begin{bmatrix} 1 & 0 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix}$ , then the value of  $P^4$  is equal to

- a)  $2P^2 - I$
- b)  $3P^2 + I$
- c)  $2P^2 + I$
- d)  $3P^2 - I$

11. The value  $\lim_{x \rightarrow 0} \frac{1}{x^3} \left( \int_0^x \frac{t \log(1+t)}{t^4 + 4} dt \right)$  is

- a)  $1/56$
- b)  $1/24$
- c)  $1/12$
- d)  $0$

12. The definite integral  $\int_0^{\infty} x^{\frac{1}{2}} e^{-\frac{x^3}{8}} dx$  evaluates to

- a)  $\frac{\sqrt{\pi}}{3}$
- b)  $\frac{\sqrt{2\pi}}{3}$
- c)  $\sqrt{2\pi}$
- d)  $2 \frac{\sqrt{\pi}}{3}$

13. The area enclosed between the curves  $y^2 = x + 4$  and  $y^2 = -x + 4$  is equal to

- a)  $\frac{64}{3}$  sq units
- b)  $\frac{32}{3}$  sq units
- c)  $\frac{16}{3}$  sq units
- d)  $\frac{8}{3}$  sq units

14. If  $f(x) = \begin{cases} x^2 \sin \frac{1}{x} & \text{if } x \neq 0 \\ 0 & \text{if } x = 0 \end{cases}$ , then

- a)  $f(x)$  is differentiable at  $x = 0$
- b)  $f(x)$  is not differentiable at  $x = 0$

- c)  $f(x)$  is continuous but not differentiable at  $x = 0$
- d)  $f(x)$  is not continuous at  $x = 0$

15. The minimum value of the function  $x^3 + y^3 - 24xy$  is

- a) 0
- b) 512
- c) -64
- d) -512

16. The marks obtained by 200 students in a placement drive exam are given in the following table:

Marks Obtained (out of 100)	85	80	75	70	60
Number of Students	40	50	60	30	20

The mean, median, and mode of the marks are given by which one of the following?

- a) Mean= 75, Median=75 and Mode=75
- b) Mean= 76, Median=75 and Mode=75
- c) Mean= 75, Median=76 and Mode=75
- d) Mean= 76, Median=75 and Mode=76

17. The LED bulbs manufacturing factories A, B and C supply LED bulbs to the market in the ratio 3:2:5. It is found that 2% of the items produced in factory A, 1% of the items produced in factory B and 3% of the items produced in factory C are defective. If a bulb is selected at random from the market and found to be defective, then the probability that it was produced by factory B is

- a)  $5/23$
- b)  $3/23$
- c)  $2/23$
- d)  $1/23$

18. A random variable  $m$  is uniformly distributed over the interval  $(0, 5)$ . The probability that the roots of the equation  $4x^2 + 4mx + m + 2 = 0$  are real, is

- a)  $1/5$
- b)  $2/5$
- c)  $4/7$
- d)  $3/5$

19. In a Poisson distribution if  $P(X = 1) = 2.P(X = 2)$ , then the value of  $P(X \leq 2/X \geq 1)$  is

a)  $\frac{3}{2(e-1)}$

b)  $\frac{3}{2e(1-e)}$

c)  $\frac{2}{3e(1+e)}$

d)  $\frac{3}{2(1+e)}$

20. A normal variable  $X$  has mean 15 and standard deviation 6, if  $Z$  is another normal variable such that  $X - 6Z=15$ , then expected value of the random variable  $(5Z+4)$  is equal to

a) 2

b) 4

c) 5

d) 12

21. Which of the following number in Octal Number system is the result of the following subtraction:  $(A250.47)_H - (110101101111.001)_B$   
 Here,  $A250.47$  is the number represented in Hexadecimal number system whereas,  $110101101111.001$  is the number represented in Binary number system.

- a)  $(451604.047)_O$
- b)  $(112341.116)_O$
- c)  $(451604.116)_O$
- d)  $(112341.047)_O$

22. Given, K-map of Boolean function of five variables A, B, C, D, and E. What will be the minimum sum-of-product (SOP) expression for the given function?

	AB	00	01	11	10
CD		00	0	0	0
		01	1	0	0
		11	1	0	0
		10	0	0	0

E = 0

	AB	00	01	11	10
CD		00	0	1	1
		01	0	0	0
		11	0	0	0
		10	0	1	1

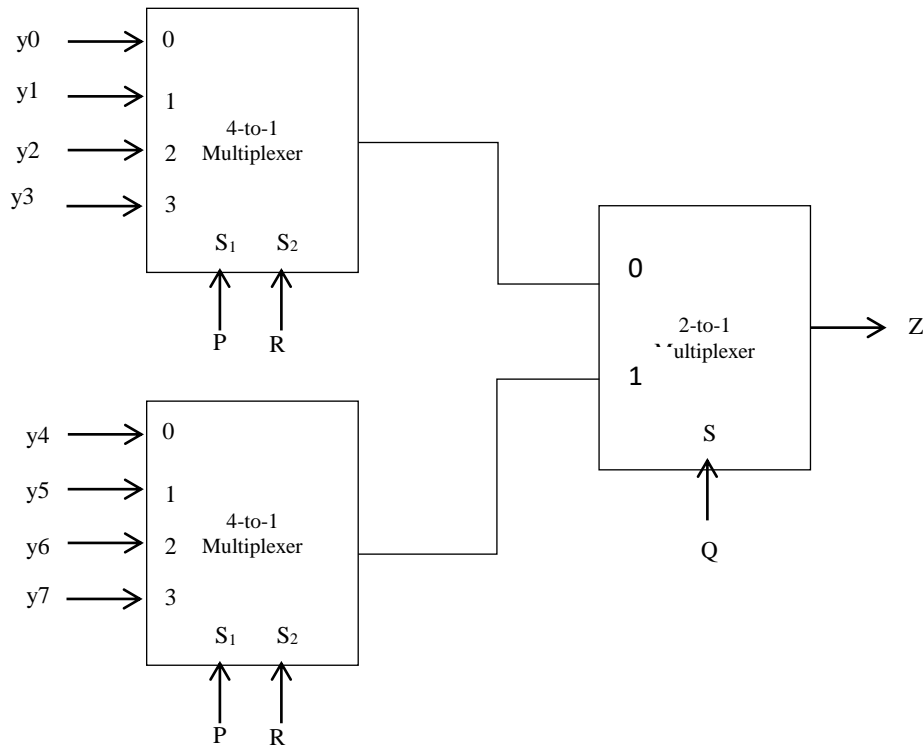
E = 1

- a)  $A'B'DE' + AB'SE' + BC'D'E + BCD'E$
- b)  $B'DE' + BD'E$
- c)  $B'DE + BD'E'$
- d)  $B'D + BD'$

23. An eight-bit ripple-carry adder is designed for computing the sum of P and Q, where P and Q represent two distinct integers in 2's complement form. Assuming that P has a decimal value of one, calculate the decimal value of Q that leads the longest latency for the sum to stabilize.

- a) 1
- b) -1
- c) 0
- d) 2

24. A digital circuit built using three multiplexers (two 4-to-1 multiplexers and one 2-to-1 multiplexer) is given as follows:



What will be the values of  $y_0, y_1, y_2, y_3, y_4, y_5, y_6,$  and  $y_7$  in order to get the output  $Z = P' + P'R' + PQ'R$ ?

- a) 1, 1, 0, 1, 0, 0, 1, 1
- b) 1, 0, 1, 1, 1, 1, 0, 0
- c) 1, 1, 0, 1, 1, 1, 0, 0
- d) 1, 0, 1, 0, 1, 1, 0, 1

25. Four Boolean functions (of three variables,  $A, B,$  and  $C$ ) are given as follows:

- I.  $A + C + AB$
- II.  $(A + B)(A + C)$
- III.  $A + AC + AB$
- IV.  $A + AB + BC$

Which of the above Boolean functions is equivalent to another Boolean function:  $A + BC$  ?

- a) II, and IV
- b) I, and IV
- c) II, III, and IV
- d) II only

26. Consider a non-pipelined processor operated with a clock frequency of 1 GHz. It consumes 4 clock cycles per ALU operation, 2 clock cycles per branch operation and 6 clock cycles per data transfer operation. The relative frequencies of above instructions are 40%, 20%, and 40% respectively. Assume that 0.4 ns overhead is added when it is implemented to pipelined processor with the same clock frequency while executing the large number of instructions. Its average instruction time is 1 clock. What will be its speed up (rounded to 2 decimal points)?
- a) 4.41
  - b) 5.23
  - c) 2.82
  - d) 3.14
27. Two processors  $R_1$  and  $R_2$  are executing the same instruction set. When given the same input, the program running on  $R_1$  takes 30% less time than the program running on  $R_2$ . However, it requires 25% more clock cycles per instruction (CPI) as compared to  $R_2$ . If the clock frequency of  $R_2$  is 2 GHz, determine the clock frequency of  $R_1$  (in GHz and rounded to 1 decimal point).
- a) 1.8
  - b) 2.5
  - c) 3.6
  - d) 1.6
28. The computer has 256 KB; 8-way set associative cache memory with block size of 64 bytes. The physical address generated by the processor is 32 bits. What is the number of bits in tag field of an address?
- a) 12
  - b) 14
  - c) 17
  - d) 16
29. A processor with 32 registers and an instruction set of size thirteen is given. There are five different fields with each instruction namely, opcode, three source register, one destination register, and eight bits immediate value. Given, instruction is stored in byte-aligned form. What is the size of memory (in bytes) consumed by the program, if program has 200 instructions?
- a) 500 B
  - b) 800 B
  - c) 1000 B
  - d) 1200 B



30. A computer supports 2-address and 1-address instructions. It has 30 bits instructions and 12 bits addresses. Find the maximum number of 1 address instructions that can be formulated, if a 2-address instruction has used 62.

- a) 1024
- b) 2048
- c) 4096
- d) 8192

31. What is the output of the following C program?

```
#include <stdio.h>
int incr(int i)
{
    static int count = 0;
    count = count + i*2 + 3;
    return count;
}
int main()
{
    int i, j;
    for (i = 0; i <= 4; i++)
    {
        j = incr(i);
        printf("%d ", j);
    }
    return 0;
}
```

- a) 3 8 15 24 35
- b) 3 10 15 22 33
- c) 3 6 9 12 15
- d) 3 5 8 12 17

32. Consider the following C declaration (not full program).

```
struct {
    short s [10];
    union {
        float y;
        long double z;
    } u;
} t;
```

Assume that objects of the type short, float and long occupy 2 bytes, 4 bytes and 10 bytes, respectively. Ignoring memory alignment or structure padding, which of the following represents the memory requirement for the variable t?

- a) 20 bytes
- b) 36 bytes
- c) 30 bytes
- d) 56 bytes

33. What is the output of the following C program?

```
#include <stdio.h>
int f(int n)
{
    static int i = 1;
    if (n >= 10)
        return n;
    n = n + i;
    i++;
    return f(n);
}
int main()
{
    printf("%d ", f(3));
    return 0;
}
```

- |       |       |
|-------|-------|
| a) 6  | b) 13 |
| c) 10 | d) 15 |

34. What is the output of the following c program?

```
#include <stdio.h>
#include <string.h>
int main()
{
    char p[20];
    char *s = "This is my first program";
    int length = strlen(s);
    int i;
    for (i = 0; i < length; i = i + 1)
        p[i] = s[length - 1 - i * 2];
    p[length] = '\0';
    printf("%s", p);
    getchar();
}
```

- |                         |                             |
|-------------------------|-----------------------------|
| a) marorp tsrif ym sihT | b) program first my is This |
| c) mroprfy ish          | d) mpro rsfty ih            |

35. Consider the C code of a function, func1() as follows:

```
int func1(int n)
{
    if(n < 0)
        return 0;
    if(n == 0 || n == 1)
        return n;
    else
        return (2*func1(n-1) + 2*func1(n-2) + 2*func1(n-3));
}
```

The function func1() is called in the main function of your C program by passing the argument as 5, *i.e.* in main(), this function is called as func1(5). Which of the following is the return value by func1(5) in main()?

- a) 52
- b) 50
- c) 56
- d) 45

36. Consider a two dimensional array A[20][10]. Assume 4 words per memory cell, the base address of array A is 100, elements are stored in row-major order and first element is A[0][0]. What is the address of A[10][5] ?

- a) 520
- b) 560
- c) 760
- d) 660

37. Consider the following code:

```
void fun1(struct node* head, int print)
{
    if (head == NULL)
        return;
    if (print)
        printf("%d ", head->data);
    fun1(head->next, !print);
}
```

If the function is called as fun1(head, 1), what will be the output for a linked list?

- a) Prints all nodes of linked lists
- b) Prints all nodes of linked list in reverse order
- c) Prints alternate nodes of Linked List
- d) Prints alternate nodes in reverse order

38. Consider the following pseudocode that uses a stack:

```
declare a stack of characters
while ( there are more characters in the word to read )
{
read a character
push the character on the stack
}
while ( the stack is not empty )
{
pop a character off the stack
write the character to the screen
}
```

What is output given by the above pseudocode, if, character by character following input is read: DATA\_STRUCTURES?

- a) DATA\_STRUCTURES
- b) STRUCTURES\_DATA
- c) SERUTCURTS\_ATAD
- d) ATAD\_SERUTCURTS

39. Consider a standard Circular Queue 'q' implementation (which has the same condition for Queue Full and Queue Empty) whose size is 11 and the elements of the queue are q[0], q[1], q[2].....,q[10]. The front and rear pointers are initialized to point at q[5]. In which position will the seventh element be added?

- a) q[2]
- b) q[1]
- c) q[0]
- d) q[10]

40. Consider a binary search tree (BST) with the following elements inserted in the order shown: 50, 30, 70, 20, 40, 60, 80, 74, 10, 39, 55, 62. If you want to find the level of the key 62 in this BST, what would be the result? Assume root is at Level 0.

- a) Level 2
- b) Level 3
- c) Level 4
- d) Level 5

41. Given a hash table T with 40 slots that stores 5000 elements, the load factor  $\alpha$  for T is \_\_\_\_\_.

- a) 150
- b) 125
- c) 40
- d) 200

42. Using the approach of Divide and Conquer, the minimum number of comparisons required to find the minimum and the maximum of 500 numbers (random order) is \_\_\_\_\_.

- a) 999
- b) 290
- c) 748
- d) 853

43. Which algorithm out of the following options uses the least number of comparisons (among the array elements) to sort the given array in ascending order?

11	13	19	21	25	27	35	42	55	63
----	----	----	----	----	----	----	----	----	----

- a) Selection sort
- b) Merge sort
- c) Insertion sort
- d) Quick sort using the last element as pivot

44. Consider a set of characters with probabilities given as follows: a (0.25), b (0.20), c (0.18), d (0.15), and e (0.22). If an optimal Huffman coding technique is applied, what is the average length of the resulting codes?

- a) 2.05
- b) 2.33
- c) 2.50
- d) 2.75

45. Which of the following is not an approach to find out the shortest distance between any two vertices of a weighted graph?

- a) Dijkstra's Algorithm
- b) Prim's Algorithm
- c) Floyd-Warshall Algorithm
- d) Bellmon Ford Algorithm

46. Select the regular expression which follows the given language "set of all strings consisting two consecutive a and two consecutive b".

- a)  $(a + b)^* aabb (a + b)^* + (a + b)^* bbaa (a + b)^*$
- b)  $(a + b)^* aa (a + b)^* + (a + b)^* bb (a + b)^*$
- c)  $aa (a + b)^* bb + bb (a + b)^* aa$
- d)  $(a + b)^* (aa (a + b)^* bb + bb (a + b)^* aa) (a + b)^*$

47. Consider  $G1 = \{\alpha \in \{a, b\}^* \mid \alpha \text{ has at least as many occurrences of } (bba)\text{'s as } (abb)\text{'s}\}$ .  
 $G2 = \{\alpha \in \{a, b\}^* \mid \alpha \text{ has at least as many occurrences of } (aaa)\text{'s as } (bbb)\text{'s}\}$ . Among the following options, which one is TRUE?
- $G1$  is regular, but not  $G2$
  - $G2$  is regular, but not  $G1$
  - Both  $G1$  and  $G2$  are regular
  - Neither  $G1$  nor  $G2$  are regular
48. The following languages are given:  
 $G1 = \{p^y q^x r^x \mid y \geq 1, x \geq 1\}$   
 $G2 = \{p^y q^y r^x \mid y \geq 1, x \geq 1\}$   
Among the following select the correct statement
- $G1 \cap G2 = \phi$
  - $G1$  and  $G2$  are not DCFL's
  - $G1 \cap G2$  is not a DCFL
  - $G1$  is a DCFL but  $G2$  is not
49. Given, a context free grammar  $M = (\{S\}, \{0,1\}, X, S)$  with the rule set  $X$  is given by:  

$$S \rightarrow 0S1 \mid SS \mid \epsilon$$
Among the following options select the correct statement.
- It is possible to find a deterministic finite state automaton that accepts  $L(M)$
  - There is a deterministic pushdown automaton that accepts  $L(M)$
  - $M$  is not ambiguous
  - There exist  $i, j \in L(M)$  such that  $ij \notin L(M)$
50. Consider the following context free grammar ( $G$ ).  
 $S \rightarrow pSq \mid pPq \mid pQq$   
 $P \rightarrow pP \mid p$   
 $Q \rightarrow Qq \mid q$   
Among the following which language is generated by  $G$ ?
- $\{p^y q^x \mid x, y > 0, |y-x| > 0\}$
  - $\{p^y q^x \mid x, y > 1, |y-x| > 1\}$
  - $\{p^y q^x \mid x, y > 0, |y-x| > 1\}$
  - $\{p^y q^x \mid x, y > 0, |y-x| > 2\}$
51. Which tool is used for grouping of characters in tokens in the compiler?
- Parser
  - Scanner
  - Code Optimizer
  - Code Generator

52. Select the grammar which is free from the left recursion.

a)  $S \rightarrow PQ$   
 $P \rightarrow Pp \mid q$   
 $Q \rightarrow r$

b)  $S \rightarrow Pp \mid Qq \mid r$   
 $P \rightarrow Qs \mid \varepsilon$   
 $Q \rightarrow Pt \mid$

c)  $S \rightarrow Pq \mid Qq \mid r$   
 $P \rightarrow Qs \mid \varepsilon$   
 $Q \rightarrow t$

d)  $S \rightarrow Pp \mid Q$   
 $P \rightarrow Qq \mid S r \mid \varepsilon$   
 $Q \rightarrow s$

53. Select among the following statements is/are FALSE

I. LALR parser is more powerful than Canonical LR parser.

II. Canonical LR parser is more powerful than SLR parser.

III. LALR parser is more powerful than SLR parser and less powerful than Canonical LR parser

a) I only

b) II only

c) III only

d) I and II

54. Consider the given syntax directed translation scheme (SDTS), what will be the output printed by the bottom-up parser, for input xxy?

$S \rightarrow xX\{\text{print @}\}$

$S \rightarrow x\{\text{print #}\}$

$X \rightarrow Sy\{\text{print \$}\}$

Where,  $\{S, X\}$  are non-terminals, and  $\{x, y\}$  are terminals

a) @ \$ #

b) # # \$

c) # \$ @

d) Syntax Error

55. Consider the following basic block.

$a = b + c$

$b = a - d$

$c = b + c$

$d = a - d$

Compute the minimum number of nodes and edges present in the Directed Acyclic Graph representation of the given basic block.

a) 3 and 4

b) 6 and 6

c) 5 and 4

d) 8 and 10

56. The following processes are being scheduled using a pre-emptive, round robin scheduling algorithm.

Process	Priority	Burst	Arrival
P1	40	20	0
P2	30	25	25
P3	30	25	30
P4	35	15	60
P5	5	10	100
P6	10	10	105

Each process is assigned a numerical priority, with a higher number indicating a higher relative priority. In addition to the processes listed above, the system also has an idle task (which consumes no CPU resources and is identified as P idle). This task has priority 0 and is scheduled whenever the system has no other available processes to run. The length of a time quantum is 10 units. If a process is pre-empted by a higher-priority process, the pre-empted process is placed at the end of the queue. What are the average turnaround time and CPU utilization rate?

- a) 30, and 87.5
- b) 12.5, and 89.78
- c) 30, and 89.78
- d) 12.5, and 87.5

57. Consider a computer system with three physical frames. Given the page reference sequence (1, 2, 3, 4, 1, 2, 5, 1, 2, 3, 4, 5). What is the difference in page fault rates between the least recently used page replacement policy and the optimal page replacement policy?

- a) 0.37
- b) 0.25
- c) 0.45
- d) 0.15

58. In a computer system with 16 KB pages and a 48 bit physical address space, each page table entry includes a valid bit, a dirty bit, four permission bits, and a translation. Given, a process has a maximum page table size of 40 MB, find the length of the virtual address supported by the system.

- a) 38
- b) 36
- c) 42
- d) 37



59. State which of the given statement is/are TRUE?

- I. Peterson's algorithm can be used to enforce mutual exclusion on a multiprocessor.
- II. Once a thread has acquired a lock (using lock acquire()), it cannot be preempted by the scheduler until it has released the lock by calling lock release
- III. "Belady's anomaly" refers to a situation in which a process with a smaller virtual address space experiences more page faults than a process with a larger virtual address space.
- IV. A test-and-set instruction can be used to enforce mutual exclusion on a multiprocessor.

Select among the following options:

- a) I, III and IV
- b) II and III
- c) IV only
- d) I and IV

60. A paging system with one level page table is in main memory and TLB for address translation. A main memory access takes 80 ns, and Translation Look aside Buffer (TLB) with a search time of 10 ns. Each page transfer to/from the disk takes 6000 ns. It is assumed that the TLB hit ratio is 90%, and a page fault rate is 15%. Assume that for 25% of the total page faults, a dirty page has to be written back to disk before the required page is read from disk. The TLB update time is considered negligible.

Compute the average memory access time (in ns) and select the appropriate range.

- a) 176.5 to 177.5
- b) 154.5 to 155.5
- c) 521.5 to 522.5
- d) 425 to 426

61. Considering two distinct functions in() and out() to implement critical section of a process are realized using test-and-set instruction as given below:

```
void in(M)
{
    while(test-and-set(M));
}

void out(M)
{
    M = 0;
}
```

In the above solution, M is a memory location associated with the critical section and is initialized to 0. Given, the following statements:

- I. The provided solution is starvation free
- II. The provided solution is deadlock free
- III. More than one process can enter the critical section at the same time
- IV. The processes entering into critical section follows LIFO order

Among the following, select the correct statement (s).

- a) III only
- b) I and II
- c) I and IV
- d) II only

62. Assume that a storage disk comprises 4 platters (0, 1, ... ,3), 200 cylinders (0,1, ... , 199), and 256 sectors per track (0,1, ... ,255). The disk controller receives the following 6 disk requests of the form [sector number, cylinder number, platter number] simultaneously: [120, 72, 2], [180, 134, 1], [60, 20, 0], [212, 86, 3], [56, 116, 2], and [118, 16, 1]. Currently head is positioned at sector number 100 of cylinder 80, and is moving towards higher cylinder numbers. The average power dissipation in moving the head over 100 cylinders is 20 milliwatts and for reversing the direction of the head movement once is 10 milliwatts. Power dissipation associated with rotational latency and switching of head between different platters is negligible. What will be the total power consumption in milliwatts to satisfy all of the above disk requests using the Shortest Seek Time First disk scheduling algorithm?

- a) 58.39 milliwatts
- b) 85 milliwatts
- c) 70 milliwatts
- d) 42 milliwatts

63. Consider the following pseudo code, where S is a semaphore initialized to 5 in line no. 2 and counter is a shared variable initialized to 0 in line no. 1. Assume that the increment operation in line no. 7 is not atomic.

```
1. int counter = 0;
2. Semaphore S = init (5);
3. Void paraop (void)
4. {
5. wait(S);
6. wait(S);
7. counter++;
8. signal(S);
9. signal(S);
10. }
```

If five threads execute the function paraop concurrently, then which of the following behaviour is possible?

- I. There is a deadlock involving all the threads
- II. The value of counter is 5 after all the threads successfully complete the execution of paraop
- III. The value of counter is 1 after all the threads successfully complete the execution of paraop
- IV. The value of counter is 0 after all the threads successfully complete the execution of paraop

Among the following options, choose the correct one.

- a) II, III, and, IV
- b) I, II, and, III
- c) I, III, and, IV
- d) None

64. Consider a processor that generates 56-bit virtual address with page size 8KB and implements n-level paging scheme with page table entry at all levels as 32 Bytes. Then, what will be the value of 'n' and 3<sup>rd</sup> level page table size respectively (numbered from 1)?

- a) 6, 16MB
- b) 5, 64MB
- c) 6, 4GB
- d) 5, 4GB

65. A demand paged memory environment has physical memory access time of 50 microseconds and page fault service time of 5000 microseconds if the replaced page is not dirty. The page fault service time of 100 milliseconds if a dirty page is replaced. Assume that among all pages which are getting replaced, only 2% are dirty, and 95% page hit ratio, then what will be the effective memory access time (in microseconds)?

- a) 514
- b) 981
- c) 233
- d) 440

66. Consider the following SQL query:  
SELECT AVG(salary) AS avg\_salary  
FROM employees  
GROUP BY department\_id  
HAVING COUNT(\*) > 1;  
What does this query return?
- a) The average salary for each department with more than one employee.
  - b) The average salary for each department with exactly one employee.
  - c) The average salary for all departments.
  - d) An error because the GROUP BY and HAVING clauses cannot be used together.
67. Given the following SQL query:  
SELECT MAX(salary) AS max\_salary  
FROM employees  
WHERE department\_id IN (SELECT department\_id FROM departments WHERE  
location\_id = 1700);  
What does this query return?
- a) The maximum salary in all departments.
  - b) The maximum salary in the department with location\_id equal to 1700.
  - c) An error because a subquery cannot be used in the WHERE clause.
  - d) The maximum salary for each department with location\_id equal to 1700.
68. Consider the following SQL query:  
SELECT employee\_id, salary  
FROM employees  
WHERE salary > ANY (SELECT salary FROM employees WHERE job\_id = 'CLERK');  
What does this query return?
- a) All employees with a salary greater than the average salary of CLERK job.
  - b) All employees with a salary greater than any CLERK's salary.
  - c) An error because the ANY keyword cannot be used in this context.
  - d) All employees with a salary greater than the minimum salary of CLERK job.

69. Consider the following SQL query:  
 SELECT department\_name, SUM(salary) AS salary1  
 FROM departments  
 LEFT JOIN employees ON departments.department\_id = employees.department\_id  
 GROUP BY department\_name;  
 What does this query aim to achieve?
- Retrieve the total salary cost for each department, including those with no employees.
  - Retrieve the average salary for each department, excluding those with no employees.
  - Retrieve the total number of employees in each department, including those with no salary.
  - Gives an error

70. Consider the following SQL query:  
 SELECT department\_name, AVG(salary) AS avg\_salary  
 FROM employees  
 INNER JOIN departments ON departments.department\_id = employees.department\_id  
 GROUP BY department\_name  
 HAVING AVG(salary) = (  
   SELECT MAX(avg\_salary)  
   FROM (  
     SELECT AVG(salary) AS avg\_salary  
     FROM employees  
     GROUP BY department\_id  
   ) AS subquery  
 );

What is the purpose of this query?

- Retrieve the average salary for each department.
- Retrieve the department names with the highest average salary.
- Retrieve the department names with the lowest average salary.
- Retrieve the maximum salary for each department.

71. Consider the following schema:  
 Sailors (sid, sname, rating, age)  
 Boats (bid, bname, colour)  
 Reserves (sid, bid, day)  
 What does the following relational algebra expression represent?

$$\pi_{sid}(\sigma_{age>20}Sailors) - \pi_{sid}((\sigma_{color='red'}Boats) \bowtie Reserves \bowtie Sailors)$$

- Names of sailors who have reserved at least one red boat.
- Names of sailors whose age is greater than 20 but have reserved red boat.
- Names of sailors whose age is lesser than 20 but have not reserved any red boat.
- Names of sailors whose age is greater than 20 but have not reserved any red boat.

72. Consider the following schema:

Sailors (sid, sname, rating, age)

Boats (bid, bname, colour)

Reserves (sid, bid, day)

What does the following relational algebra expression represent?

$$\{P \mid \exists S \in \text{Sailors} \exists R \in \text{Reserves} (R.\text{sid} = S.\text{sid} \wedge P.\text{sname} = S.\text{sname} \wedge \exists B \in \text{Boats} (B.\text{bid} = R.\text{bid} \wedge B.\text{color} = \text{'red'}))\}$$

- a) Names of sailors who have reserved a red boat.
- b) Names of sailors who have not reserved any red boat.
- c) Names of sailors who have reserved at least one red boat.
- d) Names of sailors who have reserved at most one red boat.

73. Consider the following relational schemes for a university database:

Course (CourseCode, Title, Instructor, Department, Credits)

Student (StudentID, Name, Major, Department)

Enrollment (StudentID, CourseCode, Grade)

with the following functional dependencies:

- I. CourseCode Instructor  $\twoheadrightarrow$  Title, Department, Credits
- II. StudentID CourseCode  $\twoheadrightarrow$  Grade
- III. Department  $\twoheadrightarrow$  Instructor

Assume {StudentID, CourseCode} is the key for the Enrollment scheme. Which of the following statements is true?

- a) Both Course and Student are in BCNF.
- b) Both Course and Student are in 3NF only.
- c) Course is in 2NF, and Student is in 3NF.
- d) Both Course and Student are in 2NF only.

74. Given a relation R(X, Y, Z) with the functional dependencies:

$X \rightarrow Y$

$Y \rightarrow Z$

$Z \rightarrow X$

What is the minimum number of relations needed to decompose R into Boyce-Codd Normal Form (BCNF)?

- a) 1
- b) 2
- c) 3
- d) 4

75. R has been decomposed using one set of functional dependencies F, while another set of functional dependencies G has been used to decompose S. One of the decompositions is definitely in BCNF, and the other is definitely in 3NF, but it is not known which is which. To reliably determine the identification, which of the following tests should be applied to the decompositions? (Assume that the closures of F and G are available).
- a) Dependency-preservation
  - b) Lossless-join
  - c) BCNF definition
  - d) 3NF definition
76. Which of the following database systems implement record identifiers differently from the others, particularly using logical record ids in the presence of a clustered index?
- a) IBM DB2
  - b) Informix
  - c) Microsoft SQL Server
  - d) Oracle 8
77. Consider a disk with the following characteristics: sector size of 512 bytes, 2,000 tracks per surface, 50 sectors per track, 5 double-sided platters, average seek time of 10 msec.  
What is the capacity of the disk?
- a) 25,600,000 bytes
  - b) 128,000,000 bytes
  - c) 256,000,000 bytes
  - d) 512,000,000 bytes
78. Suppose a FAT (File Allocation Table) based file system is being used, and the total overhead of each entry in the FAT is 6 bytes in size. Given a  $120 \times 10^6$  bytes disk on which the file system is stored and a data block size of 120 bytes, what is the maximum size of a file that can be stored on this disk in units of  $10^6$  bytes?
- a) 119.15 to 119.25
  - b) 120.6 to 121.5
  - c) 112.8 to 114.1
  - d) 108.9 to 111.0

79. A data file containing 180,496 employee records is stored on a hard disk with a block size of 5104 bytes. The data file is sorted on the primary key EmpID. Each employee record has a candidate key attribute called SSN of size 14 bytes, and the size of a record pointer for this disk is 8 bytes. An index file is built on the SSN attribute, and each index record consists of the SSN value and the record pointer to the corresponding employee record.

What is the number of blocks in the index file?

- a) 440
- b) 512
- c) 621
- d) 778

80. Consider the following log sequence of two transactions on a bank account, with an initial balance of 15000, that transfer 2500 to a loan payment and then apply a 3% interest.

1. T1 start
2. T1 B old=15000 new=12500
3. T1 L old=0 new=2500
4. T1 commit
5. T2 start
6. T2 B old=12500 new=12925
7. T2 commit

Suppose the database system crashes just before log record 7 is written. When the system is restarted, which one statement is true of the recovery procedure?

- a) We must redo log record 6 to set B to 12925.
- b) We must undo log record 6 to set B to 12500 and then redo log records 2 and 3.
- c) We need not redo log records 2 and 3 because transaction T1 has committed.
- d) We can apply redo and undo operations in arbitrary order because they are idempotent.

81. What technology enables speeds up to 40 Mbps over the local loop by dividing it into multiple subcarriers running in parallel, surpassing the rates of traditional telephone modems?

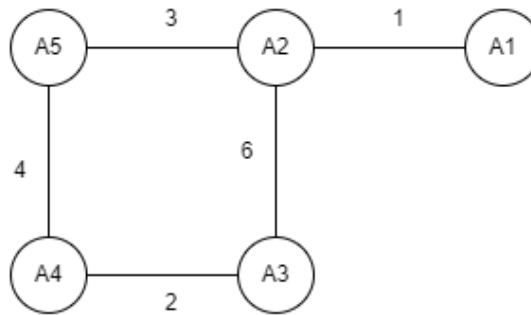
- a) Frequency division multiplexing (FDM)
- b) Amplitude modulation (AM)
- c) Time division multiplexing (TDM)
- d) Asymmetric Digital Subscriber Line (ADSL)



82. In a selective repeat protocol at the data link layer, what distinguishes it from other protocols like go-back-n?
- a) It uses a sliding window for bidirectional communication.
  - b) The sender discards all frames other than the next one in sequence.
  - c) The receiver buffers out-of-order frames and sends negative acknowledgments.
  - d) It relies on stop-and-wait algorithm for error control.
83. In the context of wireless networks, what role does CSMA/CA play in addressing challenges associated with IEEE 802.11, particularly in mitigating collisions?
- a) CSMA/CA introduces small gaps between transmissions to avoid collisions.
  - b) CSMA/CA reduces contention by dynamically dividing stations into groups.
  - c) CSMA/CA uses a bitmap protocol to eliminate contention entirely.
  - d) CSMA/CA relies on a spanning tree algorithm to manage collisions.
84. In the context of network layer protocols, what are some methods used to address congestion and achieve a promised quality of service, specifically focusing on applications that prioritize throughput and delay/jitter?
- a) Distance vector routing, traffic shaping, and RSVP
  - b) Link state routing, admission control, and MPLS
  - c) Fragmentation, reserving resources at routers, and BGP
  - d) Flooding, shedding load, and differentiated services
85. In computer networks, what is the main purpose of the Flooding algorithm?
- a) To find the shortest path and adapt to changes in network topology.
  - b) To send a packet along all paths in a datagram network.
  - c) To set up virtual circuits in virtual-circuit networks.
  - d) To reserve resources at routers for quality of service.
86. A client-server system uses a satellite network, with the satellite at a height of 40,000 km. What is the best-case round-trip time (RTT) in response to a request in this scenario? (Avoid other factors such as processing delays, protocol overhead, or any other network-related delays.)
- a) 0.1334 seconds
  - b) 0.2667 seconds
  - c) 0.4000 seconds
  - d) 0.5334 seconds
87. An uncompressed image is  $1600 \times 1200$  pixels with 3 bytes/pixel. How long does it take to transmit this image over a 56-kbps modem channel?
- a) Approximately 10 minutes
  - b) Approximately 12 minutes
  - c) Approximately 13 minutes
  - d) Approximately 19 minutes

88. A regional telephone company has 10 million subscribers. Each of their telephones is connected to a central office by a copper twisted pair. The average length of these twisted pairs is 10 km. How much is the copper in the local loops worth? Assume that the cross-section of each strand is a circle 1 mm in diameter, the density of copper is 9.0 grams/cm<sup>3</sup>, and that copper sells for \$6 per kilogram.
- a) \$2.3 billion
  - b) \$4.5 billion
  - c) \$6.7 billion
  - d) \$8.4 billion
89. Consider a token ring network with a length of 2 km having 12 stations including a monitoring station. The propagation speed of the signal is  $2 \times 10^8$  m/s and the token transmission time is ignored. If each station is allowed to hold the token for 2  $\mu$ sec, the minimum time for which the monitoring station should wait (in  $\mu$ sec) before assuming that the token is lost is \_\_\_\_\_.
- a) 28 to 30
  - b) 22 to 26
  - c) 0 to 2
  - d) 32 to 34
90. The message 11001001 is to be transmitted using the CRC polynomial  $x^3 + 1$  to protect it from errors. The message that should be transmitted is:
- a) 11001001000
  - b) 11001001011
  - c) 11001001110
  - d) 11001001111

91. Consider a network with five nodes, A1 to A5, as shown below.



The network uses a Distance Vector Routing protocol. Once the routes have stabilized, the distance vectors at different nodes are as following.

A1: (0,1,7,8,4)

A2: (1,0,6,7,3)

A3: (7,6,0,2,6)

A4: (8,7,2,0,4)

A5: (4,3,6,4,0)

Each distance vector is the distance of the best-known path at that instance to nodes, A1 to A5, where the distance to itself is 0. Also, all links are symmetric, and the cost is identical in both directions. In each round, all nodes exchange their distance vectors with their respective neighbours. Then all nodes update their distance vectors. In between two rounds any change in cost of a link will cause the two incident nodes to change only that entry in their distance vectors.

The cost of link A2-A3 reduces to 2 in (both directions). After the next round of updates, what will be the new distance vector at node A3?

- a) (3, 2, 0, 2, 5)
- b) (3, 2, 0, 2, 6)
- c) (7, 2, 0, 2, 5)
- d) (7, 2, 0, 2, 6)

92. A subnetted Class B network has the following broadcast address: 137.17.95.255. Select among the following its possible subnet mask is/are

- I. 255.255. 224.0
- II. 255.255.240.0
- III. 255.255.248.0
- IV. 255.255.254.0

Which of the following option is correct?

- a) I only
- b) I and III only
- c) I, II and IV only
- d) I, II, III and IV

93. Node A transmits 2KB frames to Node B over a link using stop and wait ARQ protocol. If the transmission rate at A is 256kbps and transmission rate at B is 16kbps. The acknowledgement is 200 bytes and the propagation delay is 20ms. What will be the sender throughput in (kbps)? (Assuming no frame is lost)
- a) 54.62
  - b) 80.31
  - c) 72.54
  - d) 69.22

94. Given ISP has a BLOCK 205.65.0.0/19. A company requires IP address for 700 computers. Which of the following is eligible range of IP address can be assigned company?

- I. 205.65.16.0/22
- II. 205.65.25.0/22
- III. 205.65.56.0/22
- IV. 205.65.28.0/22

Select among the following.

- a) I and IV
- b) II and III
- c) I, II and III
- d) II and IV

95. Assume selective repeat sliding window protocol that uses a frame size of 6KB to send data on a 3Mbps link with a one-way latency of 60ms. What is the minimum number of bits needed to represent the sequence number field, if link utilization is 70%?
- a) 5
  - b) 4
  - c) 3
  - d) 6

96. Consider the data transfer using TCP over a 1 Mbps. What will be the minimum number of bits needed for the sequence number field of the TCP header, to prevent the sequence number space from wrapping around during the MSL? (Assume maximum segment lifetime (MSL) is 120 seconds.)
- a) 35
  - b) 32
  - c) 26
  - d) 24

97. A network linking two systems separated by a distance of 6000 km, with a network bandwidth of  $200 \times 10^5$  bps and media propagation speed of  $3 \times 10^6$  m/s. For this network, a Go-Back-N sliding window protocol needs to be designed. The average packet size is  $10^6$  bits. The network is to be used to its full capacity. Assume negligible processing delays at nodes. What is the minimum required size in bits of the sequence number?
- a) 9
  - b) 5
  - c) 7
  - d) 6
98. The address of a class B host is being divided into subnets with a 4-bit subnet number. What will be the maximum number of subnets and the maximum number of hosts in each subnet?
- a) 14 subnets and 4094 hosts
  - b) 16 subnets and 4096 hosts
  - c) 14 subnets and 51242 hosts
  - d) 16 subnets and 51244 hosts
99. Consider an IP packet with a total length of 5200 bytes, that includes a 30-byte IPv4 header and a 50-byte TCP header. The packet is forwarded to an IPv4 router with a Maximum Transmission Unit (MTU) set at 750 bytes. Assume that the length of the IP header in all the outgoing fragments of this packet is 30 bytes. In addition to this, the fragmentation offset value stored in the first fragment is 0. Compute the fragmentation offset value stored in the fourth fragment.
- a) 180
  - b) 270
  - c) 360
  - d) 450
100. A program on machine P attempts to open a UDP connection to port 4256 on a machine Q, and a TCP connection to port 7832 on machine R. However, there are no applications listening at the corresponding ports on Q and R. Among the following which machine will generate an ICMP port Unreachable?
- a) Neither Q nor R
  - b) Both Q and R
  - c) Q but not R
  - d) R but not Q