1. The man who is now Municipal Commissioner worked as _____.
A. the security guard at a university
B. a security guard at the university
C. a security guard at university
D. the security guard at the university

2. Nobody knows how the Indian cricket team is going to cope with the difficult and seamer-friendly wickets in Australia.
Choose the option which is closest in meaning to the underlined phase in the above sentence.
A. put up with
B. put in with
C. put down to
D. put up against

3. Find the odd one in the following group of words.
Mock, deride, praise, jeer
A. mock
B. deride
C. praise
D. jeer

4. Pick the odd one from the following options.
A. CADBE
B. JHKIL
C. XVYWZ
D. ONPMQ

5. In a quadratic function, the value of the product of the roots $(\alpha, \beta)$ (a,b) is 4. Find the value of $\frac{\alpha^n + \beta^n}{\alpha^{-n} + \beta^{-n}}$

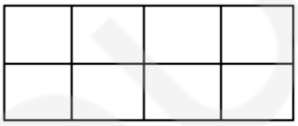
A. $n^4$
B. $4^n$
C. $2^{2n-1}$
D. $4^{n-1}$

6. Among 150 faculty members in an institute, 55 are connected with each other through Facebook and 85 are connected through WhatsApp. 30 faculty members do not have Facebook or WhatsApp accounts. The number of faculty members connected only through Facebook accounts is _____.
A. 35
B. 45
C. 65
D. 90

7. Computers were invented for performing only high-end useful computations. However, it is no understatement that they have taken over our world today. The internet, for example, is ubiquitous. Many believe that the internet itself is an unintended consequence of the original invention with the advent of mobile computing on our phones, a whole new dimension is now enabled. One is left wondering if all these developments are good or more importantly, required.
Which of the statement(s) below is/are logically valid and can be inferred from the above paragraph?
(i) The author believes that computers are not good for us
(ii) Mobile computers and the internet are both intended inventions
A. (i)
B. (ii) only
C. both (i) and (ii)
D. neither (i) nor (ii)

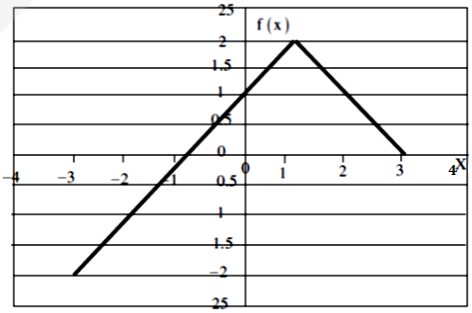
8. All hill-stations have a lake. Ooty has two lakes.
Which of the statement(s) below is/are logically valid and can be inferred from the above sentences?
(i) Ooty is not a hill-station
(ii) No hill-station can have more than one lake.
A. (i) Only
B. (ii) Only
C. both (i) and (ii)
D. neither (i) nor (ii)

9. In a 2×4 rectangle grid shown below, each cell is a rectangle. How many rectangles can be observed in the grid?



A. 21
B. 27
C. 30
D. 36

10. Chose the correct expression for f(x) given in the graph.




A. $f(x) = 1 - |x - 1|$
B. $f(x) = 1 + |x - 1|$
C. $f(x) = 2 - |x - 1|$
D. $f(x) = 2 + |x - 1|$

11. Consider the following expressions:
(i) false
(ii) Q
(iii) true
(iv) P ∨ Q
(v) ¬Q ∨ P
The number of expressions given above that are logically implied by $P \wedge (P \Rightarrow Q)$ is_____.

A. 1
B. 2
C. 3
D. 4

12. Let f(x) be a polynomial and $g(x) = f'(x)$ be its derivative. If the degree of $(f(x) + f(-x))$ is 10, then the degree of $(g(x) - g(-x))$ is _____.

A. 8
B. 9
C. 10
D. 11

13. The minimum number of colours that is sufficient to vertex-colour any planar graph is _____.

A. 1
B. 2
C. 3
D. 4

14. Consider the systems, each consisting of m linear equations in n variables.
I. If m < n, then all such systems have a solution
II. If m > n, then none of these systems has a solution
III. If m = n, then there exists a system which has a solution
Which one of the following is CORRECT?

A. I, II and III are true
B. Only II and III are true
C. Only III is true
D. None of them is true

15. Suppose that a shop has an equal number of LED bulbs of two different types. The probability of an LED bulb lasting more than 100 hours given that it is of Type 1 is 0.7, and given that it is of Type 2 is 0.4. The probability that an LED bulb chosen uniformly at random lasts more than 100 hours is _____.

A. 0.11
B. 0.23
C. 0.55
D. 0.62

16. Suppose that the eigen values of matrix A are 1, 2, 4. The determinant of $(A^{-1})^T$ is ____.

A. 0.125
B. 0.415
C. 0.715
D. 0.925

17. Consider an eight-bit ripple-carry adder for computing the sum of A and B, where A and B are integers represented in 2's complement form. If the decimal value of A is one, the decimal value of B that leads to the longest latency for the sum to stabilize is _____.

A. -1
B. -2
C. -3
D. -4

18. Let, $x_1 \oplus x_2 \oplus x_3 \oplus x_4 = 0$ where $x_1, x_2, x_3, x_4$ are Boolean variables, and $\oplus$ is the XOR operator.
Which one of the following must always be TRUE?

A. $x_1x_2x_3x_4 = 0$
B. $x_1x_3 + x_2 = 0$
C. $\bar{x}_1 \oplus \bar{x}_3 = \bar{x}_2 \oplus \bar{x}_4$
D. $x_1 + x_2 + x_3 + x_4 = 0$

19. Let X be the number of distinct 16-bit integers in 2's complement representation. Let Y be the number of distinct 16-bit integers in sign magnitude representation. Then X – Y is _____.

A. 1
B. 2
C. 3
D. 4

20. A processor has 40 distinct instructions and 24 general purpose registers. A 32-bit instruction word has an opcode, two register operands and an immediate operand. The number of bits available for the immediate operand field is _____.

A. 11
B. 12
C. 14
D. 16

21. Breadth First Search (BFS) is started on a binary tree beginning from the root vertex. There is a vertex t at a distance four from the root. If t is the n-th vertex in this BFS traversal, then the maximum possible value of n is _____.

A. 11
B. 21
C. 31
D. 41

22. The value printed by the following program is _____.

```
void f(int* p, int m){
m = m + 5;
*p = *p + m;
return;
}
void main(){
int i=5, j=10;
f(&i, j);
printf("%d", i+j);
}
```

A. 10
B. 20
C. 30
D. 40

23. Assume that the algorithms considered here sort the input sequences in ascending order. If the input is already in ascending order, which of the following are TRUE?
I. Quick sort runs in $\Theta(n^2)$ time
II. Bubble sort runs in $\Theta(n^2)$ time
III. Merge sort runs in $\Theta(n)$ time
IV. Insertion sort runs in $\Theta(n)$ time

A. I and II only
B. I and III only
C. II and IV only
D. I and IV only

24. The Floyd-Warshall algorithm for all-pair shortest paths computation is based on
A. Greedy paradigm
B. Divide-and-Conquer paradigm.
C. Dynamic Programming paradigm.
D. Neither Greedy nor Divide-and-Conquer nor Dynamic Programming paradigm

25. N items are stored in a sorted doubly linked list. For a delete operation, a pointer is provided to the record to be deleted. For a decrease-key operation, a pointer is provided to the record on which the operation is to be performed. An algorithm performs the following operations on the list in this order: Θ(N) delete, O(log N) insert, O(log N) find, and Θ(N) decrease-key. What is the time complexity of all these operations put together?
A. $O(\log^2 N)$
B. O(N)
C. $O(N^2)$
D. $\theta(N^2 \log N)$

26. The number of states in the minimum sized DFA that accepts the language defined by the regular expression is _____.
$(0+1)^*(0+1)(0+1)^*$
A. 1
B. 2
C. 3
D. 4

27. Language $L_1$ is defined by the grammar:
$S_1 \rightarrow aS_1b \mid \varepsilon$
Language $L_2$ is defined by the grammar: $S_2 \rightarrow abS_2 \mid \varepsilon$
Consider the following statements:
P: $L_1$ is regular
Q: $L_2$ L2 is regular
Which one of the following is TRUE?
A. Both P and Q are true
B. P is true and Q is false
C. P is false and Q is true
D. Both P and Q are false

28. Consider the following types of languages: $L_1$ : Regular, $L_2$ : Context-free, $L_3$ : Recursive, $L_4$ : Recursively enumerable. Which of the following is/are TRUE?
I. $\bar{L}_3 \cup L_4$ is recursively enumerable
II. $\bar{L}_2 \cup L_3$ is recursive
III. $L_1^* \cap L_2$ is context-free
IV. $L_1 \cup \bar{L}_2$ is context-free
A. I only
B. I and III only
C. I and IV only
D. I, II and III only

29. Match the following:

| | |
|---|---|
| (P) Lexical analysis | (i) Leftmost derivation |
| (Q) Top down parsing | (ii) Type checking |
| (R) Semantic analysis | (iii) Regular expressions |
| (S) Runtime environments | (iv) Activation records |

A. P ↔ i, Q ↔ ii, R ↔ iv, S ↔ iii
B. P ↔ iii, Q ↔ i, R ↔ ii, S ↔ iv
C. P ↔ ii, Q ↔ iii, R ↔ i, S ↔ iv
D. P ↔ iv, Q ↔ i, R ↔ ii, S ↔ iii

30. In which one of the following page replacement algorithms it is possible for the page fault rate to increase even when the number of allocated frames increases?
A. LRU (Least Recently Used)
B. OPT (Optimal Page Replacement)
C. MRU (Most Recently Used)
D. FIFO (First In First Out)

31. B+ Trees are considered BALANCED because
A. the lengths of the paths from the root to all leaf nodes are all equal.
B. the lengths of the paths from the root to all leaf nodes differ from each other by at most 1.
C. the number of children of any two non-leaf sibling nodes differ by at most 1.
D. the number of records in any two leaf nodes differ by at most 1.

32. Suppose a database schedule S involves transactions $T_1, \ldots\ldots, T_n$. Construct the precedence graph of S with vertices representing the transactions and edges representing the conflicts. If S is serializable, which one of the following orderings of the vertices of the precedence graph is guaranteed to yield a serial schedule?
A. Topological order
B. Depth-first order
C. Breadth-first order
D. Ascending order of transaction indices

33. Anarkali digitally signs a message and sends it to Salim. Verification of the signature by Salim requires
A. Anarkali's public key
B. Salim's public key
C. Salim's private key
D. Anarkali's private key

34. In an Ethernet local area network, which one of the following statements is TRUE?
A. A station stops to sense the channel once it starts transmitting a frame.
B. The purpose of the jamming signal is to pad the frames that are smaller than the minimum frame size.
C. A station continues to transmit the packet even after the collision is detected.
D. The exponential backoff mechanism reduces the probability of collision on retransmissions.

35. Identify the correct sequence in which the following packets are transmitted on the network by a host when a browser requests a webpage from a remote server, assuming that the host has just been restarted.
A. HTTP GET request, DNS query, TCP SYN
B. DNS query, HTTP GET request, TCP SYN

C. DNS query, TCP SYN, HTTP GET request
D. TCP SYN, DNS query, HTTP GET request

36. A binary relation R on N × N is defined as follows: (a, b)R(c, d) if a ≤ c or b ≤ d.
Consider the following propositions:
P: R is reflexive
Q: R is transitive
Which one of the following statements is TRUE?
A. Both P and Q are true
B. P is true and Q is false
C. P is false and Q is true
D. Both P and Q are false

37. Which one of the following well-formed formulae in predicate calculus is NOT valid?
A. (∀x p(x) ⇒ ∀x q(x)) ⇒ (∃x ¬ p(x) ∨ ∀x q(x))
B. (∃x p(x) ∨ ∃x q(x)) ⇒ ∃x ( p(x) ∨ q(x))
C. ∃x ( p(x) ∧ q(x)) ⇒ (∃x p(x) ∧ ∃x q(x))
D. ∀x ( p(x) ∨ q(x)) ⇒ (∀x p(x) ∨ ∀x q(x))

38. Consider a set U of 23 different compounds in a Chemistry lab. There is a subset S of U of 9 compounds, each of which reacts with exactly 3 compounds of U.
Consider the following statements:
I. Each compound in U \ S reacts with an odd number of compounds.
II. At least one compound in U \ S reacts with an odd number of compounds. III. Each compound in U \ S reacts with an even number of compounds.
Which one of the above statements is ALWAYS TRUE?
A. Only I
B. Only II
C. Only III
D. None

39. The value of the expression $13^{99} (\text{mod } 17)$, in the range 0 to 16, is _____.
A. 1
B. 2
C. 3
D. 4

40. Suppose the functions F and G can be computed in 5 and 3 nanoseconds by functional units $U_F$ and $U_G$ respectively. Given two instances of $U_F$ and two instances of $U_G$ it is required to implement the computation $F(G(X_i))$ for $1 \le i \le 10$. Ignoring all other delays, the minimum time required to complete this computation is _____ nanoseconds.
A. 18
B. 28
C. 38
D. 48

41. Consider a processor with 64 registers and an instruction set of size twelve. Each instruction has five distinct fields, namely, opcode, two source register identifiers, one destination register identifier, and a twelve-bit immediate value. Each instruction must be stored in memory in a byte-aligned fashion. If a program has 100 instructions, the amount of memory (in bytes) consumed by the program text is _____.
A. 300
B. 400
C. 500
D. 600

42. The width of the physical address on a machine is 40 bits. The width of the tag field in a 512 KB 8-way set associative cache is _____ bits.
A. 14
B. 24
C. 34
D. 44

43. Consider a 3 GHz (gigahertz) processor with a three-stage pipeline and stage latencies $\tau_1, \tau_2$, and $\tau_3$ such that $\tau_1 = 3\tau_2/4 = 2\tau_3$. If the longest pipeline stage is split into two pipeline stages of equal latency, the new frequency is ___ GHz, ignoring delays in the pipeline registers.
A. 1
B. 2
C. 3
D. 4

44. A complete binary min-heap is made by including each integer in [1, 1023] exactly once. The depth of a node in the heap is the length of the path from the root of the heap to that node. Thus, the root is at depth 0. The maximum depth at which integer 9 can appear is _____.
A. 6
B. 7
C. 8
D. 9

45. The following function computes $X^Y$ for positive integers X and Y.
```
int exp (int X, int Y) {
int res = 1, a = X, b = Y;
while ( b != 0 ){
if ( b%2 == 0) { a = a*a; b = b/2; }
else { res = res*a; b = b-1; }
}
return res;
}
```
Which one of the following conditions is TRUE before every iteration of the loop?
A. $X^Y = a^b$
B. $(res * a)^Y = (res * X)^b$
C. $X^Y = res * a^b$
D. $X^Y = (res * a)^b$

46. Consider the following New-order strategy for traversing a binary tree:
• Visit the root;
• Visit the right subtree using New-order;
• Visit the left subtree using New-order;
The New-order traversal of the expression tree corresponding to the reverse polish expression 3 4 * 5 – 2 ^ 6 7 * 1 + – is given by:
A. + - 1 6 7 * 2 ^ 5 - 3 4 *
B. - + 1 * 6 7 ^ 2 - 5 * 3 4
C. - + 1 * 7 6 ^ 2 - 5 * 4 3
D. 1 7 6 * + 2 5 4 3 * - ^ -

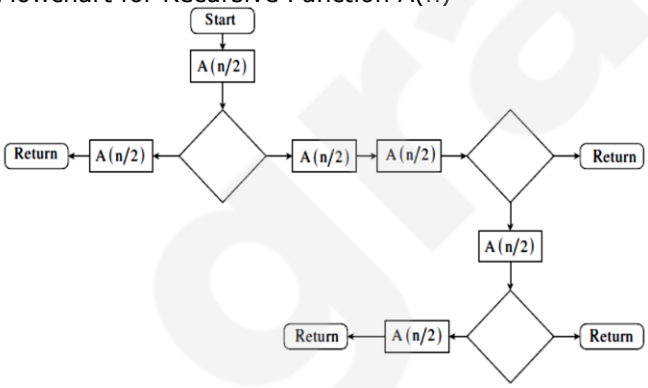
47. Consider the following program:

```
int f(int * p, int n)
{
if (n <= 1) return 0;
else return max(f(p+1,n-1), p[0]-p[1]);
}
int main()
{
int a[ ] = {3,5,2,6,4};
printf("%d", f(a,5));
}
```

Note: max(x,y) returns the maximum of x and y.
The value printed by this program is _____.
A. 1
B. 2
C. 3
D. 4

48. Let $A_1, A_2, A_3,$ and $A_4$ be four matrices of dimensions $10\times5, 5\times20, 20\times10,$ and $10\times5,$ respectively. The minimum number of scalar multiplications required to find the product $A_1A_2A_3A_4$ using the basic matrix multiplication method is _____.
A. 1000
B. 1500
C. 2000
D. 2500

49. The given diagram shows the flowchart for a recursive function A(n). Assume that all statements, except for the recursive calls, have O(1) time complexity. If the worst case time complexity of this function is $O(n^{\alpha})$, then the least possible value (accurate up to two decimal positions) of α is _____.
Flowchart for Recursive Function A(n)




A. 1.32
B. 2.32
C. 3.32
D. 4.32

50. The number of ways in which the numbers 1, 2, 3, 4, 5, 6, 7 can be inserted in an empty binary search tree, such that the resulting tree has height 6, is _____.
Note: The height of a tree with a single node is 0.
A. 34
B. 44
C. 54
D. 64

51. In an adjacency list representation of an undirected simple graph G = (V, E), each edge (u, v) has two adjacency list entries: [v] in the adjacency list of u, and [u] in the adjacency list of v. These are called twins of each other. A twin pointer is a pointer from an adjacency list entry to its twin. If |E| = m and |V| = n, and the memory size is not a constraint, what is the time complexity of the most efficient algorithm to set the twin pointer in each entry in each adjacency list?
A. $\Theta(n^2)$
B. $\Theta(n+m)$
C. $\Theta(m^2)$
D. $\Theta(n^4)$

52. Consider the following two statements:
I. If all states of an NFA are accepting states then the language accepted by the NFA is $\Sigma*$.
II. There exists a regular language A such that for all languages B, A ∩ B is regular.
Which one of the following is CORRECT?
A. Only I is true
B. Only II is true
C. Both I and II are true
D. Both I and II are false

53. Consider the following languages:
$L_1 = \{a^n b^m c^{n+m} : m, n \geq 1\}$
$L_2 = \{a^n b^n c^{2n} : n \geq 1\}$
Which one of the following is TRUE?
A. Both $L_1$ and $L_2$ are context-free.
B. $L_1$ is context-free while $L_2$ is not context-free.
C. $L_2$ is context-free while $L_1$ is not context-free.
D. Neither $L_1$ nor $L_2$ is context-free.

54. Consider the following languages.
$L_1 = \{\langle M\rangle \mid M$ takes at least 2016 steps on some input$\}$,
$L_2 = \{\langle M\rangle \mid M$ takes at least 2016 steps on all inputs$\}$ and
$L_3 = \{\langle M\rangle \mid M$ accepts ε$\}$,
where for each Turing machine M, $\langle M\rangle$ denotes a specific encoding of M. Which one of the following is TRUE?
A. $L_1$ is recursive and $L_2, L_3$ are not recursive
B. $L_2$ is recursive and $L_1, L_3$ are not recursive
C. $L_1, L_2$ are recursive and $L_3$ is not recursive
D. $L_1, L_2, L_3$ are recursive

55. Which one of the following grammars is free from left recursion?
A. $S \to AB$
$A \to Aa \mid b$
$B \to c$
B. $S \to Ab \mid Bb \mid c$
$A \to Bd \mid \varepsilon$
$B \to e$
C. $S \to Aa \mid B$

$A \rightarrow Bb \quad | Sc \quad | \varepsilon$

D. $S \rightarrow Aa \quad | Bb \quad | c$

$A \rightarrow Bd \quad | \varepsilon$

$B \rightarrow Ae \quad | \varepsilon$

56. A student wrote two context-free grammars G1 and G2 for generating a single C-like array declaration. The dimension of the array is at least one. For example,
int a[10][3];
The grammars use D as the start symbol, and use six terminal symbols int ; id [ ] num.
Grammar G1
$D \rightarrow$ int L;
$L \rightarrow$ id [E
$E \rightarrow$ num]
$E \rightarrow$ num] [E
Grammar G2
$D \rightarrow$ int L;
$L \rightarrow$ id E
$E \rightarrow E$[num]
$E \rightarrow$[num]
Which of the grammars correctly generate the declaration mentioned above?
A. Both G1 and G2
B. Only G1
C. Only G2
D. Neither G1 nor G2

57. Consider the following processes, with the arrival time and the length of the CPU burst given in milliseconds. The scheduling algorithm used is preemptive shortest remaining time first.

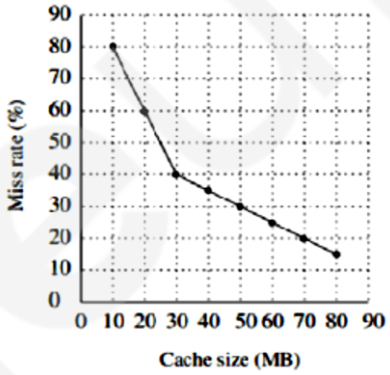
| Process | Arrival Time | Burst Time |
|---|---|---|
| P1 | 0 | 10 |
| P2 | 3 | 6 |
| P3 | 7 | 1 |
| P4 | 8 | 3 |

The average turnaround time of these processes is _____ milliseconds.
A. 3.45
B. 5.34
C. 8.25
D. 9.34

58. Consider the following two-process synchronization solution
Process 0
---
Entry: loop while (turn == 1); (critical section)
Exit: turn = 1;
Process 1
---
Entry: loop while (turn == 0); (critical section)
Exit: turn = 0;
The shared variable turn is initialized to zero. Which one of the following is TRUE?
A. This is a correct two-process synchronization solution.
B. This solution violates mutual exclusion requirement.
C. This solution violates progress requirement.
D. This solution violates bounded wait requirement.

59. Consider a non-negative counting semaphore S. The operation P(S) decrements S, and V (S) increments S. During an execution, 20 P(S) operations and 12 V (S) issued in some order. The largest initial value of S for which at least one P(S) operation will remain blocked is _____.
A. 6
B. 7
C. 8
D. 9

60. A file system uses an in-memory cache to cache disk blocks. The miss rate of the cache is shown in the figure. The latency to read block from the cache is 1ms and to read a block from the disk is 10 ms. Assume that the cost of checking whether a block exists in the cache is negligible. Available cache sizes are in multiples of 10 MB.




The smallest cache size required to ensure an average read latency of less than 6 ms is _____ MB.
A. 30
B. 40
C. 50
D. 60

61. Consider the following database schedule with two transactions, T1 and T2.

$$S = r_2(X); r_1(X); r_2(Y); w(X); r_1(Y); w_2(X); a_2; a_2$$

where $r_i(Z)$ denotes a read operation by transaction $T_i$ on a variable Z, $w_i(Z)$ denotes a write operation by $T_i$ on a variable Z, $a_i$ denotes an abort by transaction $T_i$.
Which one of the following statements about the above schedule is TRUE?
A. S is non-recoverable
B. S is recoverable, but has a cascading abort
C. S does not have a cascading abort
D. S is strict

62. Consider the following database table named water schemes:

| Water schemes | | |
|---|---|---|
| Scheme no | District name | Capacity |
| 1 | Ajmeer | 20 |
| 1 | Bikaner | 10 |
| 2 | Bikaner | 10 |
| 3 | Bikaner | 20 |
| 1 | Churu | 10 |
| 2 | Churu | 20 |
| 1 | Dungargarh | 10 |

The number of tuples returned by the following SQL query is _____.
with total(name, capacity) as
select district_name, sum(capacity)
from water_schemes
group by district_name
with total_avg (capacity) as select avg(capacity)
from total
select name
from total, total_avg
where total.capacity ≥ total_avg.capacity
A. 1
B. 2
C. 3
D. 4

63. A network has a data transmission bandwidth of $20 \times 10^6$ bits per second. It uses CSMA/CD in the MAC layer. The maximum signal propagation time from one node to another node is 40 microseconds. The minimum size of a frame in the network is _____bytes.
A. 100
B. 200
C. 300
D. 400

64. For the IEEE 802.11 MAC protocol for wireless communication, which of the following statements is/are TRUE?
I. At least three non-overlapping channels are available for transmissions.
II. The RTS-CTS mechanism is used for collision detection.
III. Unicast frames are ACKed.
A. All I, II, and III
B. I and III only
C. II and III only
D. II only

65. Consider a 128 × 103 bits/second satellite communication link with one way propagation delay of 150 milliseconds. Selective retransmission (repeat) protocol is used on this link to send data with a frame size of 1 kilobyte. Neglect the transmission time of acknowledgement. The minimum number of bits required for the sequence number field to achieve 100% utilization is _____.
A. 1
B. 2
C. 3
D. 4

***