

11. The security system at an IT office is composed of 10 computers of which exactly four are working. To check whether the system is functional, the officials inspect four of the computers picked at random (without replacement). The system is deemed functional if at least three of the four computers inspected are working. Let the probability that the system is deemed functional be denoted by p . Then $100p =$ _____.

- A. 11.9
- B. 13.1
- C. 14.2
- D. 15.3

12. Each of the nine words in the sentence "The quick brown fox jumps over the lazy dog" is written on a separate piece of paper. These nine pieces of paper are kept in a box. One of the pieces is drawn at random from the box. The expected length of the word drawn is _____.

- A. 3.8
- B. 4.2
- C. 5.2
- D. 6.3

13. The maximum number of edges in a bipartite graph on 12 vertices is _____.

- A. 25
- B. 36
- C. 41
- D. 53

14. If the matrix A is such that

$$A = \begin{bmatrix} 2 \\ -4 \\ 7 \end{bmatrix} \begin{bmatrix} 1 & 9 & 5 \end{bmatrix}$$

Then the determinant of A is equal to _____.

- A. 0
- B. 1
- C. 2
- D. 3

15. A non-zero polynomial $f(x)$ of degree 3 has roots at $x = 1$, $x = 2$ and $x = 3$. Which one of the following must be TRUE?

- A. $f(0)f(4) < 0$
- B. $f(0)f(4) > 0$
- C. $f(0) + f(4) > 0$
- D. $f(0) + f(4) < 0$

16. The dual of a Boolean function

$F(x_1, x_2, \dots, x_n, \dots, x_n')$ written as F^D , is the same

expression as that of F with $+$ and $*$ swapped. F is said to be self-dual if $F = F^D$. The number of self-dual functions with n Boolean variables is

- A. 2^n
- B. 2^{n-1}
- C. 2^{2^n}

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

17. Let $k = 2^n$. A circuit is built by giving the output of an n -bit binary counter as input to an n to 2^n bit decoder. This circuit is equivalent to a

- A. k -bit binary up counter.
- B. k -bit binary down counter.
- C. k -bit ring counter.
- D. k -bit Johnson counter.

18. Consider the equation $(123)_5 = (x8)_y$ with x and y as unknown. The number of possible solutions is _____

- A. 1
- B. 3
- C. 5
- D. 7

19. A 4-way set-associative cache memory unit with a capacity of 16 KB is built using a block size of 8 words. The word length is 32 bits. The size of the physical address space is 4 GB. The number of bits for the TAG field is _____

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

20. Consider the function func shown below:

```
int func(int num) {
    int count = 0;
    while (num) {
        count++;
        num >>= 1;
    }
    return (count);
}
```

The value returned by $\text{func}(435)$ is _____.

- A. 1
- B. 4
- C. 9
- D. 11

21. Suppose n and p are unsigned int variables in a C program. We wish to set p to ${}^n C_3$. If n is large, which one of the following statements is most likely to set p correctly?

- A. $p = n * (n - 1) * (n - 2) / 6;$
- B. $p = n * (n - 1) / 2 * (n - 2) / 3;$
- C. $p = n * (n - 1) / 3 * (n - 2) / 2;$
- D. $p = n * (n - 1) / 2 * (n - 2) / 6.0;$

22. A priority queue is implemented as a Max-Heap. Initially, it has 5 elements. The level-order traversal of the heap is: 10, 8, 5, 3, 2. Two new elements 1 and 7 are inserted into the heap in that order. The level-order traversal of the heap after the insertion of the elements is:

- A. 10, 8, 7, 3, 2, 1, 5
- B. 10, 8, 7, 2, 3, 1, 5

- C. 10, 8, 7, 1, 2, 3, 5
 D. 10, 8, 7, 5, 3, 2, 1

23. Which one of the following correctly determines the solution of the recurrence relation with $T(1) = 1$?

$$T(n) = 2T\left(\frac{n}{2}\right) + \log n$$

- A. $\theta(n)$
 B. $\theta(n \log n)$
 C. $\theta(n^2)$
 D. $\theta(\log n)$

24. Consider the tree arcs of a BFS traversal from a source node W in an unweighted, connected, undirected graph. The tree T formed by the tree arcs is a data structure for computing

- A. the shortest path between every pair of vertices.
 B. the shortest path from W to every vertex in the graph.
 C. the shortest paths from W to only those nodes that are leaves of T.
 D. the longest path in the graph.

25. If $L_1 = \{a^n \mid n \geq 0\}$ and $L_2 = \{b^n \mid n \geq 0\}$, Consider

- I. $L_1.L_2$ is a regular language
 II. $L_1.L_2 = \{a^n b^n \mid n \geq 0\}$

Which one of the following is CORRECT?

- A. Only (I)
 B. Only (II)
 C. Both (I) and (II)
 D. Neither (I) nor (II)

26. Let $A \leq_m B$ denotes that language A is mapping reducible (also known as many-to-one reducible) to language B. Which one of the following is FALSE?

- A. If $A \leq_m B$ and B is recursive then A is recursive.
 B. If $m A \leq_m B$ and A is undecidable then B is undecidable.
 C. If $A \leq_m B$ and B is recursively enumerable then A is recursively enumerable.
 D. If $A \leq_m B$ and B is not recursively enumerable then A is not recursively enumerable.

27. Consider the grammar defined by the following production rules, with two operators * and +

- $S \rightarrow T * P$
 $T \rightarrow U \mid T * U$
 $P \rightarrow Q + P \mid Q$
 $Q \rightarrow Id$
 $U \rightarrow Id$

Which one of the following is TRUE?

- A. + is left associative, while * is right associative
 B. + is right associative, while * is left associative
 C. Both + and * are right associative
 D. Both + and * are left associative

28. Which one of the following is NOT performed during compilation?

- A. Dynamic memory allocation
 B. Type checking
 C. Symbol table management
 D. Inline expansion

29. Which one of the following is TRUE?

- A. The requirements document also describes how the requirements that are listed in the document are implemented efficiently.
 B. Consistency and completeness of functional requirements are always achieved in practice.
 C. Prototyping is a method of requirements validation.
 D. Requirements review is carried out to find the errors in system design.

30. A FAT (file allocation table) based file system is being used and the total overhead of each entry in the FAT is 4 bytes in size. Given a 100×10^6 bytes disk on which the file system is stored and data block size is 10^3 bytes, the maximum size of a file that can be stored on this disk in units of 10^6 bytes is _____.

- A. 99.6
 B. 70.6
 C. 80.6
 D. 60.6

31. The maximum number of super keys for the relation schema R (E, F, G, H) with E as the key is _____.

- A. 5
 B. 7
 C. 8
 D. 10

32. Given an instance of the STUDENTS relation as shown below:

Student D	Student Name	Student Email	Student Age	CPI
2345	Shankar	Shankar@math	X	9.4
1287	Swati	swati@ee	19	9.5
7853	Shankar	Shankar@cse	19	9.4
9876	Swati	swati@mech	18	9.3
8765	Ganesh	ganesh@civil	19	8.7

For (Student Name, Student Age) to be a key for this instance, the value X should NOT be equal to_____.

- A. 11
 B. 19
 C. 25
 D. 29

33. Which one of the following is TRUE about the interior gateway routing protocols – Routing Information Protocol (RIP) and Open Shortest Path First (OSPF)?

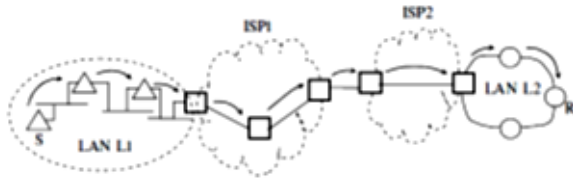
- A. RILP uses distance vector routing and OSPF uses link state routing

- B. OSPF uses distance vector routing and RIP uses link state routing
- C. Both RIP and OSPF use link state routing
- D. Both RIP and OSPF use distance vector routing

34. Which one of the following socket API functions converts an unconnected active TCP socket into a passive socket?

- A. connect
- B. bind
- C. listen
- D. accept

35. In the diagram shown below, L1 is an Ethernet LAN and L2 is a Token-Ring LAN. An IP packet originates from sender S and traverses to R, as shown. The links within each ISP and across the two ISPs, are all point-to-point optical links. The initial value of the TTL field is 32. The maximum possible value of the TTL field when R receives the datagram is _____.



- A. 26
- B. 36
- C. 46
- D. 56

36. Consider the store and forward packet switched network given below. Assume that the bandwidth of each link is 106 bytes / sec. A user on host A sends a file of size 103 bytes to host B through routers R1 and R2 in three different ways. In the first case a single packet containing the complete file is transmitted from A to B. In the second case, the file is split into 10 equal parts, and these packets are transmitted from A to B. In the third case, the file is split into 20 equal parts and these packets are sent from A to B. Each packet contains 100 bytes of header information along with the user data. Consider only transmission time and ignore processing, queuing and propagation delays. Also assume that there are no errors during transmission. Let T1, T2 and T3 be the times taken to transmit the file in the first, second and third case respectively. Which one of the following is CORRECT?



- A. $T_1 < T_2 < T_3$
- B. $T_1 > T_2 > T_3$
- C. $T_2 = T_3, T_3 < T_1$
- D. $T_1 = T_3, T_3 > T_2$

37. An IP machine Q has a path to another IP machine H via three IP routers R1, R2, and R3.

Q—R1—R2—R3—H

H acts as an HTTP server, and Q connects to H via HTTP and downloads a file. Session layer encryption is used, with DES as the shared key encryption protocol. Consider the following four pieces of information:

- [I1] The URL of the file downloaded by Q
 - [I2] The TCP port numbers at Q and H
 - [I3] The IP addresses of Q and H
 - [I4] The link layer addresses of Q and H
- Which of I1, I2, I3, and I4 can an intruder learn through sniffing at R2 alone?
- A. Only I1 and I2
 - B. Only I1
 - C. Only I2 and I3
 - D. Only I3 and I4

38. A graphical HTML browser resident at a network client machine Q accesses a static HTML webpage from a HTTP server S. The static HTML page has exactly one static embedded image which is also at S. Assuming no caching, which one of the following is correct about the HTML webpage loading (including the embedded image)?

- A. Q needs to send at least 2 HTTP requests to S, each necessarily in a separate TCP connection to server S
- B. Q needs to send at least 2 HTTP requests to S, but a single TCP connection to server S is sufficient
- C. A single HTTP request from Q to S is sufficient, and a single TCP connection between Q and S is necessary for this
- D. A single HTTP request from Q to S is sufficient, and this is possible without any TCP connection between Q and S

39. Consider the following schedule S of transactions T1, T2, T3, T4:

T1	T2	T3	T4
Writes [x] Commit	Reads[X]		
		Writes[X] Commit	
	Writes[Y] Reads [Z] Commit		
			Reads[X] Reads[Y] Commit

Which one of the following statements is CORRECT?

- A. S is conflict-serializable but not recoverable
- B. S is conflict-serializable but is recoverable
- C. S is both conflict-serializable and recoverable
- D. S is neither conflict-serializable nor is it recoverable

40. Consider a join (relation algebra) between relations r(R) and s(S) using the nested loop method. There are 3 buffers each of size equal to disk block size, out of which one buffer is reserved for intermediate results. Assuming $\text{size}(r(R)) < \text{size}(s(S))$, the join will have fewer number of disk block accesses if

- A. relation r(R) is in the outer loop.
- B. relation s(S) is in the outer loop.
- C. join selection factor between r(R) and s(S) is more than 0.5
- D. join selection factor between r(R) and s(S) is less than 0.5

41. Consider the procedure below for the Producer-Consumer problem which uses semaphores:

```

Semaphore n = 0;
Semaphore s = 1;
Void producer ()
{
while (true)
{
Produce ();
SemWait (s);
addToBuffer ();
semSignal (s);
semSignal (n);
}
}
Void consumer()
{
while(true)
{
semWait (s);
semWait (n);
removeFromBuffer ();
semsignal (s);
consume ( );
}
}
    
```

Which one of the following is TRUE?

- A. The producer will be able to add an item to the buffer, but the consumer can never consume it.
- B. The consumer will remove no more than one item from the buffer.
- C. Deadlock occurs if the consumer succeeds in acquiring semaphore s when the buffer is empty.
- D. The starting value for the semaphore n must be 1 and not 0 for deadlock-free operation.

42. Three processes A, B and C each execute a loop of 100 iterations. In each iteration of the loop, a process performs a single computation that requires t_c CPU milliseconds and then initiates a single I/O operation that lasts for t_o milliseconds. It is assumed that the computer where the processes execute has sufficient number of I/O devices and the OS of the computer assigns different I/O devices to each process. Also, the scheduling overhead of the OS is negligible. The processes have the following characteristics:

Process id	t_c	t_o
A	100ms	500ms
B	350ms	500ms
C	200ms	500ms

The processes A, B, and C are started at times 0, 5 and 10 milliseconds respectively, in a pure time sharing system (round robin scheduling) that uses a time slice of 50 milliseconds. The time in milliseconds at which process C would complete its first I/O operation is _____.

- A. 1000
- B. 2000
- C. 3000
- D. 4000

43. A computer has twenty physical page frames which contain pages numbered 101 through 120. Now a program accesses the pages numbered 1, 2, ..., 100 in that order, and repeats the access sequence THRICE. Which one of the following page replacement policies experiences the same number of page faults as the optimal page replacement policy for this program?

- A. Least-recently-used
- B. First-in-first-out
- C. Last-in-first-out
- D. Most-recently-used

44. For a C program accessing $X[i][j][k]$, the following intermediate code is generated by a compiler. Assume that the size of an integer is 32 bits and the size of a character is 8 bits.

```

t0 = i * 1024
t1 = j * 32
t2 = k * 4
t3 = t1 + t0
t4 = t3 + t2
t5 = X[t4]
    
```

Which one of the following statements about the source code for the C program is CORRECT?

- A. X is declared as "int X[32][32][8]".
- B. X is declared as "int X[4][1024][32]".
- C. X is declared as "char X[4][32][8]".
- D. X is declared as "char X[32][16][2]".

45. Let $\langle M \rangle$ be the encoding of a Turing machine as a string over $\Sigma = \{0, 1\}$. Let $L = \{\langle M \rangle \mid M \text{ is a Turing machine that accepts a string of length } 2014\}$. Then, L is

- A. decidable and recursively enumerable
- B. undecidable but recursively enumerable
- C. undecidable and not recursively enumerable
- D. decidable but not recursively enumerable

46. Let $L_1 = \{w \in \{0, 1\}^* \mid w \text{ has at least as many occurrences of } (110)\text{'s as } (011)\text{'s}\}$.

Let $L_2 = \{w \in \{0, 1\}^* \mid w \text{ has at least as many occurrences of } (000)\text{'s as } (111)\text{'s}\}$. Which one of the following is TRUE?

- A. L_1 is regular but not L_2
- B. L_2 is regular but not L_1
- C. Both L_1 and L_2 are regular
- D. Neither L_1 nor L_2 are regular

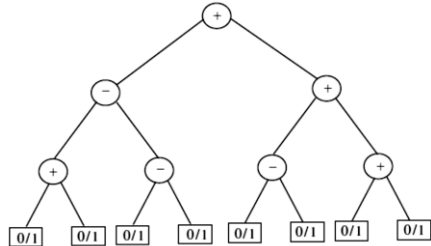
47. Consider two strings A = "qpqrr" and B = "pqprrp". Let x be the length of the longest common subsequence (not necessarily contiguous) between A and B and let y be the number of such longest common subsequences between A and B. Then $x+10y =$ _____.

- A. 24
- B. 34
- C. 38
- D. 43

48. Suppose P, Q, R, S, T are sorted sequences having lengths 20, 24, 30, 35, 50 respectively. They are to be merged into a single sequence by merging together two sequences at a time. The number of comparisons that will be needed in the worst case by the optimal algorithm for doing this is _____.

- A. 259
- B. 358
- C. 450
- D. 551

49. Consider the expression tree shown. Each leaf represents a numerical value, which can either be 0 or 1. Over all possible choices of the values at the leaves, the maximum possible value of the expression represented by the tree is _____.



- A. 5
- B. 6
- C. 7
- D. 8

50. Consider the following function
 double f(double x) {
 if (abs (x*x - 3) < 0. 01) return x;
 else return f (x / 2 + 1.5/x);
 }

Give a value q (to 2 decimals) such that f(q) will return q: _____

- A. 1.73
- B. 1.89
- C. 1.93
- D. 2.34

51. Suppose a stack implementation supports an instruction REVERSE, which reverses the order of elements on the stack, in addition to the PUSH and POP instructions. Which one of the following statements is TRUE with respect to this modified stack?

- A. A queue cannot be implemented using this stack.
- B. A queue can be implemented where ENQUEUE takes a single instruction and DEQUEUE takes a sequence of two instructions.
- C. A queue can be implemented where ENQUEUE takes a sequence of three instructions and DEQUEUE takes a single instruction.
- D. A queue can be implemented where both ENQUEUE and DEQUEUE take a single instruction each.

52. Consider the C function given below

```
int f(int j)
{
    static int i = 50;
    int k;
    if (i == j)
    {
```

```
    printf("something");
    k = f(i);
    return 0;
    }
else return 0;
}
```

Which one of the following is TRUE?

- A. The function returns 0 for all values of j.
- B. The function prints the string something for all values of j.
- C. The function returns 0 when j = 50.
- D. The function will exhaust the runtime stack or run into an infinite loop when j = 50.

53. In designing a computer's cache system, the cache block (or cache line) size is an important Parameter. Which one of the following statements is correct in this context?

- A. A smaller block size implies better spatial locality
- B. A smaller block size implies a smaller cache tag and hence lower cache tag overhead
- C. A smaller block size implies a larger cache tag and hence lower cache hit time
- D. A smaller block size incurs a lower cache miss penalty

54. If the associativity of a processor cache is doubled while keeping the capacity and block size unchanged, which one of the following is guaranteed to be NOT affected?

- A. Width of tag comparator
- B. Width of set index decoder
- C. Width of way selection multiplexor
- D. Width of processor to main memory data bus

55. The value of a float type variable is represented using the single-precision 32-bit floating point format of IEEE-754 standard that uses 1 bit for sign, 8 bits for biased exponent and 23 bits for mantissa. A float type variable X is assigned the decimal value of -14.25. The representation of X in hexadecimal notation is

- A. C1640000H
- B. 416C0000H
- C. 41640000H
- D. C16C0000H

56. The product of the non-zero eigenvalues of the matrix

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 1 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 1 & 0 & 0 & 0 & 1 \end{bmatrix}$$

is _____.

- A. 5
- B. 6
- C. 7
- D. 8

57. The probability that a given positive integer lying between 1 and 100 (both inclusive) is NOT divisible by 2, 3 or 5 is _____ .
 A. 0.26
 B. 0.36
 C. 0.46
 D. 0.56

58. The number of distinct positive integral factors of 2014 is _____
 A. 5
 B. 7
 C. 8
 D. 10

59. Consider the following relation on subsets of the set S of integers between 1 and 2014. For two distinct subsets U and V of S we say $U < V$ if the minimum element in the symmetric difference of the two sets is in U. Consider the following two statements:

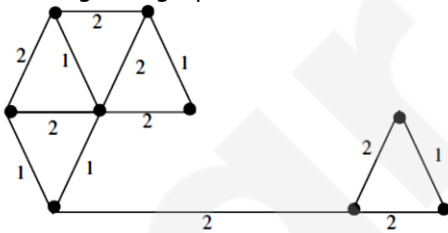
S1: There is a subset of S that is larger than every other subset.
 S2: There is a subset of S that is smaller than every other subset.

Which one of the following is CORRECT?

- A. Both S1 and S2 are true
- B. S1 is true and S2 is false
- C. S2 is true and S1 is false
- D. Neither S1 nor S2 is true

60. A cycle on n vertices is isomorphic to its complement. The value of n is _____.
 A. 5
 B. 7
 C. 8
 D. 10

61. The number of distinct minimum spanning trees for the weighted graph below is



- A. 5
- B. 6
- C. 7
- D. 8

62. Which one of the following Boolean expressions is NOT a tautology?

- A. $((a \rightarrow b) \wedge (b \rightarrow c)) \rightarrow (a \rightarrow c)$
- B. $(a \leftrightarrow c) \rightarrow (\sim b \rightarrow (a \wedge c))$
- C. $(a \wedge b \wedge c) \rightarrow (c \wedge a)$
- D. $a \rightarrow (b \rightarrow a)$

63. SQL allows duplicate tuples in relations, and correspondingly defines the multiplicity of tuples in the result of joins. Which one of the following queries always gives the same answer as the nested query shown below:
 Select * from R where a in (select S. a from S)

- A. Select R. * from R, S where R. a=S. a
- B. Select distinct R. * from R,S where R. a=S. a
- C. Select R. * from R, (select distinct a from S) as S1 where R. a=S1.a
- D. Select R. * from R, S where R.a = S. a and is unique R

64. Consider a main memory system that consists of 8 memory modules attached to the system bus, which is one word wide. When a write request is made, the bus is occupied for 100 nanoseconds (ns) by the data, address, and control signals. During the same 100 ns, and for 500 ns thereafter, the addressed memory module executes one cycle accepting and storing the data. The (internal) operation of different memory modules may overlap in time, but only one request can be on the bus at any time. The maximum number of stores (of one word each) that can be initiated in 1 millisecond is _____

- A. 5000
- B. 7000
- C. 8000
- D. 10000

65. In the Newton-Raphson method, an initial guess of $x_0 = 2$ is made and the sequence x_0, x_1, x_2, \dots is obtained for the function

$$0.75x^3 - 2x^2 - 2x + 4 = 0$$

Consider the statements

- (I) $x_3 = 0$.
- (II) The method converges to a solution in a finite number of iterations. Which of the following is TRUE?
- A. Only I
- B. Only II
- C. Both I and II
- D. Neither I nor II
