INFORMATION TECHNOLOGY

ONE MARKS QUESTIONS (1-20)

1. In a certain town, the probability that it will rain in the afternoon is known to be 0.6. Moreover, meteorological data indicates that if the temperature at noon is less than or equal to 25°C, the probability that it will rain in the afternoon is 0.4. The temperature at noon is equally likely to be above 25°C, or at/below 25°C. What is the probability that it will rain in the afternoon on a day when the temperature at noon is above 25°C?

   a. 0.4
   b. 0.6
   c. 0.8
   d. 0.9

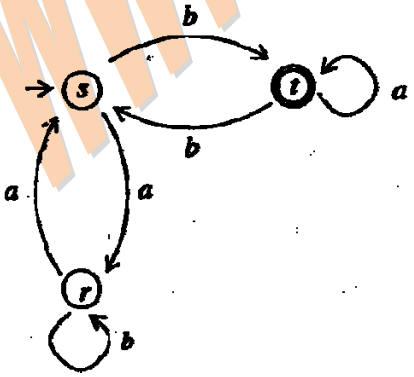
2. For the set N of natural numbers and a binary operation $f : N \times N \rightarrow N$, an element $z \in N$ is called an identity for f if $f(a,z) = a = f(z,a)$, for all $a \in N$.

   Which of the following binary operations have an identity?

   1. $f(x,y) = x + y - 3$
   2. $f(x,y) = \max(x,y)$
   3. $f(x,y) = x^y$

   a. 1 and 2 only
   b. 2 and 3 only
   c. 1 and 3 only
   d. None of these

3. In the automaton below, s is the start state and t is the only final state.



   Consider the strings u = abbaba, v = bab, and w = aabb. Which of the following states is true?

   a. The automaton accepts u and i' but not w
   b. The automaton accepts each of a, v, and w
   c. The automaton rejects each of a, v, and w
   d. The automaton accepts a but rejects v and w

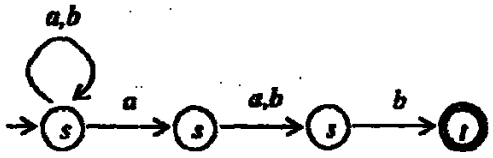
4. In the context-free grammar below, S is the start symbol, a and b are terminals, and ε denotes the empty string

   $S \rightarrow aSa \mid bSb \mid a \mid b \mid \varepsilon$

   Which of the following strings is NOT generated by the grammar?

   a. aaaa
   b. baba
   c. abba
   d. babaaabab

5. Which regular expression best describes the language accepted by the nondeterministic automaton below?



   a. (a + b)* a(a + b)b
   b. (abb)*
   c. (a + b)* a(a + b)* b(a + b)*
   d. (a + b)*

6. Given a boolean function $f(x_1, x_2, ...x_n)$ which of the following equations is NOT true

   a. $f(x_1, x_2, ..., x_n) = x_1' f(x_1, x_2 ...., x_n) + x_1 f(x_1, x_2, ..., x_n)$

   b. $f(x_1, x_2, ..., x_n) = x_2 f(x_1, x_2 ...., x_n) + x_2' f(x_1, x_2, ..., x_n)$

   c. $f(x_1, x_2, ..., x_n) = x_n' f(x_1, x_2 ...., 0) + x_n f(x_1, x_2, ..., 1)$

d. $f(x_1, x_2, ..., x_n) = f(0, x_2 .... x_n) + f(1, x_2, ..., x_n)$

7. The addition of 4-bit, two's complement, binary numbers 1101 and 0100 results in
   a. 0001 and an overflow
   b. 1001 and no overflow
   c. 0001 and no overflow
   d. 1001 and an overflow

8. Which of the following DMA transfer modes and interrupt handling mechanisms will enable the highest I/O bandwidth?
   a. Transparent DMA and Polling interrupts
   b. Cycle-stealing and Vectored interrupts
   c. Block transfer and Vectored interrupts
   d. Block transfer and Polling interrupts

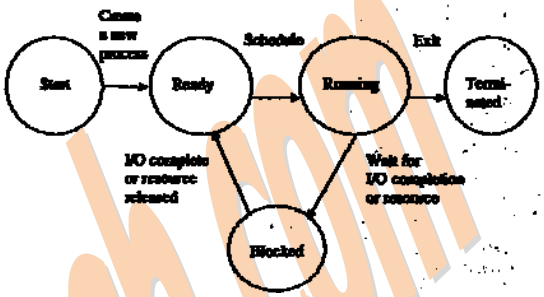
9. In a binary tree, the number of internal nodes of degree 1 is 5, and the number of internal nodes of degree 2 is 10. The number of leaf nodes in the binary tree is
   a. 10
   b. 11
   c. 12
   d. 15

10. A problem in NP is NP-complete if
   a. it can be reduced to the 3-SAT problem in polynomial time
   b. the 3-SAT problem can be reduced to it in polynomial time
   c. it can be reduced to any other problem in NP in polynomial time
   d. some problem in NP can be reduced to it in polynomial time

11. If all the edge weights of an undirected graph are positive, then any subset of edges that connects all the vertices and has minimum total weight is a
   a. Hamiltonian cycle
   b. grid
   c. hypercube
   d. tree

12. In the working-set strategy, which of the following is done by the operating system to prevent thrashing?
   1. It initiates another process if there are enough extra frames.
   2. It selects a process to suspend if the sum of the sizes of the working-sets exceeds the total number of available frames.
   a. 1 only
   b. 2 only
   c. Neither 1 nor 2
   d. Both 1 and 2

13. The process state transition diagram of an operating system is as given below.



Which of the following must be FALSE about the above operating system?
   a. It is a multi programmed operating system
   b. It uses preemptive scheduling
   c. It uses non-preemptive scheduling
   d. It is a multi-user operating system

14. Consider the relations $r_1(P, Q, R)$ and $r_2(R, S, T)$ with primary keys P. and R respectively. The relation r_1 contains 2000 tuples and r_2 contains 2500 tuples. The maximum size of the join $r_1 \bowtie r_2$ is
   a. 2000
   b. 2500
   c. 4500
   d. 5000

15. Which of the following relational query languages have the same expressive power?
   1. Relational algebra
   2. Tuple relational calculus restricted to safe expressions
   3. Domain relational calculus restricted to safe expressions
   a. 2 and 3 only
   b. 1 and 2 only
   c. 1 and 3 only
   d. 1, 2 and 3

16. The cyclomatic complexity of the flow graph of a program provides
   a. an upper bound for the number of tests that must be conducted to ensure that

all statements have been executed at most once

b. a lower bound for the number of tests that must be conducted to ensure that all statements have been executed at most once

c. an upper bound for the number of tests that must be conducted to ensure that all statements have been executed at least once

d. a lower bound for the number of tests that must be conducted to ensure that all statements have been executed at least once

17. With respect to software testing, consider a flow graph G with one connected component. Let E be the number of edges, N be the number of nodes, and P be the number of predicate nodes of C. Consider the following four expressions:

1. E – N + P
2. E – N + 2
3. P + 2
4. P + 1

The cyclomatic complexity of G is given by

a. 1 or 3
b. 2 or 3
c. 2 or 4
d. 1 or 4

18. HELO and PORT, respectively, are commands from the protocols

a. FTP and HTP
b. TELNET and POP3
c. HTTP and TELNET
d. SMTP and FTP

19. Which of the following statements is TRUE?

a. Both Ethernet frame and IP packet include checksum fields
b. Ethernet frame includes a checksum field and IF packet includes a CRC field
c. Ethernet frame includes a CRC field and IF packet includes a checksum field
d. Both Ethernet frame and IP packet include CRC fields

20. Which of the following statement(s) is TRUE?

1. A hash function takes a message of arbitrary length and generates a fixed length code.
2. A hash function takes a message of fixed length and generates a code of variable length.
3. A hash function may give the same hash value for distinct messages.

a. 1 only
b. 2 and 3 only
c. 1 and 3 only
d. 2 only

TWO MARKS QUESTIONS (21-75)

21. Consider the following first order logic formula in which R is a binary relation symbol.

$$\forall x \forall y \left(R(x, y) \Rightarrow R(y, x) \right)$$

The formula is

a. satisfiable and valid
b. satisfiable and so is its negation
c. unsatisfiable but its negation is valid
d. satisfiable but its negation is unsatisfiable

22. When a coin is tossed, the probability of getting a Head is p, $0 < p < 1$. Let N be the random variable denoting the number of tosses till the first Head appears, including the toss where the Head appears. Assuming that successive tosses are independent, the expected value of N is

a. 1/p
b. 1/(1 – p)
c. $1/p^2$
d. $1/(1 - p)^2$

23. Let P, Q, and R be sets. Let Δ denote the symmetric difference operator defined as $p \Delta Q = (P \cup Q) - (P \cap Q)$. Using Venn diagrams, determine which of the following is/are TRUE.

1. $p \Delta (Q \cup R) = (P \Delta Q) \cap (P \Delta R)$
2. $p \cap (Q \Delta R) = (P \cap Q) \Delta (P \cap R)$

a. 1 only
b. 2 only
c. Neither 1 nor 2
d. Both 1 and 2

24. What is the cardinality of the set of integers X defined below?

X = {n | 1 ≤ n ≤ 123, n is not divisible by either 2, 3 or 5)

a. 28
b. 33
c. 37
d. 44

25. Consider the undirected graph G defined as follows. The vertices of G are bit strings of length n. We have an edge between vertex n and vertex u if and only if is and v differ in exactly one bit position (in other words, v can be obtained from u by flipping a single bit). The ratio of the chromatic number of G to the diameter of G is

a. $1/2^{n-1}$
b. 1/n
c. 2/n
d. 3/n

26. What are the eigenvalues of the matrix P given below?

$$P = \begin{pmatrix} a & 1 & 0 \\ 1 & a & 1 \\ 0 & 1 & a \end{pmatrix}$$

a. $a, a-\sqrt{2}, a+\sqrt{2}$
b. a, a, a
c. $0, a, 2a$
d. $-a, 2a, 2a$

27. Match the following iterative methods for solving algebraic equations and their orders of convergence.

Method

A. Bisection
B. Newton-Raphson
C. Secant
D. Regula falsi

Order of convcrence

1. 2 or more
2. 1.62
3. 1
4. 1 bit per iteration

Codes;

	A	B	C	D
a.	3	4	1	2
b.	4	1	2	3
c.	4	2	3	1
d.	4	1	2	3

28. The following definite integral evaluates to

$$\int_{-\infty}^{0} e^{-\left(\frac{x^2}{20}\right)_{dx}}$$

a. 1/2
b. $\pi\sqrt{10}$
c. $\sqrt{10}$
d. π

29. Consider the regular grammar below.

$S \to bS \mid aA \mid \varepsilon$

$A \to aS \mid bA$

The Myhill-Nerode equivalence classes for the language generated by the grammar are

a. $\{w \in (a+b)^* \mid \#_a(w)$ is even$\}$ and $\{w \in (a+b)^* \mid \#_a(w)$ is odd$\}$
b. $\{w \in (a+b)^* \mid \#_b(w)$ is even$\}$ and $\{w \in (a+b)^* \mid \#_b(w)$ is odd$\}$
c. $\{w \in (a+b)^* \mid \#_a(w) = \#_b(w)\}$ and $\{w \in (a+b)^* \mid \#_a(w) \neq \#_b(w)\}$
d. $\{\varepsilon\}, \{wa \mid w \in (a+b)^*\}$ and $\{wb \mid w \in (a+b)^*\}$

30. Which of the following statements about regular languages is NOT true?

a. Every language has a regular superset
b. Every language has a regular subset
c. Every subset of a regular language is regular
d. Every subset of a finite language is regular

31. Which of the following languages is accepted by a non-deterministic pushdown automaton (PDA) but NOT by a deterministic PDA?

a. $\{a^n b^n c^n \mid n \geq 0\}$
b. $\{a^l b^m c^n \mid l \neq m \text{ or } m \neq n\}$
c. $\{a^n b^n \mid n \geq 0\}$
d. $\{a^m b^n \mid m, n \geq 0\}$

32. Let L be a context-free language and M a regular language. Then the language L∩M is

a. always regular
b. never regular

c. always a deterministic context-free language

d. always a context-free language

33. Consider the pushdown automaton (PDA) below which runs over the input alphabet {a, b, c}. It has the stack alphabet {Z_0, X) where Z_0 is the bottom-of-stack marker. The set of states of the PDA is {s,t,u,f} where s is the start state and *f* is the final state. The PDA accepts by final state. The transitions of the PDA given below are depicted in a standard manner. For example, the transition (s,b,X) → (r, XZ_0) means that if the PDA is in state s and the symbol on the top of the stack is X, then it can read b from the input and move to state: after popping the top of stack and pushing the symbols Z_0 and X (in that order) on the stack.

$$(s,a,Z_0) \rightarrow (s,XXZ_0)$$
$$(s,\varepsilon,Z_0) \rightarrow (f,\varepsilon)$$
$$(s,a,X) \rightarrow (s,XXX)$$
$$(s,b,X) \rightarrow (t,\varepsilon)$$
$$(t,b,X) \rightarrow (t,\varepsilon)$$
$$(t,c,X) \rightarrow (u,\varepsilon)$$
$$(u,c,X) \rightarrow (u,\varepsilon)$$
$$(u,\varepsilon,Z_0) \rightarrow (f,\varepsilon)$$

The language accepted by the PDA is

a. $\{a^l b^m c^n \mid l = m = n\}$

b. $\{a^l b^m c^n \mid l = m\}$

c. $\{a^l b^m c^n \mid 2l = m + n\}$

d. $\{a^l b^m c^n \mid m = n\}$

34. In the context-free grammar below, S is the start symbol, a and b are terminals, ε denotes the empty string.

$S \rightarrow aSAb \mid \varepsilon$

$A \rightarrow bA \mid \varepsilon$

The grammar generates the language

a. $((a+b)^*b)^*$

b. $\{a^m b^n \mid m \le n\}$

c. $\{a^m b^n \mid m = n\}$

d. a^*b^*

35. The boolean function for a combinational circuit with four inputs is represented by the following Karnaugh map.

RS \ PQ	00	01	11	10
00	1	0	0	1
01	0	0	1	1
11	1	1	1	0
10	1	0	0	1

Which of the product terms given below is an essential prime implicant of the function?

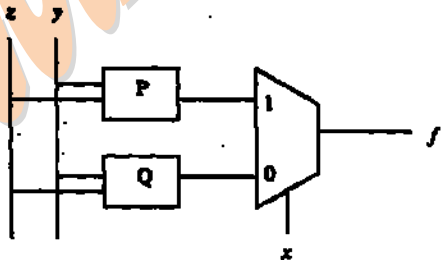
a. QRS

b. PQS

c. PQ′S′

d. Q′S′

36. The majority function is a Boolean function f(x, y, z) that takes the value 1 whenever a majority of the variables x, y, z are 1. In the circuit diagram for the majority function shown below, the logic gates for the boxes labeled P and Q are, respectively,



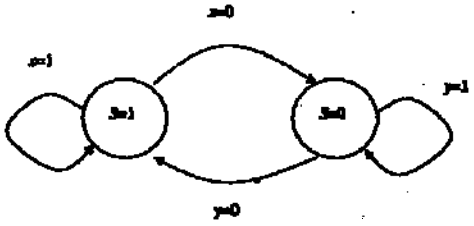
a. XOR, AND

b. XOR, XOR

c. OR, OR

d. OR, AND

37. For a state machine with the following state diagram, the expression for the next state S^+ in terms of the current state S and the input variables x and y is



a. $S^+ = S'.y' + S.x$

b. $S^+ = S.x.y' + S'.y.x'$

c. $S^+ = x.y'$

d. $S^+ = S'.y + S.x'$

38. When multiplicand Y is multiplied by multiplier $X = x_{n-1}x_{n-2}.....x_0$ using bit-pair recoding in Booth's algorithm, partial products are generated according to the following table.

Row	x_{i+1}	x_i	x_{i-1}	Partial Product
1	0	0	0	0
2	0	0	1	Y
3	0	1	0	Y
4	0	1	1	2Y
5	1	0	0	?
6	1	0	1	-Y
7	1	1	0	-Y
8	1	1	1	?

The partial products for rows 5 and 8 are

a. 2Y and Y
b. -2Y and 2Y
c. -2Y and 0
d. 0 and Y

39. Which of the following statements about relative addressing mode is FALSE?

a. It enables reduced instruction size
b. It allows indexing of array elements with same instruction
c. It enables easy relocation of data
d. It enables faster address calculations than absolute addressing

40. The memory locations 1000, 1001 and 1020 have data values 18, 1 and 16 respectively before the following program is executed.

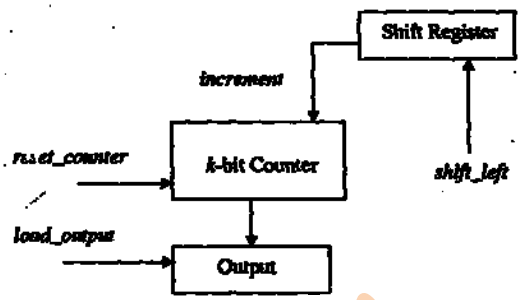
```
MOVI   Rs, 1          ; Move immediate
LOAD   Rd, 1000(Rs)   ; Load from memory
ADDI   Rd, 1000       ; Add immediate
STOREI 0(Rd), 20      ; Store immediate
```

Which of the statements below is TRUE after the program is executed?

a. Memory location 1000 has value 20
b. Memory location 1020 has value 20
c. Memory location 1001 has value 20
d. Memory location 1021 has value 20

41. The data path shown in the figure computes the number of is in the 32-bit input word corresponding to an unsigned even integer stored in the shift register.

The unsigned counter, initially zero, is incremented if the most significant bit of the shift register is 1.



The micro program for the control is shown in the table below with missing control words for microinstructions I_1, I_2,…..,I_n.

Microinstruction	reset_counter	shift_left	load_output
BEGIN	1	0	0
I_1	?	?	?
:	:	:	:
I_n	?	?	?
END	0	0	1

The counter width (k), the number of missing microinstructions (n), and the control word for microinstructions I_1, I_2, ……, I_n are, respectively,

a. 32, 5, 010
b. 5, 32, 010
c. 5, 31, 011
d. 5, 31, 010

42. A cache line is 64 bytes. The main memory has latency 32ns and bandwidth 1GBytes/s. The time required to fetch the entire cache line from the main memory is

a. 32 ns
b. 64 ns
c. 96 ns
d. 128 ns

43. A computer system has a level-1 instruction cache (I-cache), a level-1 data cache (D-cache) and a level-2 cache (L2-cache) with the following specifications:

	Capacity	Mapping method	Block size
I-cache	4K words	Direct mapping	4 words
D-cache	4K words	2-way set-associative mapping	4 words
L2-cache	64K words	4-way set-associative mapping	16 words

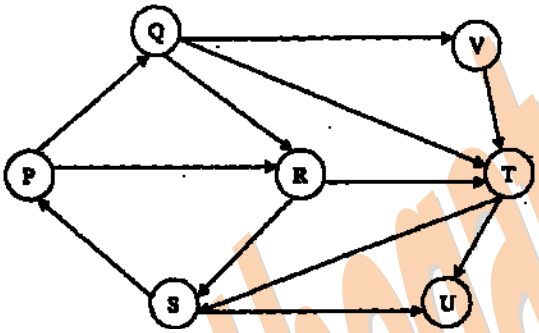
The length of the physical address of a word in the main memory is 30 bits. The capacity of the tag memory in the 1-cache, D-cache and L2-cache is, respectively,

a. 1K × l8-bit, 1K × 19-bit,4K × 16-bit
b. 1K × 16-bit, 1K × 19-bit, 4K × 18-bit
c. 1K × l6-bit, 512 × 18-bite 1K × 16-bit
d. 1K × l8-bit, 512 × 18-bit, 110 × 18-bit

44. Which of the following sequences of array elements forms a heap?
    a. {23, 17, 14,6, 13, 10, 1, 12,7,5}
    b. {23, 17, 14,6, 13, 10, 1,5,7, 12}
    c. {23, 17, 14,7, 13, 10, 1,5,6, 12}
    d. {23, 17, 14,7, 13, 10, 1, 12, 5,7}

45. Suppose that we have numbers between 1 and 100 in a binary search tree and want to search for the number 55. Which of the following sequences CANNOT be the sequence of nodes examined?
    a. {10,75,64,43,60,57,55}
    b. {90,12,68,34,62,45,55}
    c. {9,85,47,68,43, 57,55}
    d. {79,14,72,56,16,53,55}

46. Which of the following is the correct decomposition of the directed graph given below into its strongly connected components?



    a. {P,Q,R,S), {T}, {U}, {V}
    b. {P,Q,R,S,T,V}, {U}
    c. {P,Q,S,T,V}, {R), {U}
    d. {P,Q,R,S,T,U,V)

47. Consider the depth-first-search of an undirected graph with 3 vertices P. Q and R. Let discovery time d(u) represent the time instant when the vertex u is first visited, and finish time f(u) represent the time instant when the vertex ii is lat visited. Given that

    d(P) = 5 units f(P) = 12 units
    d(Q) = 6 units f(Q) = 10 units
    d(R) = 14 units f(R) = 18 units,

    which one of the following statements is TRUE about the graph?
    a. There is only one connected component
    b. There are two connected components, and P and R are connected
    c. There are two connected components, and Q and R are connected
    d. There are two connected components, and P and Q are connected

48. The characters a to h have the set of frequencies based on the first 8 Fibonacci numbers as follows:

    a:1, b:1, c:2, d:3, e:5,f:8, g:13, h:21

    A Huffman code is used to represent the characters. What is the sequence of characters corresponding to the following code?

    110111100 1110 10
    a. fdheg
    b. ecgdf
    c. dchfg
    d. fehdg

49. Which one of the choices given below would be printed when the following program is executed?

```
#include <stdio.h>
struct test {
    int i;
    char *c;
} st[]={5, "become", 4, "better", 6, "jungle", 8, "ancestor", 7,
"brother"};
main()
{
    struct test *p=st;
    p+=1;
    ++p->c;
    printf("%s,", p++->c);
    printf("%c,", *++p->c);
    printf("%d,", p[0].i);
    printf("%s\n", p[-1].c);
}
```

    a. jungle,n,8,ncestor
    b. etter,u,6,ungle
    c. cettet-,k,6,jungle
    d. etter,u,8,ncestor

50. Which one of the choices given below would be printed when the following programme is executed?

```
#include <stdio.h>
void swap(int *x, int *y)
{
        static int *temp;
        temp = x;
        x = y;
        y = temp;
}
void printab()
{
        static int i, a=-3, b=-6;
        i=0;
        while (i<=4)
        {
```

```
            if ((i++)%2==1) continue;
            a = a+i;
            b = b+i;
        }
        swap(&a,&b);
        printf("a=%d,b=%d\n", a, b);
}
main()
{
        printab();
        printab();
}
```

a. a = 0, b = 3;
   a = 0, b = 3
b. a = 3, b = 0
   a = 12, b = 9
c. a = 3, b = 6
   a = 3, b = 6
d. a = 6, b = 3
   a = 15, b = 12

51. Which one of the choices given below would be printed when the following programme is executed?

```
#include <stdio.h>
int a1[]={6,7,8,18,34,67};
int a2[]={23,56,28,29};
int a3[]={-12,27,-31};
int *x[]={a1,a2,a3};
void print(int *a[])
{
    printf("%d,", a[0][2]);
    printf("%d,", *a[2]);
    printf("%d,", *++a[0]);
    printf("%d,", *(++a)[0]);
    printf("%d\n", a[-1][+1]);
}
main()
{
    print(x);
}
```

a. 8, -12, 7, 23, 8
b. 8, 8, 7, 23, 7
c. -12, -12, 27,-31, 23
d. -12, -12, 27, -31, 56

52. The following function computes the value of $\binom{m}{n}$ correctly for all legal values m and n ($m \geq 1$, $n \geq 0$ and $m > n$).

```
int func(int m, int n)
{
      if (E) return 1;
      else return(func(m-1,n)+func(m-1,n-1));
}
```

In the above function, which of the following is the correct expression for E?

a. $(n == 0) \| (m == 1)$
b. $(n == 0) \&\& (m == 1)$
c. $(n == 0) \| (m == n)$
d. $(n == 0) \&\& (m == n)$

53. Match the following concepts and their best possible descriptions.

Concept

(i) overloading
(ii) friend
(iii) constructor
(iv) protected
(v) this
(vi) inheritance

Description

A. allows to define a class to have properties of another class
B. defining a set of similar functions
C. used in dereferencing
D. used to give a non-member function access to the private parts of an object
E. a function which is automatically called when an object is created
F. allows a derived class to have access to the private parts of the base class
G. a pointer to the object associated with the current function
H. used to obtain object persistence

Codes;

a. i-B ii-D iii-E iv-F v-G vi-A
b. i-C ii-A iii-E iv-D v-H vi-F
c. i-C ii-F iii-H iv-A v-G vi-D
d. i-B ii-E iii-C iv-F v-G vi-H

54. The arrival time, priority, and durations of the CPU and I/O bursts for each of three processes P_1, P_2 and P_3 are given in the table below. Each process has a CPU burst followed by an I/O burst followed by another CPU burst. Assume that each process has its own I/O resource.

Process	Arrival time	Priority	Burst durations (CPU, I/O, CPU)
P_1	0	2	1, 5, 3
P_2	2	3 (lowest)	3, 3, 1
P_3	3	1 (highest)	2, 3, 1

The multi-programmed operating system uses preemptive priority scheduling. What ate the finish times of the processes P_1, P_2 and P_3?

a. 11, 15, 9
b. 10, 15, 9
c. 11,16, 10
d. 12, 17, 11

55. Consider the solution to the bounded buffer producer/consumer problem by using general semaphores S. F, and F. The semaphore S is the mutual exclusion semaphore initialized to 1. The semaphore F corresponds to the number of free slots in the buffer and is initialized to N. The semaphore £ corresponds to the number of elements in the buffer and is initialized to 0.

Producer Process	Consumer Process
Produce an item;	Wait(E);
Wait (F);	Wait(S);
Wait (S);	Remove an item from the buffer;
Append the item to the buffer;	Signal(S);
Signal(S);	Signal(F);
Signal(E);	Consume the item;

Which of the following interchange operations may result in a deadlock?

1. Interchanging Wait (F) and Wait(s) in the Producer process
2. Interchanging Signal (s) and Signal(F) in the Consumer process

a. 1 only
b. 2 only
c. Neither 1 nor 2
d. Both 1 and 2

56. For each of the four processes P_1, P_2, P_3 and P_4, the total size in kilobytes (KB) and the number of segments are given below.

Process	Total size (in KB)	Number of segments
P_1	195	4
P_2	254	5
P_3	45	3
P_4	364	8

The page size is 1 KB. The size of an entry in the page table is 4 bytes. The size of an entry in the segment table is S bytes. The maximum size of a segment is 256 KB. The paging method for memory management uses two-level paging, and its storage overhead is P. The storage overhead for the segmentation method is S. The storage overhead for the segmentation and paging method is T. What is the relation among the overheads for the different methods of memory management in the concurrent execution of the above four processes?

a. P < S < T
b. S < P < T
c. S < T < P
d. T < S < P

57. The wait and signal operations of a monitor are implemented using semaphores as follows. In the following.

x is a condition variable,

mutex is a semaphore initialized to 1,

x_sem is a semaphore initialized to 0,

x_count s the number of processes waiting on semaphore x_senz , initially 0,

next is a semaphore initialized to 0,

next_count is the number of processes waiting on semaphore next, initially 0.

The body of each procedure that is visible outside the monitor is replaced with the following:

```
P(mutex);
  .
  .
body of procedure
  .
  .
if (next_count > 0)
  V(next)
else
  V(mutex);
```

Each occurrence of x.wait is replaced with the following:

```
x_count = x_count + 1;
if (next_count > 0)
  V(next)
else
  V(mutex);
-------------------------------------------E1;
x_count = x_count - 1;
```

Each occurrence of x.signal is replaced with the following:

```
if (x_count > 0)
{
  next_count = next_count + 1;
  -------------------------------------------E2;
  P(next);
  next_count = next_count - 1;
}
```

For correct implementation of the monitor, statements E_1 and E_2 arc, respectively,

a. P(x_sem), V(next)
b. V(next), P(x_sem)
c. P(next), V(x_sem)
d. P(x_sem), V(x_sem,)

58. A software program consists of two modules M_1 and M_2 that can fail independently, but never simultaneously. The program is considered to have failed if any of these modules fads. Both the modules are 'repairable' and so the

program starts working again as soon as the repair is done. Assume that the mean time to failure (MTTF) of M_1 is T_1 with a mean time to repair (MTTR) of R_1. The MTTF of M_2 is T_2 with an MTTR of R_2. What is the availability of the overall program given that the failure and repair times are all exponentially distributed random variables?

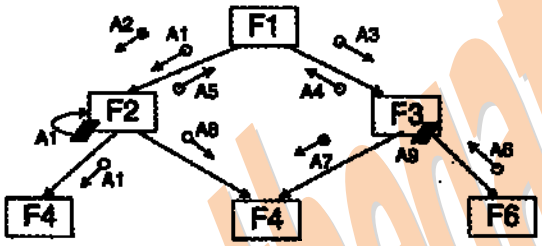
a. $\frac{T_1T_2}{T_1R_1+T_2R_2}$

b. $\frac{R_1R_2}{T_1R_1+T_2R_2}$

c. $\frac{T_1T_2}{T_1T_2+T_1R_1+T_2R_2}$

d. $\frac{T_1T_2}{T_1T_2+T_1R_2+T_2R_1}$

59. Consider the following structure chart diagram. The boxes have function names embedded in them, while the variables are indicated along the arcs.



Given below are a set of statements relevant to the above diagram.

1. F3 and F6 can be in the same module.
2. F4 and F6 can be in the same module.
3. A4 is both an output and a control variable.
4. It is incorrect to pass Al as data and use it as a control variable.

Which combination of these statements is TRUE?

a. 3 and 4
b. 1 and 4
c. 2 and 4
d. 1, 2, and 4

60. Consider a relation R with five attributes V, W, X, Y, and Z. The following functional dependencies hold: VY → W, WX → Z, and ZY → V. Which of the following is a candidate key for R?

a. VXZ
b. VXY
c. VWXY
d. VWXYZ

61. In a database file structure, the search key field is 9 bytes long, the block size is 512 bytes, a record pointer is 7 bytes and a block pointer is 6 bytes. The largest9 possible order of a non-leaf node in a Bt tree implementing this file structure is

a. 23
b. 24
c. 34
d. 44

62. Consider the following XML DTD describing course information in a university:

```
<!ELEMENT Univ (Course+, Prof+)>
<!ELEMENT Course (Title, Eval*)>
<!ATTLIST Course Number ID #REQUIRED Instructor IDREF #IMPLIED>
<!ELEMENT Title (#PCDATA)>
<!ELEMENT Eval (#PCDATA)>
<!ATTLIST Eval Score CDATA #REQUIRED>
<!ELEMENT Prof EMPTY>
<!ATTLIST Prof Name ID #REQUIRED Teaches IDREF #IMPLIED>
```

What is returned by the following X Query?

```
let $as := //@Score
for $c in /Univ/Course[Eval]
let $cs := $c/Eval/@Score
where min($cs) > avg($as)
return $c
```

a. The professor with the lowest course evaluation
b. Professors who have all their course evaluations above the university average
c. The course with the lowest evaluation
d. Courses with all evaluations above the university average

63. A router uses the following routing table:

Destination	Mask	Interface
144.16.0.0	255.255.0.0	*eth0*
144.16.64.0	255.255.224.0	*eth1*
144.16.68.0	255.255.255.0	*eth2*
144.16.68.64	255.255.255.224	*eth3*

A packet bearing a destination address 144.16.68.117 arrives at the router. On which interface will it be forwarded?

a. eth0
b. eth1
c. eth2
d. erh3

64. Suppose that it takes 1 unit of time to transmit a packet (of fixed size) on a communication link. The link layer uses a window flow control protocol with a window size of N packets. Each packet causes an ack or a nak to be generated by the receiver, and acklnak transmission times are negligible. Further, the round trip time on the link is equal to N units. Consider time i > N. If only acks have been received till time i (no naks), then the goodput evaluated at the transmitter at time i (in packets per unit time) is
   a. 1 - N/i
   b. i/(N + i)
   c. 1
   d. $1 - e^{(i/N)}$

65. In the 48/SB encoding scheme, every 4 bits of data are encoded in a 5-bit codeword. It is required that the codewords have at most 1 leading and at most 1 trailing zero. How many such codewords are possible?
   a. 14
   b. 16
   c. 18
   d. 20

66. A router has two full-duplex Ethernet interfaces each operating at 100 Mb/s. Ethernet frames are at [east 84 bytes long (including the Preamble and the Inter-Packet-Gap). The maximum packet processing time at the router for wire speed forwarding to be possible is (in micro-seconds)
   a. 0.01
   b. 3.36
   c. 6.72
   d. 8

67. A link of capacity 100 Mbps is carrying traffic from a number of sources. Each source generates an on-off traffic stream; when the source is on, the rate of traffic is 10 Mbps, and when the source is off, the rate of traffic is zero. The duty cycle, which is the ratio of on-time to off-time, is 1:2. When there is no buffer at the link, the minimum number of sources that can be multiplexed on the link so that link capacity is not wasted and no data loss occurs is S_1. Assuming that all sources are synchronized and that the link is provided with a large buffer, the maximum number of sources that can be multiplexed so that no data loss occurs is S_2. The values of S_1 and S_2 are, respectively,
   a. 10 and 30
   b. 12 and 25
   c. 5 and 33
   d. 15 and 22

68. On a wireless link, the probability of packet error is 0.2. A stop-and-wait protocol is used to transfer data across the link. The channel condition is assumed to be independent from transmission to transmission. What is the average number of transmission attempts required to transfer 100 packets?
   a. 100
   b. 125
   c. 150
   d. 200

69. A program on machine X attempts to open a UDP connection to port 5376 on a machine Y, and a TCP connection to port 8632 on machine Z. However, there are no applications listening at the corresponding ports on Y and Z. An ICMP Port Unreachable error will be generated by
   a. Y but not Z
   b. Z but not Y
   c. Neither Y nor Z
   d. Both Y and Z

70. A subnetted Class B network has the following broadcast address: 144.16.95.255. Its subnet mask
   a. is necessarily 255.255.224.0
   b. is necessarily 255.255.240.0
   c. is necessarily 255.255.248.0
   d. could be any one of 255.255.224.0, 255.255.240.0, 255.255.248.0

Common Data for Questions (71 - 73)

An array X of ii distinct integers is interpreted as a complete binary tree. The index of the first element of the array is 0.

71. The index of the parent of element X[i], i ≠ 0, is
   a. $\lfloor i/2 \rfloor$
   b. $\lceil (i-1)/2 \rceil$

c. $\lceil i/2 \rceil$

d. $\lceil i/2 \rceil - 1$

72. If only the root node does not satisfy the heap property, the algorithm to convert the complete binary tree into a heap has the best asymptotic time complexity of

a. O(n)

b. O(log n)

c. O(n log n)

d. O(n log log n)

73. If the root node is at level 0, the level of element X [i], $i \neq 0$, is

a. $\lfloor \log_2 i \rfloor$

b. $\lceil \log_2 (i+1) \rceil$

c. $\lfloor \log_2 (i+1) \rfloor$

d. $\lceil \log_2 i \rceil$

Common Data for Questions (74 & 75)

Consider the following program module:

```
void swap(float* A1, float* A2)
{
    float temp;
    if(*A1 == *A2) return;
    temp = *A1;
    *A1 = *A2;
    *A2 = temp;
    return;
}
```

74. The program volume for the above module using Halstead's method is

a. 60

b. 63

c. 66

d. 69

75. The program effort for the above module using Halstead's method is

a. 315

b. 330

c. 393

d. 403

Statement for Linked Answer Question (76 and 77)

Consider the following set of linear equations:

x + 3/2 = 9

3x + y = 10

76. The value of the Frobenius norm for the above system of equations is

a. 0.75

b. 0.5

c. 1.5

d. 2.0

77. What can be said about the Gauss-Siedel iterative method for solving the above set of linear equations?

a. It will converge

b. It will diverge

c. It will neither converge nor diverge

d. It is not applicable

Statement for Linked Answer Question (78 and 79)

A pipelined processor uses a 4-stage instruction pipeline with the following stages: Instruction fetch (IF), Instruction decode (ID), Execute (EX) and Write back (WB). The arithmetic operations as well as the load and store operations are carried out in the EX stage. The sequence of instructions corresponding to the statement X = (S – R* (P+Q))/T is given below. The values of variables P. Q, R, S and T are available in the registers R0, R1, R2, R3 and R4 respectively, before the execution of the instruction sequence.

```
ADD    R5, R0, R1   ; R5 ← R0 + R1
MUL    R6, R2, R5   ; R6 ← R2 * R5
SUB    R5, R3, R6   ; R5 ← R3 – R6
DIV    R6, R5, R4   ; R6 ← R5 / R4
STORE  R6, X        ; X ← R6
```

78. The number of Read-After-Write (RAW) dependencies, Write-After-Read (WAR) dependencies, and Write-After-Write (WAW) dependencies in the sequence of instructions arc, respectively,

a. 2,2,4

b. 3,2,3

c. 4,2,2

d. 3,3,2

79. The IF, ID and WB stages take 1 clock cycle each. The EX stage takes 1 clock cycle each for the ADD, SUB and STORE operations, and 3 clock cycles each for MUL and DIV operations. Operand forwarding from the EX stage to the ID stage is used. The number of clock cycles

required to complete the sequence of instructions is

a. 10
b. 12
c. 14
d. 16

Statement for Linked Answer Question (80 and 81)

Let L be a regular language. Consider the constructions on L below:

(I) $repeat(L) = \{ww \mid w \in L\}$

(II) $prefix(L) = \{u \mid \exists v : uv \in L\}$

(III) $suffix(L) = \{v \mid \exists u : uv \in L\}$

(IV) $half(L) = \{u \mid \exists v : |v| = |u| and\ uv \in L\}$

80. Which of the constructions could lead to a non-regular language?

a. Both I and IV
b. Only I
c. Only IV
d. Both II and III

81. Which choice of L is best suited to support your answer above?

a. (a + b)*
b. {ε, a, ab, bab}
c. (ab)*
d. $\{a^n b^n \mid n \geq 0\}$

Statement for Linked Answer Question (82 and 83)

A software project has four phases P1, P2, P3 and P4. Of these phases, Pt is the first one and needs to be completed before any other phase can commence. Phases P2 and P3 can be executed in parallel. Phase P4 cannot commence until both P2 and PS are completed. The optimistic, most likely, and pessimistic estimates of the phase completion times in days, for P1, P2, P3 and P4 are, respectively, (11, 15, 25), (7, 8, 15), (8,9,22), and (3, 8, 19).

82. The critical path for the above project and the slack of P2 are, respectively,

a. P1-P2-P4, 1 day
b. P1-P3-P4, 1 day
c. P1-P3-P4, 2 days
d. P1-P2-P4, 2 days

83. The costs (in Rupees per day) of crashing the expected phase completion times for (he four phases, respectively, are 100. 2000, 50, and 1000. Assume that the expected phase completion times of the phases cannot be crashed below their respective most likely completion times. The minimum and the maximum amounts (in Rupees) that can be spent on crashing so that ALL paths are critical are, respectively,

a. 100 and 1000
b. 100 and 1200
c. 150 and 1200
d. 200 and 2000

Statement for Linked Answer Question (82 and 83)

Consider a database with three relation instances shown below. The primary keys for the Drivers and Cars relation are did and cid respectively and the records are stored in ascending order of these primary keys as given in the tables. No indexing is available in the database.

D: Drivers relation

did	*dname*	*rating*	*age*
22	Karthikeyan	7	25
29	Salman	1	33
31	Boris	8	55
32	Arnoldt	8	25
58	Schumacher	10	35
64	Sachin	7	35
71	Senna	10	16
74	Sachin	9	35
85	Rahul	3	25
95	Ralph	3	53

R: Reserves relation

did	*cid*	*day*
22	101	10/10/06
22	102	10/10/06
22	103	8/10/06
22	104	7/10/06
31	102	10/11/06
31	103	6/11/06
31	104	12/11/06
64	101	5/9/06
64	102	8/9/06
74	103	8/9/06

C: Cars relation

cid	*cname*	*color*
101	Renault	blue
102	Renault	red
103	Ferrari	green
104	Jaguar	red

84. What is the output of the following SQL query?

```
select D.dname
from Drivers D
where D.did in (
        select R.did
        from Cars C, Reserves R
        where R.cid = C.cid and C.color = 'red'

        intersect

        select R.did
        from Cars C, Reserves R
        where R.cid = C.cid and C.color = 'green'
        )
```

a. Karthikeyan, Boris
b. Sachin, Salman
c. Karthikeyan, Boris, Sachin
d. Schumacher, Senna

85. Let ii be the number of comparisons performed when the above SQL query is optimally executed. If linear search is used to locate a tuple in a relation using primary key, then ii lies in the range

a. 3640
b. 44-48
c. 60-64
d. 100-104